Final

BLACKJACK CREEK WATERSHED ASSESSMENT AND PROTECTION AND RESTORATION PLAN

Watershed Protection and Restoration Plan

Prepared for
Suquamish Tribe

December 29, 2017

Blackjack Creek and associated wetlands, just upstream of SE Dogwood Road

Final

BLACKJACK CREEK WATERSHED ASSESSMENT AND PROTECTION AND RESTORATION PLAN

Watershed Protection and Restoration Plan

Prepared by:

Ilon Logan

Pete Lawson

Christina Hersum

ESA

5309 Shilshole Avenue, NW
Suite 200
Seattle, WA 98107
206.789.9658
www.esassoc.com

DEPARTMENT OF ECOLOGY State of Washington

THE SUQUAMISH TRIBE

This project has been funded wholly or in part by the United States Environmental Protection Agency (US EPA) under Assistance Agreement PC-J9401 to ECOLOGY and US EPA assistance agreement #00J99801 (Puget Sound Tribal Capacity Building). The contents of this document do not necessarily reflect the views and polices of the Environmental Protection Agency, nor does mention of trade names or commercial projects constitute endorsement or recommendation for use.

Acknowledgements

The Blackjack Watershed Assessment and Protection and Restoration Plan benefited greatly from the participation at workshops and site visits, review, and comments on technical reports received from the following individuals and organizations:

Earl Prentice
Roberta Myers
Brandon Nickerson
Craig Nickerson
Ron Rice
Dick Brown
Julie Mentzer (Wildlands Inc.)
Nick Bond (City of Port Orchard)
Keri Sallee (City of Port Orchard)
Zack Holt (City of Port Orchard)
Kathy Peters (Kitsap County)
Kirvie Mesebeluu-Yobech (Kitsap County)
David Nash (Kitsap County)
Marian Berejikian (Kitsap County)
Carrie Byron (Ecology)
Colin Hume (Ecology)
Stephen Stanley (Ecology)
Chris Waldbillig (WDFW)
Brittany Gordon (WDFW)
Nam Siu (WDFW)
Carin Anderson (Kitsap Conservation District)
Jamie Glasgow (Wild Fish Conservancy)
Jonathan Decker (Great Peninsula Conservancy)
Erik Pedersen (Great Peninsula Conservancy)
Jennifer Holderman (Mason Conservation District)
Jeanette Dorner (Mid Sound Salmon Enhancement Group)
Marty Ereth (Pierce County)
Amber Moore (Puget Sound Partnership)
Amy Bahr (Washington State Recreation and Conservation Office)
Katy Doctor-Shelby (NOAA)
Chance Berthiaume (City of Bremerton)
Brenda Padgham (Bainbridge Land Trust)

TABLE OF CONTENTS

Blackjack Creek Watershed Assessment and Protection and Restoration Plan

Page

1 Introduction 1

2 Previous Assessments and Ongoing Investigations 1

3 Watershed Assessment Findings 2

4 Protection and Restoration Strategies 9
- 4.1 Protection Strategies 9
- 4.2 Restoration Strategies 11
- 4.3 Results Chains 14

5 Recommended Actions 15
- 5.1 Lower Blackjack Creek 15
- 5.2 Middle Blackjack Creek 26
- 5.3 Upper Blackjack Creek 33
- 5.4 Ruby Creek 37
- 5.5 Square Creek 47
- 5.6 Square Lake 53

6 Prioritization Framework for Actions 55
- 6.1 Process-based Principles 55
- 6.2 Additional Considerations 56
  - Landscape Controls and Degradation 57
  - Biological Benefits 59
  - Climate Change 59
  - Other Factors 61

7 Potential Monitoring Indicators 62

8 Data Gaps and Recommendations for Future Work 65

9 References 69

Appendices

Appendix A - Blackjack Creek Synthesis of Existing Data and Reports Memorandum (ESA, 2016)
Appendix B - Blackjack Creek Strategies and Sub-Strategies
Appendix C - Blackjack Creek Results Chains

List of Figures

Figure 1. Blackjack Creek Watershed and Subbasins 3
Figure 2. Basic Components of a Results Chain 14
Figure 3. Protection and Restoration Actions – Lower Blackjack Creek Subbasin 17
Figure 4. Protection and Restoration Actions – Middle Blackjack Creek Subbasin.....27
Figure 5. Protection and Restoration Actions – Upper Blackjack Creek Subbasin 34
Figure 6. Protection and Restoration Actions – Ruby Creek Subbasin 38
Figure 7. Protection and Restoration Actions – Square Creek Subbasin 48
Figure 8. Protection and Restoration Actions – Square Lake Subbasin.....54

List of Tables

Table 1. Subbasin Characteristics of the Blackjack Creek Watershed.....2
Table 2. Ecosystem Components and Categories for the Blackjack Creek Watershed Assessment.....4
Table 3. Pressure Categories and Stressors on Ecosystem Components.....4
Table 4. Summary of Reach-scale Stream Evaluations of Watershed Processes and Key Ecological Attributes in the Blackjack Creek Watershed 8
Table 5. Recommended Protection Strategies and Sub-strategies.....9
Table 6. Recommended Restoration Strategies and Sub-strategies.....11
Table 7. Recommended Actions – Lower Blackjack Creek Subbasin 16
Table 8. Recommended Actions – Middle Blackjack Creek Subbasin 26
Table 9. Recommended Actions – Upper Blackjack Creek Subbasin 33
Table 10. Recommended Actions – Ruby Creek Subbasin.....37
Table 11. Recommended Actions – Square Creek Subbasin.....47
Table 12. Summary of Restoration Action Types and Their Ability to Ameliorate Climate Change Effects (Table III from Beechie et al. 2013) 61
Table 13. Potential KEA and Pressure Indicators at the Watershed Scale for Blackjack Creek. 62
Table 14. Potential Salmonid KEA Indicators for Blackjack Creek. 64

1 INTRODUCTION

The Blackjack Creek watershed covers an area of 12.3 square miles in eastern Kitsap County and is considered one of the largest and most productive salmon watersheds in the south Kitsap subregion (May and Peterson, 2003). The watershed supports two genetically distinct runs of chum salmon, a summer run and a late fall run, as well as Chinook and coho salmon, steelhead, and cutthroat trout. The Suquamish Tribe conducted an assessment of the watershed that identified critical ecosystem components and key ecological attributes (KEAs), their current status, and human-caused pressures on KEAs. The goal of the watershed assessment is to develop a Watershed Plan for protection and restoration strategies and actions in the Blackjack Creek watershed that will protect and restore watershed, riparian, floodplain and stream habitats. In particular, the Tribe is focused on protecting and restoring processes and habitat functions that support the recovery and self-maintenance, resilience and persistence of native salmonid populations and their life history diversity, such that salmonid populations can support tribal harvest for future generations.

This Blackjack Creek Watershed Protection and Restoration Plan (hereafter referred to as the Watershed Plan) includes a summary overview of the watershed assessment findings, a set of strategies for addressing degraded watershed processes, and 46 recommended actions for the protection and restoration of ecological processes and habitats in the Blackjack Creek watershed. The plan also includes a step-wise framework and considerations for prioritizing protection and restoration actions and a comprehensive list of data gaps and recommendations for future work.

The watershed assessment and this plan have been developed with support from a National Estuary Program (NEP) Watershed Protection and Restoration Grant from the Washington Department of Ecology (Ecology #SEANEP-2014-SuquTr-00072) and US EPA assistance agreement #00J99801 (Puget Sound Tribal Capacity Building).

2 PREVIOUS ASSESSMENTS AND ONGOING INVESTIGATIONS

This project began with a comprehensive review of existing data, technical reports, studies, and assessments of the Blackjack Creek watershed. The *Synthesis of Existing Data and Reports Memorandum* (ESA, 2016) summarizes key findings of existing studies and provides an inventory of previous and ongoing restoration and protection activities in the watershed (see Appendix A).

Several documents related to salmonid habitat, stream typing, fish passage, flow regimes, stream biology, and land use in the Blackjack Creek watershed were summarized, including:

- Salmonid Habitat Limiting Factors, Water Resource Area 15 – East (Haring, 2000)
- Kitsap Salmonid Refugia Report (May and Peterson, 2003)
- West Sound Water Type Assessment – Phase II (Wild Fish Conservancy, 2014)
- Fish Passage and Diversion Screening Inventory (Washington Department of Fish and Wildlife [WDFW], 2016a)
- Blackjack Creek Comprehensive Management Plan for the City of Port Orchard (FishPro, 1987)
- Sinclair Inlet Enhancement Opportunities-Aquascape II (Naval Facilities, 2010)

A compilation of existing data from several historic or ongoing sources included:

- Streamflow Data for Blackjack Creek (historic and ongoing)
- Stream temperature data collected by Suquamish Tribe from 2003-present (ongoing)
- WDFW and Suquamish Tribe Salmon Spawner Monitoring (ongoing)
- Kitsap County Stream Benthic Macroinvertebrate Monitoring (ongoing)
- Sinclair Inlet Fecal Pollution Reduction Project (2013)
- Kitsap Water Pollution Identification & Correction Program: 2015 Annual Water Quality Report (2015)

A more complete list of existing data sources and publications is provided in the memorandum (Appendix A).

3 WATERSHED ASSESSMENT FINDINGS

The Blackjack Creek *Key Ecological Attributes and Pressures Assessment* (ESA, 2017a) summarized available information for salmonids in the watershed, including existing habitat conditions, and examined pressures and stressors on ecosystem processes in the watershed. Key findings of the watershed assessment are summarized in this section to provide context for the strategies and actions recommended in this Watershed Plan.

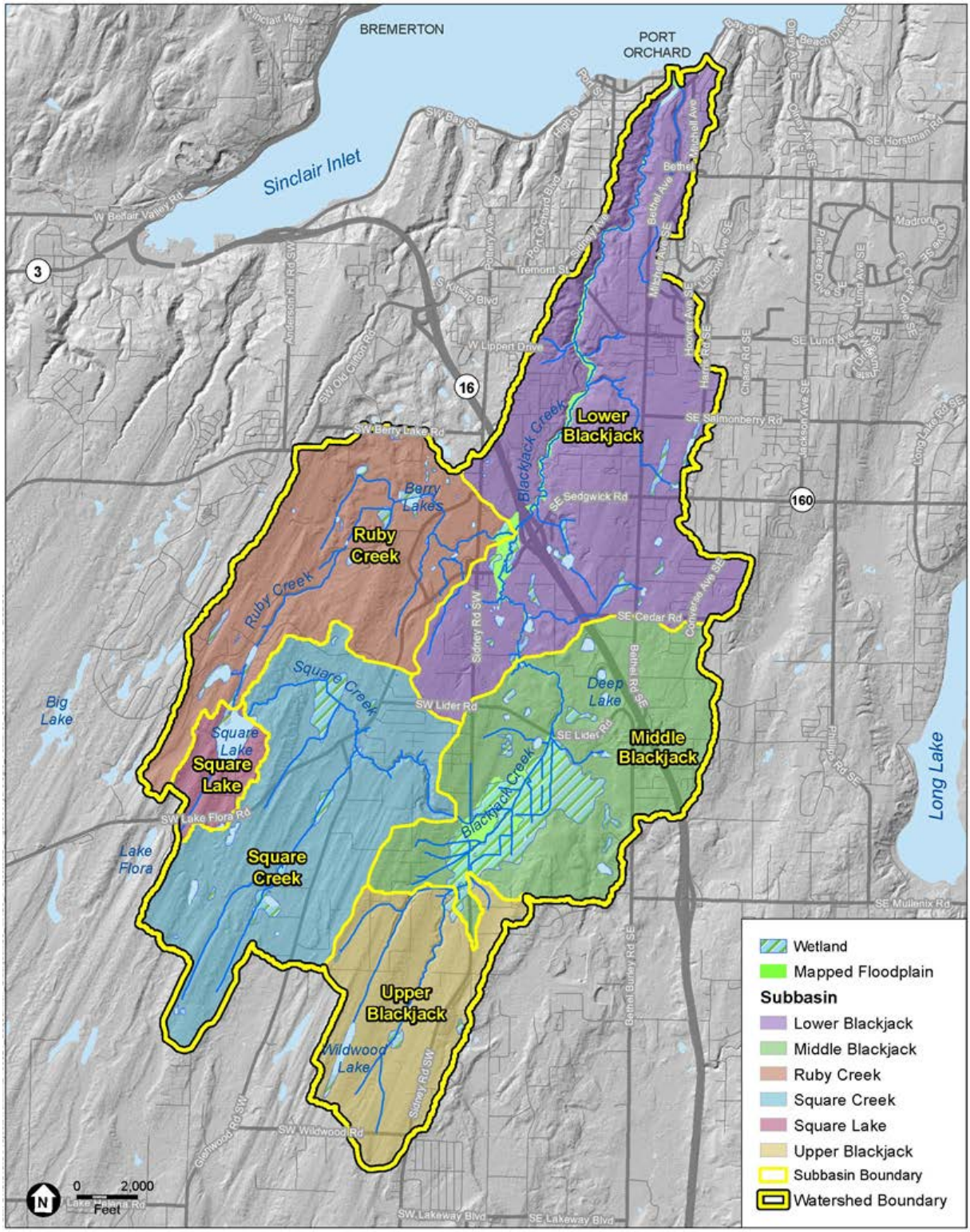
The Blackjack Creek watershed is comprised of six subbasins: Lower Blackjack Creek, Middle Blackjack Creek, Upper Blackjack Creek, Ruby Creek, Square Creek, and Square Lake subbasins (Figure 1). There are two primary tributary streams of Blackjack Creek, Ruby Creek and Square Creek, both of which originate at Square Lake, a shallow 30-acre lake in the western portion of the watershed. There are 36 miles of stream channels in the watershed, 20 of which are classified as fish habitat (WFC, 2014). The Lower Blackjack Creek subbasin is the largest at 3.8 square miles (Table 1).

Table 1. Subbasin Characteristics of the Blackjack Creek Watershed

Subbasin	Drainage Area (mi^2)	Topographic Relief (ft)
Ruby Creek	2.0	383.0
Square Creek	2.5	320.8
Square Lake	0.3	147.7
Lower Blackjack Creek	3.8	391.0
Middle Blackjack Creek	2.4	272.8
Upper Blackjack Creek	1.3	275.9
Watershed Total	12.3	N/A

Five salmonid species (chum, coho, and Chinook salmon, and steelhead and cutthroat trout) are found in the Blackjack Creek watershed. Chum and coho salmon have documented presence in all subbasins of the watershed, except for Square Lake. Chum is the most abundant salmon species in the watershed and includes fish from two distinctive stocks designated by spawn timing: a summer run and a late fall run. Steelhead trout have documented presence only in the Lower, Middle, and Upper Blackjack Creek subbasins. Other salmonid species with presence in Blackjack Creek watershed include Chinook salmon, and cutthroat trout, which occur in more limited numbers than chum and coho salmon. More information on salmonid populations, including abundance estimates and distribution maps, can be found in the *Key Ecological Attributes and Pressures Assessment* (ESA, 2017a).

Critical ecosystem components for protection and restoration in the Blackjack Creek watershed are listed in Table 2. The categories and components listed align with the region's Chinook Salmon Recovery Plan (PSRITT, 2015).



SOURCES: Puget Sound LiDAR Consortium, 2000; ESA, 2016; Open Street Maps, 2016; Kitsap County, 2016

Figure 1.
Blackjack Creek Watershed and Subbasins

Table 2. Ecosystem Components and Categories for the Blackjack Creek Watershed Assessment

Category	Ecosystem Component
Freshwater Habitat	Upland Stream channel <50 m bankfull width Side channels Floodplains and wetlands Lakes
Estuarine and Marine Habitat	Tidal delta Bluff-backed beaches
Species	Chinook salmon Chum salmon Coho salmon Cutthroat trout Steelhead

Like many watersheds in Puget Sound, historic and current land uses in the Blackjack Creek watershed have substantially altered the ecological and watershed processes that drive habitat structure and ecosystem functions. Human activities have been the major cause of ecosystem destruction, degradation, and impairment through habitat conversion, pollution, and alteration of watercourses and flow patterns. The watershed assessment identified a set of stressors that affect the critical ecosystem components (Table 3). The stressors and pressure categories are aligned with the Puget Sound Pressures Assessment (PSPA) (McManus et al. 2014), which is adapted from the region's Chinook Recovery Framework (PSRITT, 2015).

Table 3. Pressure Categories and Stressors on Ecosystem Components

Pressure Category	Stressor (PSPA Identification)
Habitat Loss and Conversion	Land conversion (A1, A2, A3) Terrestrial habitat fragmentation (B) Shoreline hardening and stabilization (C) Terrestrial and freshwater species disturbance in human dominated areas and in natural landscapes (G1 and G2) Displacement by non-native species (R2)
Fish Migration Barriers and Barriers to Longitudinal Habitat Connectivity	Culverts as fish passage barriers (E2) In-channel structural barriers to water, sediment, debris flows (M1)
Alteration in Hydrologic Regime	Altered peak flows and low flows from land cover change (J1 and K1) Altered peak flows and low flows from climate change (J2 and K2) Altered low flows from withdrawals (K3) Changing precipitation amounts and patterns (AA)

Pressure Category	Stressor (PSPA Identification)
Water Quality	Non-point source, persistent and non-persistent toxic chemicals in aquatic systems (U2 and V2) Nonpoint source conventional water pollutants (X2) Changes in water temperature from local causes (X3)

The assessment of critical ecosystem components and stressors included a review of existing research, technical reports, spatial data (GIS), field data, and limited site visits on freshwater habitats, the estuary, and salmonids. Key findings from the assessment include the following:

- Land cover analyses show an increased amount of impervious surface and a decreased level of forest cover in the watershed from historical conditions (i.e., predevelopment), and these changes have continued in the most recent years. Currently, only the **Lower Blackjack Creek subbasin** has a degree of **imperviousness that likely impairs the natural hydrologic regime** and negatively impacts stream health.
- Relatively intact riparian forests are found throughout the watershed, except for the Middle Blackjack Creek and parts of the Ruby subbasins. These areas support **agricultural land uses** (or did in the recent past) that have impacted vegetative cover and stream habitat. The **Middle Blackjack Creek subbasin** also supports the **greatest amount of wetlands** in the watershed, suggesting that protection and restoration of degraded conditions will be particularly important in this subbasin for improving conditions for salmonids in the watershed.
- The **Square Creek subbasin** has the least amount of pasture and grasslands and amount of land cover associated with development (bare earth and built or impervious surfaces). Within the riparian zone in particular, it has the **least amount of development** of any subbasin in the watershed.
- Where riparian forests are present, large woody debris recruited into **Ruby and Square creeks** is likely retained within the subbasins and not exported downstream to the mainstem of Blackjack Creek. However, based on the flow regime of **Blackjack Creek** (which demonstrates significantly higher winter flows than either Ruby or Square creeks) and the **increased** stream **channel gradient**, locally recruited wood has at least some potential for downstream transport to Middle Blackjack Creek, much of which currently has little to no potential for LWD recruitment. However, the presence of a large wetland complex and the Sidney Road crossing likely limit wood transport into the downstream section of Middle Blackjack.
- **Floodplain connectivity and channel migration processes** have been impaired, particularly in the **Middle Blackjack Creek subbasin**. Upstream of Sedgwick Road, the mainstem is extensively channelized through agricultural areas, although the creek is still at an appropriate elevation to overflow onto its floodplain at high flows. Portions of **Ruby Creek** are **channelized for agricultural purposes,** although more recent wetland restoration efforts have re-established sinuosity and channel complexity in certain areas.

- Habitat connectivity between **Blackjack Creek** and its tributaries is generally functioning, with **nine complete barriers to fish passage** currently identified on Blackjack Creek and its tributaries. Most of these occur fairly high in the watershed, on Square and Ruby creeks or their tributaries, with the exception being three barriers on a right bank tributary in the Middle Blackjack Creek subbasin.
- Based on monitoring conducted by the Suquamish Tribe, **stream temperatures** in lower Blackjack Creek have exceeded the Washington State temperature standard of 16ºC 7 Day Average Daily Maximum (7DADmax) for "Core Summer Salmonid Habitat" in just 2 years between 2003 and 2017, and on an infrequent basis. More recently, monitoring in 2015–2017 indicates that some portions of **upper Ruby Creek** and upper **Blackjack Creek** are warmer and more frequently exceed temperature standards. Continued temperature monitoring is key to understanding stream temperature conditions in the watershed in response to land use, climate change, and restoration actions.
- Only two segments of Blackjack Creek have been listed as **Category 5 waters** (for **dissolved oxygen**) in the current Washington State water quality assessment. W**ater quality at the mouth** of Blackjack Creek has **improved from 2008 to 2013** and now meets Ecology standards for primary contact. This trend is supported by B-IBI data, which have shown consistently higher scores in recent years (2012–2015) after large yearly fluctuations from 2000-2011.
- The lower reach of **Ruby Creek** (which is within the Port Orchard UGA) is at particular **risk of additional commercial and residential development,** which may further reduce riparian function through clearing and conversion of forest to built environment and impervious surfaces.
- Much of the Blackjack Creek **estuary** has been filled over and highly **altered by historic development** (particularly since 1940s). Although natural tidal exchange is substantially constricted by the Bay Street crossing at the mouth of the stream, an active delta remains with a limited amount of intertidal mudflat and fringing salt marsh extending approximately 1,500 feet upstream.
- As a rain-dominated watershed, the anticipated effects on watershed hydrology, sediment dynamics, and habitat formation from climate change in the Blackjack Creek watershed are not related to projected recession of glaciers or loss of snowpack. Rather, the **projected long-term trend of increased winter storm events and precipitation intensity** could be expected **to alter flood frequency** in the region and have related impacts on geomorphic and ecologic processes. In addition, climate change may include **increased stream temperatures** and **reduced low flows** due to increased warming temperatures in the summer, both of which are expected to impact fish passage and habitat suitability.
- Although ecological processes and riparian/instream habitat conditions have been impacted by land use development, **the watershed supports moderate number**s (although much reduced from pre-development times) **of salmonids**, including distinctive runs of summer chum and a late fall chum salmon. **Lower Blackjack Creek** supports a **large amount of spawning activity for chum and coho salmon**. Upper Blackjack also provides key spawning and rearing habitat, while Ruby and Square Creek provide important flow, sediment, and temperature functions while also

supporting some spawning and rearing. Although salmonid habitat and use in the Middle Blackjack Creek subbasin is currently limited by agricultural development, if restored, this area could provide important refugia and support substantial salmonid rearing.

The result of a qualitative evaluation of stream reaches is shown in Table 4. The evaluation used existing data and limited ground truthing to classify stream segments or reaches as either “impaired,” “moderately impaired,” or “functioning” for watershed and reach scale. The results were used in the identification of protection and restoration strategies and actions presented in this plan (see Chapters 4 and 5). In general, future implementation of protection and restoration actions should aim to move indicators from “impaired” and “moderately impaired” toward “functioning.”

Table 4.
Summary of Reach-scale Stream Evaluations of Watershed Processes and Key Ecological Attributes in the Blackjack Creek Watershed

Reach	River Mile or Location	Confinement (*artificial)	Watershed Processes and Key Ecological Attributes								
			Hydrologic Regime	Sediment Regime	Riparian Areas and Wetlands	Organic Matter Inputs	Nutrient Supply	Floodplain Channel Interactions	Habitat Connectivity	Fish Passage	Water Quality
Lower Blackjack Creek											
Estuary	0.0/Mouth	**Confined***	Moderately Impaired	Moderately Impaired	**Impaired**	**Impaired**	Moderately Impaired	N/A	**Impaired**	Functioning	Functioning
Lower Mainstem	RM 0.0–3.2	**Confined**	Functioning	Functioning	Functioning	Moderately Impaired	Functioning	Functioning	Functioning	Functioning	Functioning
Upper Mainstem	RM 3.2–4.3	**Moderately Confined**	Moderately Impaired	Moderately Impaired	Moderately Impaired	Moderately Impaired	Functioning	Moderately Impaired	Moderately Impaired	Functioning	Functioning
Tributaries		**Confined***	**Impaired**	**Impaired**	**Impaired**	**Impaired**	**Impaired**	**Impaired**	**Impaired**	Moderately Impaired	Functioning
Middle Blackjack Creek											
Lower Reaches	RM 4.3–5.0	**Confined***	Moderately Impaired	Moderately Impaired	Moderately Impaired	Moderately Impaired	Moderately Impaired	Moderately Impaired	Moderately Impaired	Functioning	Functioning
Middle Reaches	RM 5.0–5.9	**Unconfined (some artificial)***	**Impaired**	**Impaired**	**Impaired**	**Impaired**	**Impaired**	**Impaired**	Moderately Impaired	Functioning	Functioning
Upper Reaches	RM 5.9–6.1	Unknown	Moderately Impaired	Moderately Impaired	Functioning	Functioning	Functioning	Moderately Impaired	Moderately Impaired	Functioning	Moderately Impaired
Ruby Creek											
Lower Reaches	RM 0.0–0.7	**Moderately Confined***	Moderately Impaired	Moderately Impaired	Moderately Impaired	Moderately Impaired	Moderately Impaired	Moderately Impaired	Moderately Impaired	**Impaired**	Functioning
Middle Reaches	RM 0.7–2.0	**Moderately Confined***	**Impaired**	**Impaired**	**Impaired**	**Impaired**	**Impaired**	**Impaired**	Moderately Impaired	**Impaired**	Functioning
Upper Reaches	RM 2.0–Square Lake	**Unconfined**	Functioning	Functioning	Functioning	Functioning	Functioning	Functioning	Moderately Impaired	Moderately Impaired	Functioning
Square Creek											
Mainstem	Sidney Rd–Square Lake	**Moderately Confined***	Moderately Impaired	Moderately Impaired	Moderately Impaired	Moderately Impaired	Moderately Impaired	Moderately Impaired	Functioning	Moderately Impaired	Functioning
Tributaries	East & West	**Unconfined**	Functioning	Functioning	Moderately Impaired	Moderately Impaired	Functioning	Moderately Impaired	Functioning	Moderately Impaired	Functioning
Square Lake											
Lake (no streams)	Square Lake	**N/A**	N/A	N/A	Functioning	Functioning	Functioning	N/A	Functioning	Functioning	Unknown
Upper Blackjack Creek											
Mainstem	RM 6.0–7.5	**Unconfined**	Functioning	Functioning	Functioning	Unknown	Functioning	Functioning	Functioning	Moderately Impaired	Moderately Impaired
Tributaries	West (2)	**Unconfined**	Functioning	Functioning	Functioning	Functioning	Functioning	Functioning	Functioning	Functioning	Functioning

4 PROTECTION AND RESTORATION STRATEGIES

Strategies for addressing degraded KEAs and watershed processes in the Blackjack Creek watershed include both protection and restoration approaches. Using the results of the watershed assessment, a total of 13 strategies and sub-strategies were identified by the project team. The strategies and sub-strategies were developed around process-based restoration principles and considerations as described in the *Recommended Strategies and Actions Memorandum* (ESA, 2017b).

The following sections provide a description of each strategy and sub-strategy along with the stressor addressed (per the stressors delineated and defined in the Puget Sound Pressures Assessment (PSPA) [McManus et al., 2014] and as used in the region's Chinook Salmon Recovery Plan [PSRITT, 2015]). A complete table of strategies, suggested application, and the expected benefits to salmonids and to ecosystem processes is included as Appendix B.

4.1 Protection Strategies

Protection strategies focus on increasing habitat protection in the watershed through direct acquisitions and conservation easements, improved protection of natural systems through strengthened and/or enforced land use regulations, and protecting instream flow conditions for salmonids. The protection strategy includes three sub-strategies, summarized in Table 5.

Table 5. Recommended Protection Strategies and Sub-strategies

Strategy	Sub-strategy	Description
P1. Protect Blackjack Creek habitat conditions	**P1.1 Acquisitions and conservation easements**	Protect upland, wetland, and riparian habitats that are minimally impaired by floodplain modifications and have an intact riparian forested corridor through acquisition or conservation easements. This strategy addresses the most critical stressor on ecosystem components, the conversion of land cover for residential, commercial, and industrial uses. By limiting conversion of land cover, this strategy addresses riparian and floodplain processes by protecting peak and base streamflow, sediment loading, in-stream wood presence and recruitment, channel and floodplain complexity, water temperature, and food chain support. This strategy may also be needed to implement certain restoration actions. Stressor(s) addressed: Land conversion (A1, A2, A3); Terrestrial habitat fragmentation (B)
	P1.2 Improve compliance and/or strengthen land use regulations	Improve compliance with land use regulations through better enforcement and landowner practice and also strengthen regulations to protect watershed functions and upland, wetland, and riparian habitats. This includes development standards that maintain a cumulative forest cover and effective impervious surface; planning mechanisms and incentives to use a watershed-based approach, including transfer of development rights; and locating and designing development that is informed by and consistent with spatial information developed as part of this watershed assessment. This strategy addresses riparian and floodplain processes by protecting headwater and floodplain wetlands, and protecting and restoring riparian functions such as shade, in-stream wood presence and recruitment, and natural bank stabilization. Stressor(s) addressed: Land conversion (A1, A2, A3); Terrestrial habitat fragmentation (B)

Strategy	Sub-strategy	Description
	P1.3 Protect (and improve understanding of) instream low flow conditions	Protect instream flow conditions important for salmonids by protecting aquifer recharge areas, implementing actions that enhance or promote groundwater exchange with surface waters, ensuring that permitted and permit-exempt uses account for instream flows, and through providing education and outreach. In addition, the strategy includes developing a better understanding of the relationship between groundwater and surface water in the watershed, including groundwater extraction (abstraction), and its effect on low flow conditions by evaluating existing data, modeling, and other information. This strategy addresses both a near-term action and an important data gap regarding groundwater-surface water continuity, the type and amount of out-of-stream water uses (i.e., exempt or permitted groundwater wells and surface water withdrawals), and the effect on summer low flows in the watershed. Stressor(s) addressed: Altered low flows from land cover change (K1); Altered low flows from climate change (K2); Altered low flows from withdrawals (K3)

Protecting existing habitats is a key strategy for maintaining functioning salmonid habitats and watershed processes in the Blackjack Creek watershed. However, in addition to protecting intact habitats through acquisitions and easements, a watershed-based approach to planning for future development or restoration can also preserve existing functioning watershed processes. For example, preservation of functioning subbasins where development is likely to occur (identified through downscaled watershed characterization data) could require mitigation for development such as impervious surface limits, forest cover retention, stormwater detention and treatment and other low impact development (LID) techniques, protection of critical areas, and maintenance of riparian buffers (Booth et al., 2002). Negative impacts to aquatic systems can begin in basins where effective impervious surface is as low as 2 to 3% of land cover. As impervious-area percentages approach approximately 10%, degradation of stream systems is more certain. Less empirical data have been collected to assess the direct correlation between forest cover and stream conditions than for watershed imperviousness and stream conditions, but the literature suggests at least 60 to 65% forest retention within a basin is needed to retain physical and biological stability of aquatic systems.

Existing City of Port Orchard and Kitsap County land use and environmental regulations require many of these approaches to avoid and minimize impacts (through zoning, critical areas, and stormwater standards). That said, regular review, updates, and compliance enforcement with land use regulations is essential to ongoing protection within the Blackjack Creek Watershed. Based on review of currently adopted land use regulations, the greatest opportunities could include: expansion by the City of the Greenbelt zoning district upstream of SE Lund Ave; and augmenting existing rural zoning district standards with tree protection, impervious surface limits, and increased protections by the County for wetlands and riparian corridors (e.g., buffers, allowed alterations, or permitted uses). Enforcement of land use regulations and implementation of required mitigation is necessary for these protection measures to have the intended effects to watershed processes and habitats.

The third protection sub-strategy addresses the protection of instream flow conditions. Blackjack Creek and its tributaries have been closed to further appropriation since April 5, 1960 (WAC 173-515-040). This strategy supports taking actions now to address potential negative impacts to salmonids from low flow conditions while also gaining a better understanding of the relationship between groundwater and surface

water in the watershed and its effect on low flow conditions. This relationship is currently a data gap for the watershed, and could include reviewing the amount and location of groundwater withdrawals (i.e., wells) and other out-of-stream uses and more intensive monitoring of low flow conditions in different parts of the watershed. The US Geological Survey (USGS) has been conducting modeling on this topic which should also be reviewed. Similar to P1.2, near-term actions under this strategy include strengthening or enforcing critical aquifer recharge area regulations on development that prevents recharge. Protecting instream flows also can be addressed through policies and regulations that ensure that permitted and permit-exempt uses of groundwater account for senior water rights, including instream flows. This sub-strategy also includes implementation of watershed or habitat protection and restoration actions that enhance or promote groundwater exchange with surface waters (e.g., floodplain/wetland reconnection projects, stormwater retention and LID projects). Lastly, education and outreach aimed at promoting water conservation (e.g., increasing efficiency and reduced water wastage), use of native, drought-tolerant vegetation in landscaping, replacing lawns with native vegetation and/or forgoing watering of lawns, installing low-flow fixtures, etc. The intent of these mechanisms would be to “bank” water conservation gains and not simply convert the conservation gains into additional water hook-ups.

4.2 Restoration Strategies

Restoration strategies focus on restoring impaired or altered watershed processes with the objective of improving quality and quantity of salmonid habitat in the watershed. Restoration can affect salmonid habitat and population performance in two ways: 1) improve the quality (structural complexity, water temperature, bed scour, fine sediment, etc.) of existing habitat thereby affecting salmonid density-independent survival (productivity), and 2) increase the quantity of salmonid habitat (pools, side channels, off-channel, in-stream wood, and access to habitats) thereby affecting density-dependent survival (capacity). In sum, the restoration strategies identified for Blackjack Creek improve both productivity and capacity for salmonids (Table 6).

Table 6. Recommended Restoration Strategies and Sub-strategies

Strategy	Sub-strategy	Description
R1. Reconnect isolated habitats and remove barriers to fish passage		Reconnect isolated habitats and improve fish passage through removal of barriers and replacement of culverts or other artificial structures. This strategy focuses on restoring longitudinal connectivity at road crossings, improving sediment and organic material supply and transport, nutrient cycling, and the timing and volume of water. Stressor(s) addressed: Culverts as fish passage barriers (E2); In-channel structural barriers to water, sediment, debris flows (M1)
R2. Restore wetland and floodplain storage processes		Rehabilitate, enhance, or create wetland areas and floodplains to restore natural flood storage processes. This strategy addresses the loss of storage functions in the upper and middle portions of the watershed where wetlands and stream reaches have been altered from past development or reduced beaver activity. Improving wetland and floodplain storage in upper portions of watershed would act as a buffer against increased bank erosion from peak flows that occur downstream in the steeper portions of the stream that have erodible deposits. This strategy also addresses loss of groundwater recharge functions by improving instream habitat conditions of summer base flows, dissolved oxygen, and temperatures. Stressor(s) addressed: Terrestrial and freshwater species disturbance in natural landscapes (G2); Altered peak flows from land cover change (J1); Altered peak flows from climate change (J2); Changes in water temperature from local causes (X3)

Strategy	Sub-strategy	Description
R3. Remove constraints to lateral connectivity	**R3.1 Riverine**	Restore lateral connectivity of riparian and floodplain areas through removal of constraints such as bank armor, ditches, or undersized culverts. This strategy focuses on allowing lateral channel migration; restoring sediment and organic material supply, storage, and transport; promoting or restoring the formation of side channels and off-channel habitats; floodplain connectivity; and, decreasing stream energy during peak flow events. This strategy also addresses loss of groundwater recharge functions by increasing the lateral extent of the hyporheic zone thereby reducing summer water temperatures and maintaining base flows. Stressor(s) addressed: In-channel structural barriers to water, sediment, debris flows (M1); Reduced impacts from incised stream channels and disconnected side channels
	R3.2 Tidal	Restore lateral connectivity of estuary through removal of nearshore fill, bridge abutments, and bank armor. This strategy focuses on allowing tidal exchange, formation of distributary channels, tidal marsh, and fluvial deposition. Stressor(s) addressed: Shoreline hardening and stabilization (C) and nearshore fill
R4. Restore riparian processes		Restore riparian processes through the planting of native vegetation along riparian corridors along with removal of non-native invasive vegetation. This strategy addresses riparian processes of long-term wood recruitment, stream shading, bank and floodplain stability and complexity, and food chain support. Stressor(s) addressed: Terrestrial habitat fragmentation (B); Displacement by non-native species (R2); Changes in water temperature from local causes (X3)
R5. Place in-channel large woody debris		Prevent further channel incision and improve habitat through placement of in-channel large woody material. This strategy focuses on increasing the amount of instream wood to increase hydraulic roughness and restore channel complexity in the intermediate period while riparian forests are developing. Wood placement promotes scour and deposition processes that form complex substrate, pools and bars, and secondary channel formation. Stressor(s) addressed: Land conversion (A1, A2, A3); Terrestrial habitat fragmentation (B); Reduced impacts from incised stream channels and disconnected side channels
R6. Improve habitat conditions within and adjacent to agricultural lands		Reduce habitat impacts on agricultural lands through development and implementation of farm plans or other programs that restore riparian and floodplain functions. This strategy also focuses on reducing unrestricted livestock access to streams and the potential for damaging vegetation and bank erosion through exclusion methods. Stressor(s) addressed: Non-point source, non-persistent toxic chemicals in aquatic systems (V2); Changes in water temperature from local causes (X3); Terrestrial habitat fragmentation (B); Reduced impacts from incised stream channels and disconnected side channels
R7. Improve/retrofit stormwater attenuation capacity and treatment within and adjacent to developed areas		Improve flood storage and attenuation processes by implementing low impact development activities such as new stormwater runoff facilities, facility retrofits, flow control, and water quality treatment for stormwater runoff. This strategy addresses the negative effects of altered stormwater runoff regimes associated with increased impervious surface coverage by restoring natural storage functions that protect/restore hydrologic regime. Stressor(s) addressed: Altered peak flows from land cover change (J1); Non-point source, non-persistent toxic chemicals in aquatic systems (V2); Non-point source conventional water pollutants (X2); Changes in water temperature from local causes (X3); Increased erosion/sediment transport and downstream erosion; increased stream channel capacity and flood flow that creates incised stream channels

Strategy	Sub-strategy	Description
R8. Debris Prevention and Removal		Improve water quality and instream habitat structure and condition through the prevention and removal of accumulated litter and artificial debris such as rubble, riprap, and other refuse. This strategy addresses aesthetic and environmental health issues (i.e., garbage and human waste) in localized areas. In some areas, this strategy also addresses degraded habitat conditions by removing artificial impediments to habitat-forming processes that support sediment and organic material supply and transport, nutrient cycling, and localized hydrology. Stressor(s) addressed: In-channel structural barriers to water, sediment, debris flows (M1); Non-point source, non-persistent toxic chemicals in aquatic systems (V2); Non-point source conventional water pollutants (X2); Garbage and Solid Waste (i.e., rubbish and other solid materials including those that entangle wildlife) (9.4 in PSRITT); Work and Other Activities (i.e., people spending time in or traveling in natural environments for reasons other than recreation or military activities) (6.3 in PSRITT)
R9. Public Involvement		Support citizen-based watershed monitoring groups and landowner education programs about habitat protection through development, funding, or assistance. This strategy focuses on the support and promotion of community education and outreach in the watershed such as planting and weed removal events, rain garden construction and maintenance workshops, and interpretative programs. Potential focus areas for community education include: the benefits of native plant species to the ecosystem and salmonids; ecological role and benefits of beaver on the landscape; protection of native plant communities (forests, wetlands), and soils; the relationship between impervious surface and aquatic habitat conditions; the protection of natural hydrologic regimes through stormwater retention and LID techniques; the protection of salmonid habitat through stormwater treatment; and, the protection of salmonid habitat through increased water conservation and reduced groundwater extraction (abstraction). Stressor(s) addressed: Terrestrial habitat fragmentation (B); Terrestrial and freshwater species disturbance in human dominated areas (G1); Non-point source, non-persistent toxic chemicals in aquatic systems (V2); Non-point source conventional water pollutants (X2)

4.3 Results Chains

Results chains are tools to help illustrate assumptions or hypotheses about how a recommended strategy will protect and/or restore watershed processes and habitat structure and function (CMP, 2013). They are a graphic representation of the assumed causal pathways to achieve the desired outcomes for habitat and salmonid survival in an "if – then" framework (Figure 2).

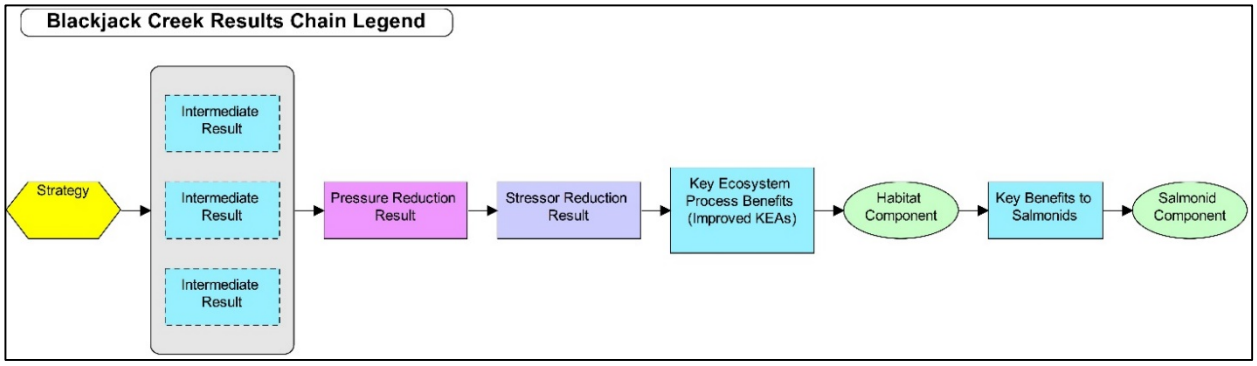


Figure 2. Basic Components of a Results Chain

Results chains are a recommended tool of the *Open Standards Framework for the Practice of Conservation*, an overarching framework of the Blackjack Creek watershed assessment. Open Standards includes a companion software (Miradi) to create the graphical depictions. For this Watershed Plan, results chains were developed for each strategy described above and are presented as Appendix C.

5 RECOMMENDED ACTIONS

Recommended actions for the protection and restoration of salmonid habitat in the Blackjack Creek watershed are presented below by subbasin. Several of the actions were recommended in previous assessments and plans and have been modified based on current conditions and for the purposes of this Watershed Plan. Actions were preliminarily identified and discussed in the *Recommended Strategies and Actions Memorandum* (ESA, 2017b), and presented to project partners and stakeholders at a workshop in November 2017, and subsequently refined based on feedback and input.

5.1 Lower Blackjack Creek

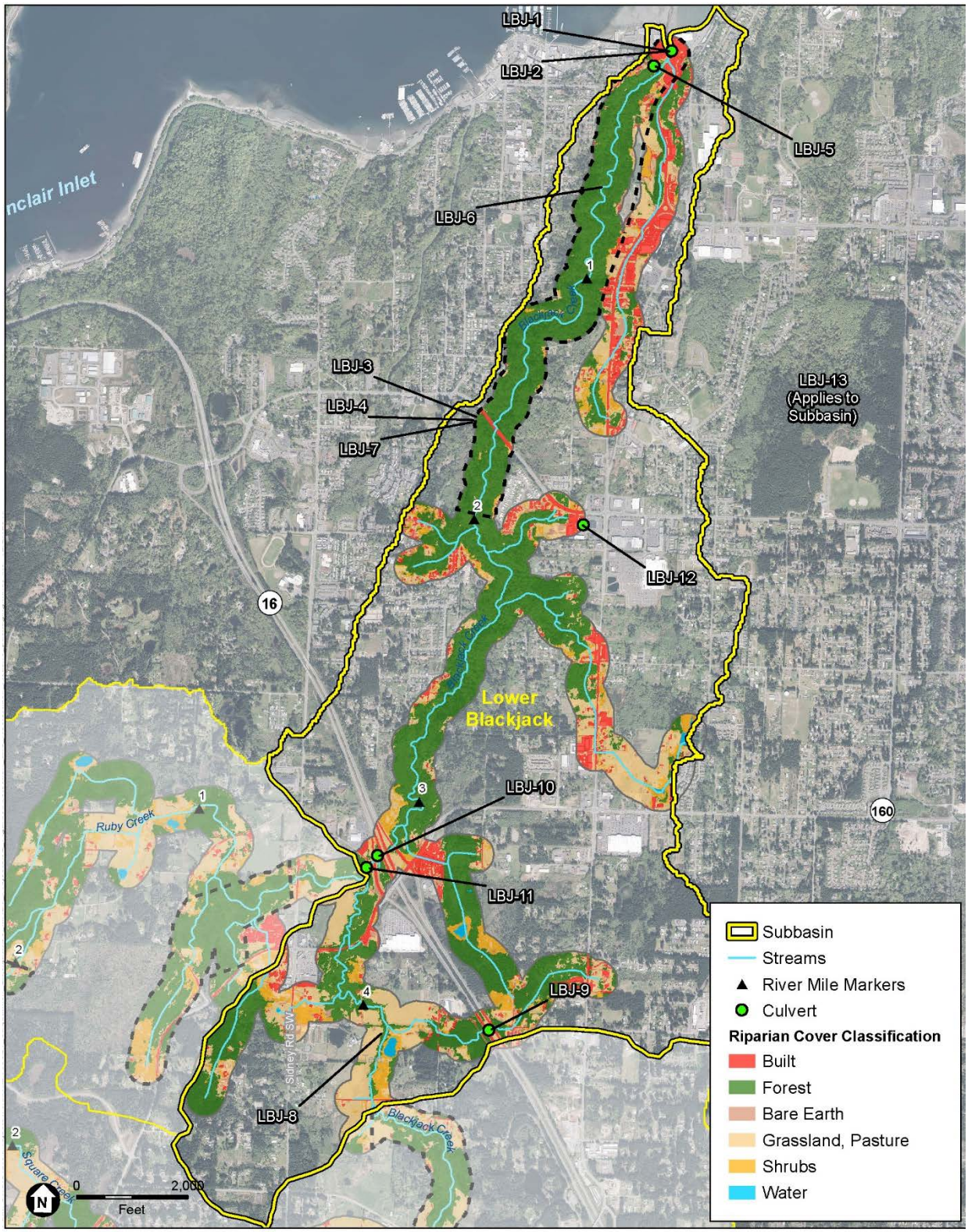
The Blackjack Creek watershed downstream of State Route (SR) 16 is characterized by a combination of residential and commercial land uses within the City of Port Orchard. Throughout this area, the lower mainstem of Blackjack Creek flows through a steep ravine of mostly forested riparian corridor that varies in width (generally between 600 feet and 1,100 feet). The overall riparian conditions in the Lower Blackjack Creek subbasin range from functioning (generally along the mainstem) to impaired (in some of the tributary streams due to tree removal and development with impervious and semi-pervious surfaces). In tributary streams where riparian conditions are impaired, the degree of imperviousness could alter downstream functions in the mainstem, especially those related to flow and water quality. Improving or retrofitting stormwater systems to provide improved treatment and attenuation would help mitigate potential impacts from ongoing land development adjacent to tributary streams.

Conversely, riparian conditions are functioning along the mainstem of Blackjack Creek where the stream flows through a steep ravine upstream of the estuary. The ravine provides some of the best riparian habitat in the watershed in terms of intactness, connectivity, riparian zone width, and vegetation composition. These qualities support stream functions that maintain suitable spawning, rearing, and migratory fish habitat conditions within the lower mainstem, and are likely the cause for relatively large amounts of spawning activity for chum and coho salmon in the subbasin. Protecting this high quality habitat through purchase, easements, or strengthened land use development standards would be appropriate in this portion of the lower mainstem reach. A particular challenge in the ravine is ongoing and unpermitted human habitation that can have impacts on water quality, vegetation, and stream bank erosion. Addressing this source of impact is also important to preserving riparian and instream habitat conditions of the mainstem.

The natural characteristics of the estuary have been highly altered or lost entirely by development including significant fill of historic intertidal area. Natural tidal exchange at the mouth of the stream is substantially constricted by the Bay Street crossing. An active tidal delta remains with a limited amount of intertidal mudflat and fringing salt marsh extending approximately 1,500 feet upstream. Restoration of the tidal delta through removal of fill, structures, and riprap along with riparian planting would increase important rearing and migratory habitat for juvenile salmonids passing through the delta as well as providing a holding area for adults moving into Blackjack Creek. Thirteen (13) actions are identified for the Lower Blackjack Creek subbasin (Table 7 and Figure 3).

Table 7. Recommended Actions – Lower Blackjack Creek Subbasin

Reach	River Mile or Location	Action
Estuary/Nearshore	0.0/Mouth	LBJ1–Tidal Delta/Nearshore Restoration LBJ2–Viewing Platform
Lower Mainstem	RM 0.0–3.2	LBJ3–Protect Riparian Habitat LBJ4–Large Woody Debris Placement LBJ5–Invasive Plant Removal LBJ6–Removal of Abandoned Foot Bridge LBJ7–Maintain or Expand Protective Zoning
Upper Mainstem	RM 3.2–4.3	LBJ8–Restoration between Sedgwick and SE Dogwood Road and also Right Bank Tributary
Tributaries	n/a	LBJ9–Fish Passage Improvements (at least 4 road crossings LBJ10–Fish Passage Improvements @ SR16 LBJ11–Restoration @ Confluence of Blackjack and Ruby Creeks LBJ12–Review and Improve Regulations and Requirements LBJ13–Stormwater Retrofits



SOURCE: NAIP, 2015; ESA, 2016; Open Street Maps, 2016; Kitsap County, 2016
FEMA, 2007

160024 - Blackjack Creek Watershed Assessment

Figure 3.
Protection and Restoration Actions – Lower Blackjack Creek Subbasin

Action	*LBJ1–Tidal Delta Restoration*
Description	Develop a master plan for the Blackjack Creek tidal delta and adjacent nearshore that includes a comprehensive review of opportunities to restore tidal processes and estuarine habitat, land ownership and feasibility, and potential impacts from sea level rise. Meanwhile, implement restoration in the estuary and/or nearshore if/when opportunities arise. Restoration actions could include: removal of intertidal fill, armoring, concrete and other debris; restoration of riparian habitat by planting native vegetation; and improvement of forage fish spawning habitat by beach restoration. [this action is modified from Aquascape Projects 71, 72, and 73]
Outcome	Restoration of the tidal delta improves the lateral connectivity of the estuary, allowing for tidal exchange, the formation of distributary channels, and fluvial deposition. Increases and improves natural shoreline habitat for beach spawning species. Planting native vegetation restores riparian processes (long-term wood recruitment, shading, bank complexity, and food chain support). This action would also include public involvement and community education due to its location in the City and along major transportation corridors.
Strategies Addressed	R3.2 Remove constraints to lateral connectivity (Tidal) R4. Restore riparian processes R8. Debris Prevention and Removal R9. Public Involvement

LBJ1 Photographs: Left: Mouth of Blackjack Creek facing downstream (pedestrian bridge in background). Right: Blackjack Creek estuary upstream of Bay Street bridge.

Action	*LBJ2–Viewing Platform*
Description	Appropriately sited (to avoid environmental impacts) viewing platform and/or interpretive area near pedestrian bridge or in the vicinity of estuary. [this action is modified from Aquascape II Project 81]
Outcome	Promotes community education and awareness of historical habitat impacts, salmon, and salmonid habitat improvement and protection in the watershed.
Strategies Addressed	P1.2 Improve compliance and/or strengthen land use regulations R9. Public Involvement

LBJ2 Photographs: Existing pedestrian bridge across tidal delta, facing north from Bay Street bridge

Action	*LBJ3–Protect Riparian Habitat*
Description	Acquire and protect high quality riparian habitat along Blackjack Creek through acquisition and/or conservation easements; continue protection and development restrictions in lower Blackjack Creek ravine. [this action is modified from Aquascape II Project 70]
Outcome	Addresses riparian and floodplain processes by protecting peak and base streamflow, sediment loading, in-stream wood, channel and floodplain complexity, water temperature, and food chain support. This action would also address the ongoing and unpermitted human habitation and the associated impacts on water quality, vegetation, and stream bank erosion. This action would improve and increase compliance of land use regulations to protect watershed functions and upland, wetland, and riparian habitats through better enforcement and landowner practice.
Strategies Addressed	P1.1 Acquisitions and conservation easements P1.2 Improve compliance and/or strengthen land use regulations R8. Debris Prevention and Removal]

LBJ3 Photograph: Riparian habitat in lower Blackjack Creek ravine.

Action	***LBJ4–Large Woody Debris Placement***
Description	Investigate conditions and develop strategy for LWD addition within the lower two miles of Blackjack Creek. This action would involve LWD placement until full riparian function is restored and would specifically target salmonid habitats that would benefit most from acceleration of forest succession. [this action is modified from Aquascape II Project 77]
Outcome	Prevents further channel incision and improves habitat through placement of in-channel large woody material. This action focuses on increasing the amount of instream wood to increase hydraulic roughness and restore channel complexity in the intermediate period while riparian forests are developing. Wood placement promotes scour and deposition processes that form complex substrate, pools and bars, and secondary channel formation to improve adult holding and spawning, and juvenile rearing habitat.
Strategies Addressed	R5. Place in-channel large woody debris

LBJ4 Photograph: Example of in-channel habitat in lower Blackjack Creek

Action	***LBJ5–Invasive Plant Removal***
Description	Invasive plant removal and riparian restoration in tidally-influenced portion of lower mainstem and upstream where invasives are present
Outcome	Restores riparian processes of long-term wood recruitment, stream shading, bank and floodplain complexity, and food chain support. This action would also improve degraded instream habitat structure and condition through the removal of accumulated litter and debris. It would allow for habitat-forming processes such as sediment and organic material supply and transport, nutrient cycling, and localized hydrology.
Strategies Addressed	R4. Restore riparian processes R8. Debris Prevention and Removal

LBJ5 Photograph: Invasive plants occur in the tidally influenced portion of lower Blackjack Creek

Action	***LBJ6– Removal of Abandoned Foot Bridge***
Description	Remove abandoned foot bridge (Kendall Street bridge) crossing at RM 0.7 and develop options for utility relocation
Outcome	Reconnects isolated off channel habitats through removal of the bridge. This action would restore longitudinal connectivity, improving sediment and organic material supply and transport, nutrient cycling, and localized hydrology, as well as allowing for lateral channel migration, promotion of side channel and off-channel habitat formation, floodplain connectivity, sediment storage, and decreasing stream energy during peak flow events.
Strategies Addressed	R8. Debris Prevention and Removal

LBJ6 Photographs: Left: Pedestrian bridge crossing Blackjack Creek at RM 0.7, facing downstream. Right: Bridge from above facing east.

Action	***LBJ7–Maintain or Expand Protective Zoning***
Description	Maintain or expand the current Greenbelt (Gb) zoning and comprehensive plan land use designations as shown in the Port Orchard Comprehensive Plan Land Use Map and City Zoning Map to ensure protection of the riparian corridor and stream and to reduce potential impacts from development and redevelopment below (north and east of) SR-16 (extending beyond current 200-foot Shoreline (as designated under the Shoreline Management Act)
Outcome	Protects watershed functions and upland, wetland, and riparian habitats through strengthened protections and better enforcement. This action would improve riparian processes by protecting and restoring riparian functions such as shade, wood recruitment, and natural bank stabilization.
Strategies Addressed	P1.2 Improve compliance and/or strengthen land use regulations

Action	***LBJ8–Restoration on Mainstem between Sedgwick and SE Dogwood Road and Right Bank Tributary***
Description	Restore stream channel, riparian and associated wetland between Sedgwick and SE Dogwood Rd on the mainstem of Blackjack Creek. Also restore riparian and associated wetlands along right bank tributary present upstream of RM4. This tributary flows east to west and crosses under SR16 via multiple culverts that are addressed in action LBJ9 (below). Restoration may also consider allowing for the presence of beaver and/or designing beaver dam analogs as an element where appropriate. This action is at the upper end of the subbasin. [this action is modified from Aquascape II Project 72]
Outcome	Restores lateral connectivity of riparian and floodplain, allowing for lateral channel migration, restoration of sediment and organic material supply, storage, and transport, promoting or restoring the formation of side channels and off-channel habitats, floodplain connectivity, and decreasing stream energy during peak flow events. This action would address loss of groundwater recharge functions by increasing the lateral extent of the hyporheic zone thereby reducing summer water temperatures and maintaining base flows. It would restore riparian habitat processes of long-term wood recruitment, stream shading, bank and floodplain connectivity, and food chain support. In addition, this action would improve habitat conditions within and adjacent to agricultural lands by reducing unrestricted livestock access and the potential for bank erosion through exclusion methods.
Strategies Addressed	P1.1 Acquisitions and conservation easements R2. Restore wetland and floodplain storage processes R3.1 Remove constraints to lateral connectivity (Riverine) R4. Restore riparian processes R6. Improve habitat conditions within and adjacent to agricultural lands

LBJ8 Photograph: Upper mainstem of Blackjack Creek and associated wetlands, facing south from SE Dogwood Rd.

Action	***LBJ9–Fish Passage Improvements (multiple)***
Description	A right bank tributary to the mainstem crosses Dogwood Rd. SE and SE Cedar Rd, both complete barrier culverts. A partial barrier culvert runs under State Hwy 16 is 50' upstream from the upper culvert. Juvenile coho and coastal cutthroat trout have been documented at SE Dogwood Road crossing by WildFish Conservancy. Action proposes fish passage improvements @ Dogwood Road SE, SE Cedar Road, SR16, and Ferate Avenue SE/SE Rose Road. Remove/ replace full and partial barriers. [this action is WFC Project N]
Outcome	Improves fish passage by addressing barriers to longitudinal migration potentially resulting in a 3,700' gain in fish habitat. Also reconnects isolated habitats and restores continuous corridors essential for fish movement, food, shelter, and reproduction. This action also addresses the supply and downstream transport of sediment, organic material (e.g., wood and detritus) and nutrients.
Strategies Addressed	R1. Reconnect isolated habitats and remove barriers to fish passage

LBJ9 Photograph: Partial barrier culvert under State Highway 16.

Action	***LBJ10–Fish Passage Improvements @ SR16***
Description	Fish passage improvements @ three culverts on mainstem Blackjack at SR16; all assessed by WSDOT as 67% passable and have individual PI Total scores of 32.03 (#996755), 31.75 (#996756), and 31.75 (#990038). All three are on U.S. District Court injunction list. These partial passage barriers were identified as a high priority by the watershed assessment (ESA, 2017a).
Outcome	Improves fish passage by addressing barriers to longitudinal migration. Also reconnects isolated habitats and restores continuous corridors essential for fish movement, food, shelter, and reproduction. This action also addresses the supply and downstream transport of sediment, organic material (e.g., wood and detritus) and nutrients.
Strategies Addressed	R1. Reconnect isolated habitats and remove barriers to fish passage

LBJ10 Photographs: Left: Culvert # 996755. Center: Culvert #996756. Right: Culvert #99008.

Action	***LBJ11–Restoration @ Confluence of Blackjack and Ruby Creeks***
Description	Re-meander channel, restore wetlands and riparian vegetation, and targeted LWD placement at confluence of Lower Blackjack Creek and Ruby Creek west of SR16 and east of Sidney Road SW. Restoration may also consider allowing for the presence of beaver and/or designing beaver dam analogs as an element where appropriate.
Outcome	Improves wetland floodplain storage to buffer against increased bank erosion from peak flows that occur downstream in steeper portions of the stream that have erodible deposits. Improves instream habitat conditions (specifically, groundwater recharge functions) of summer base flows, dissolved oxygen, and temperature. Planting of native riparian vegetation would result in long-term wood recruitment, stream shading, bank and floodplain complexity, and food chain support.
Strategies Addressed	R2. Restore wetland and floodplain storage processes R3.1 Remove constraints to lateral connectivity (Riverine) R4. Restore riparian processes R5. Place in-channel large woody debris

Action	***LBJ12–Review and Improve Regulations and Requirements***
Description	Review and improve land use regulations and stormwater requirements for two residential areas near 1,000 foot-long tributary (east of Bethel Road) and near shorter tributaries (adjacent to Lippert Drive and SE Lund Avenue); improvements could include tree retention and additional impervious surface limits, and additional expectations for use of LID to minimize runoff from future developments. Review and development of strengthened regulations should be informed by and consistent with the spatial information developed as part of this watershed assessment.
Outcome	Strengthen regulations to protect watershed functions and upland, wetland, and riparian habitats from the potential impacts from ongoing development and redevelopment adjacent to tributary streams. This action would address riparian and floodplain processes by protecting headwater and floodplain wetlands, and protecting and restoring riparian functions such as shade, wood presence and recruitment, and natural bank stabilization.
Strategies Addressed	P1.2 Improve compliance and/or strengthen land use regulations

Action	***LBJ13–Stormwater Retrofits***
Description	Coordinate with City of Port Orchard Public Works to identify existing stormwater facilities that should be prioritized for retrofit of runoff detention and water quality functions; support implementation of high priority retrofit actions. This action applies to the entire Lower Blackjack Creek subbasin.
Outcome	Improve flood storage and attenuation processes by implementing low impact development activities such as new stormwater runoff facilities, facility retrofits, and flow control and water quality treatment for stormwater runoff. This strategy addresses the negative effects of altered stormwater runoff regimes associated with increased impervious surface coverage by restoring natural storage functions.
Strategies Addressed	R7. Improve/retrofit stormwater attenuation capacity and treatment within and adjacent to developed areas

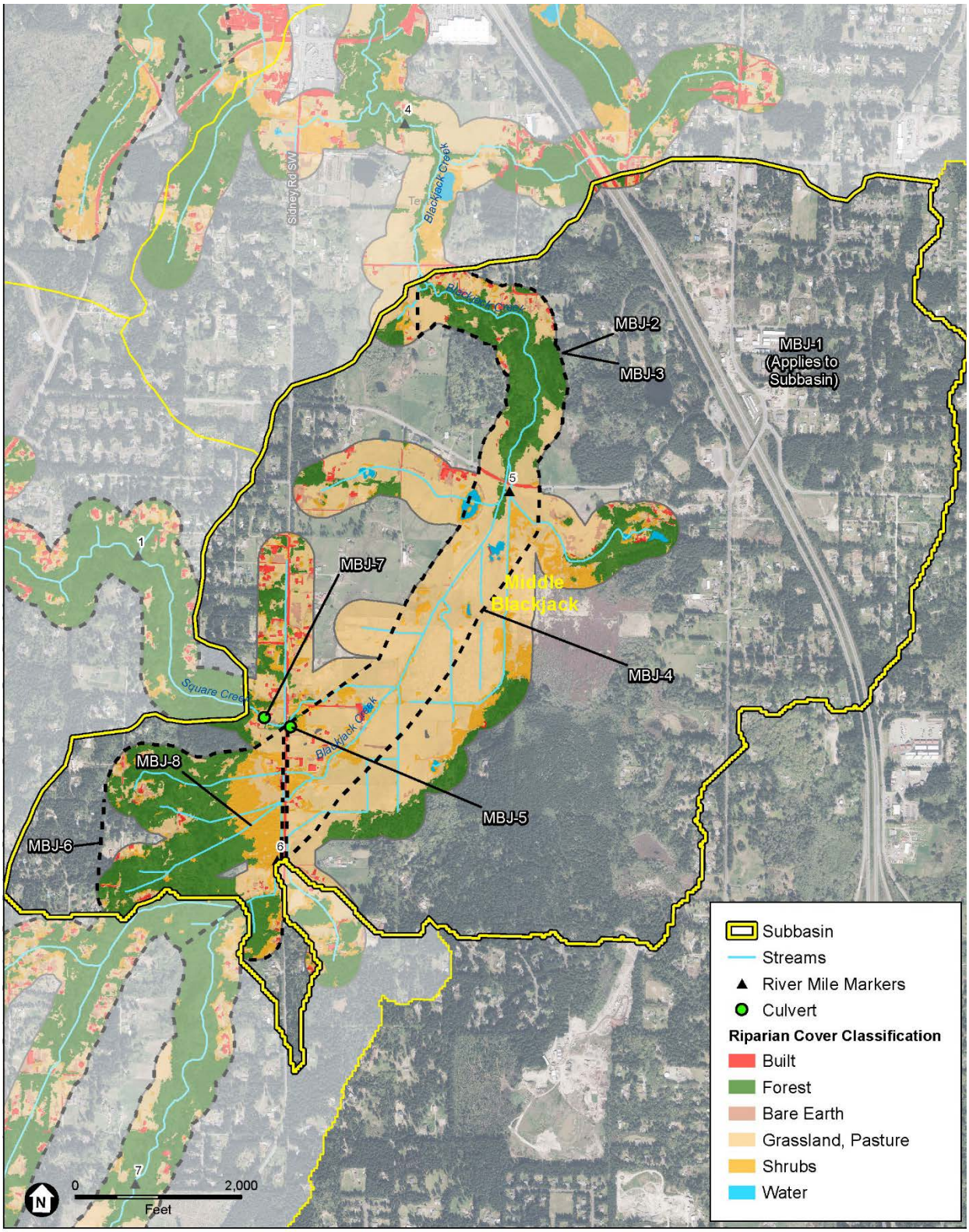
5.2 Middle Blackjack Creek

The Middle Blackjack Creek subbasin is characterized by rural residential, and current and historic agricultural land uses activities. The mainstem of Blackjack Creek and tributaries flow through patches of intact and degraded riparian cover in a mostly unconfined floodplain. In general, the riparian conditions in the Middle Blackjack Creek subbasin range from moderately impaired, in the upper portions of the subbasin, to impaired in the middle reaches, with the lower reaches assessed as moderately impaired. Rural residential development and agricultural land uses (with more extensive agricultural use in the recent past) have impacted vegetative cover and impaired floodplain connectivity as well as channel migration processes. LWD recruitment in the subbasin downstream of Sidney Road SW to SE Lider Road is severely lacking due to the absence of forest habitat within the riparian zone. LWD recruitment potential downstream of SE Lider Road is likely somewhat better than upstream, due to mixed forest cover within the riparian corridor of this reach. Although the wetland complex upstream of Sidney Road provides flood storage, alteration to the downstream portion of the floodplain has been impacted by agriculture and the Sidney Rd crossing and roadbed fill. All reaches of the subbasin demonstrate impairment to stream habitat complexity, wood recruitment and in-channel wood, sediment dynamics, and increased fine sediments which greatly limit fish use. There are also three complete barriers to fish passage on a right bank tributary within the subbasin.

Restoration activities in the floodplain would substantially improve overall riparian condition and function, and directly benefit salmonids. These activities could include wetland creation/enhancement, restoring channel sinuosity and reconnection of the channel with the floodplain, planting of native trees and shrubs, particularly along the streambanks, LWD placement, and creation/re-establishment of off-channel and side-channel features. Eight (8) actions (MBJ1 through MBJ8) are identified for the Middle Blackjack Creek subbasin (Table 8 and Figure 4).

Table 8. Recommended Actions – Middle Blackjack Creek Subbasin

Reach	River Mile or Location	Action
Lower Reaches	RM 4.3–5.0	MBJ1–Review Existing Zoning MBJ2–Large Woody Debris Placement MBJ3–Exclude Livestock from Stream
Middle Reaches	RM 5.0–5.9	MBJ4–Restoration of Wetland, Riparian Vegetation, and Floodplain between SE Lider Road and Sidney Road SW
Upper Reaches	RM 5.9–6.1	MBJ5–Fish Passage Improvements @ Sidney Road SW MBJ6–Protect Riparian Habitat MBJ7–Restoration on Mainstem west of Sidney Road SW MBJ8-Restoration of Tributaries and Headwater Wetlands west of Sidney Road SW



SOURCE: NAIP, 2015; ESA, 2016; Open Street Maps, 2016; Kitsap County, 2016
FEMA. 2007

160024 - Blackjack Creek Watershed Assessment

Figure 4.
Protection and Restoration Actions – Middle Blackjack Creek Subbasin

Action	***MBJ1–Review Existing Zoning***
Description	Review Port Orchard Land Use and Zoning designations in areas currently designated Commercial along SR-16 and above Blackjack Creek tributary (located in Lower Blackjack subbasin) to determine if Land Use and Zoning changes should be proposed in the area to ensure protection of the stream and to reduce the potential impacts from development and redevelopment. Review should be informed by and consistent with the spatial information developed as part of this watershed assessment.
Outcome	Protects watershed functions and upland, wetland, and riparian habitats through strengthened protections. This action would improve riparian processes by protecting and restoring riparian functions such as shade, wood recruitment, and natural bank stabilization.
Strategies Addressed	P1.2 Improve compliance and/or strengthen land use regulations

Action	***MBJ2–Large Woody Debris Placement***
Description	Investigate conditions and develop strategy for LWD in lower reach between SW Lider Road and SE Dogwood Road. This action would involve LWD placement until full riparian function is restored and would specifically target salmonid habitats that would benefit most from acceleration of forest succession. Restoration may also consider allowing for the presence of beaver and/or designing beaver dam analogs as an element where appropriate.
Outcome	Prevents further channel incision and improves habitat through placement of in-channel large woody material. This action focuses on increasing the amount of instream wood to increase hydraulic roughness and restore channel complexity in the intermediate period while riparian forests are developing. Wood placement promotes scour and deposition processes that form complex substrate, pools and bars, and secondary channel formation to improve stream spawning habitat.
Strategies Addressed	R5. Place in-channel large woody debris

MBJ2 Photograph: Example of stream and riparian habitat in Middle Blackjack Creek north of Lider Road

Action	***MBJ3–Exclude Livestock from Stream***
Description	Repair or install exclusion fencing to reduce unrestricted livestock access to stream and riparian habitats. The action would involve identification of specific locations and coordination with willing landowners.
Outcome	Prevents further streambank erosion, vegetation damage, and restores water quality.
Strategies Addressed	R6. Improve habitat conditions within and adjacent to agricultural lands

Action	***MBJ4–Restoration of Wetland and Floodplain between SE Lider Road and Sidney Road SW***
Description	Re-meander channelized reach, reconnect to floodplain, create off-channel habitat, install LWD, and conduct riparian restoration between SE Lider Road and Sidney Road SW (modified WFC Project M). Restoration may also consider allowing for the presence of beaver and/or designing beaver dam analogs as an element where appropriate. This area supports extensive wetland and floodplain habitat that has been ditched and drained for agricultural purposes. Approximately 80 acres is owned by Blackjack Creek Holdings LLC and a portion has been restored as mitigation project by Wildlands.
Outcome	Improves wetland floodplain storage to buffer against increased bank erosion from peak flows that occur downstream in steeper portions of the stream that have erodible deposits. Improves instream habitat conditions (specifically, groundwater recharge functions) of summer base flows, dissolved oxygen, and temperature. This action would also restore lateral connectivity of riparian and floodplain areas, allowing lateral channel migration, promotion of side channel and off-channel habitat formation, floodplain connectivity, and decreasing stream energy during peak flow events. Placement of LWD would promote near-term habitat complexity. Planting of native riparian vegetation would result in long-term wood recruitment, stream shading, bank and floodplain complexity, and food chain support. In addition, this action would improve habitat conditions within and adjacent to agricultural lands by reducing unrestricted livestock access and the potential for bank erosion through exclusion methods.
Strategies Addressed	R2. Restore wetland and floodplain storage processes R3.1 Remove constraints to lateral connectivity (Riverine) R4. Restore riparian processes R5. Place in-channel LWD R6. Improve habitat conditions within and adjacent to agricultural lands

MBJ4 Photographs: Left-Blackjack Creek floodplain and associated wetlands, facing south from Lider Road. Right-Wetland mitigation area between SE Lider Road and Sidney Road SW.

Action	***MBJ5–Fish Passage Improvements @ Sidney Road SW***
Description	Fish passage improvements @ Sidney Road SW. Site ID 931600, Passability: 67%; Total PI 31.43. [this action is modified from Aquascape II Project 74]
Outcome	Improves fish passage by addressing barriers to longitudinal migration. Also reconnects isolated habitats and restores continuous corridors essential for fish movement, food, shelter, and reproduction. This action also addresses the supply and downstream transport of sediment, organic material (e.g., wood and detritus) and nutrients.
Strategies Addressed	R1. Reconnect isolated habitats and remove barriers to fish passage

MBJ5 Photograph: Culvert under Sidney Road SW

Action	***MBJ6–Protect Riparian Habitat***
Description	Acquire and protect high quality riparian habitat along Blackjack Creek just upstream of Sidney Road SW through acquisition and/or conservation easements. [this action is modified from Aquascape II Project 70]
Outcome	Addresses riparian and floodplain processes by protecting peak and base streamflow, sediment loading, in-stream wood, channel and floodplain complexity, water temperature, and food chain support.
Strategies Addressed	P1.1 Acquisitions and conservation easements

Action	*MBJ7–Restoration on Mainstem west of Sidney Road SW*
Description	Restore wetlands and conduct riparian restoration and targeted LWD placement west of Sidney Road. This action is near the boundary of Middle Blackjack Creek and Ruby Creek subbasins.
Outcome	Improves wetland floodplain storage to buffer against increased bank erosion from peak flows that occur downstream in steeper portions of the stream that have erodible deposits. Prevents further channel incision and improves habitat through placement of in-channel large woody material. Planting of native riparian vegetation would result in long-term wood recruitment, stream shading, bank and floodplain complexity, and food chain support. This action would increase the amount of instream wood to increase hydraulic roughness and restore channel complexity in the intermediate period while riparian forests are developing. Wood placement promotes scour and deposition processes that form complex substrate, pools and bars, and secondary channel formation.
Strategies Addressed	R2. Restore wetland and floodplain storage processes R4. Restore riparian processes R5. Place in-channel large woody debris

MBJ7 Photograph: Upper mainstem of Blackjack Creek, facing west from Sidney Rd SE

Action	***MBJ8–Restoration on Tributaries and Headwater Wetlands west of Sidney Road SW***
Description	Conduct riparian and wetland restoration and targeted LWD placement along tributaries and associated headwater wetlands west of Sidney Road. Restoration may also consider allowing for the presence of beaver and/or designing beaver dam analogs as an element where appropriate. This action seeks to build on previous restoration actions for fish passage and stream habitat improvement on the Meyers Property.
Outcome	Improves wetland floodplain storage to buffer against increased bank erosion from peak flows that occur downstream in steeper portions of the stream that have erodible deposits. Prevents further channel incision and improves habitat through placement of in-channel large woody material. Planting of native riparian vegetation would result in long-term wood recruitment, stream shading, bank and floodplain complexity, and food chain support. This action would increase the amount of instream wood to increase hydraulic roughness and restore channel complexity in the intermediate period while riparian forests are developing. Wood placement promotes scour and deposition processes that form complex substrate, pools and bars, and secondary channel formation.
Strategies Addressed	R2. Restore wetland and floodplain storage processes R4. Restore riparian processes R5. Place in-channel large woody debris

MBJ8 Photograph: Tributary and wetlands west of Sidney Road SW (Myers Property)

5.3 Upper Blackjack Creek

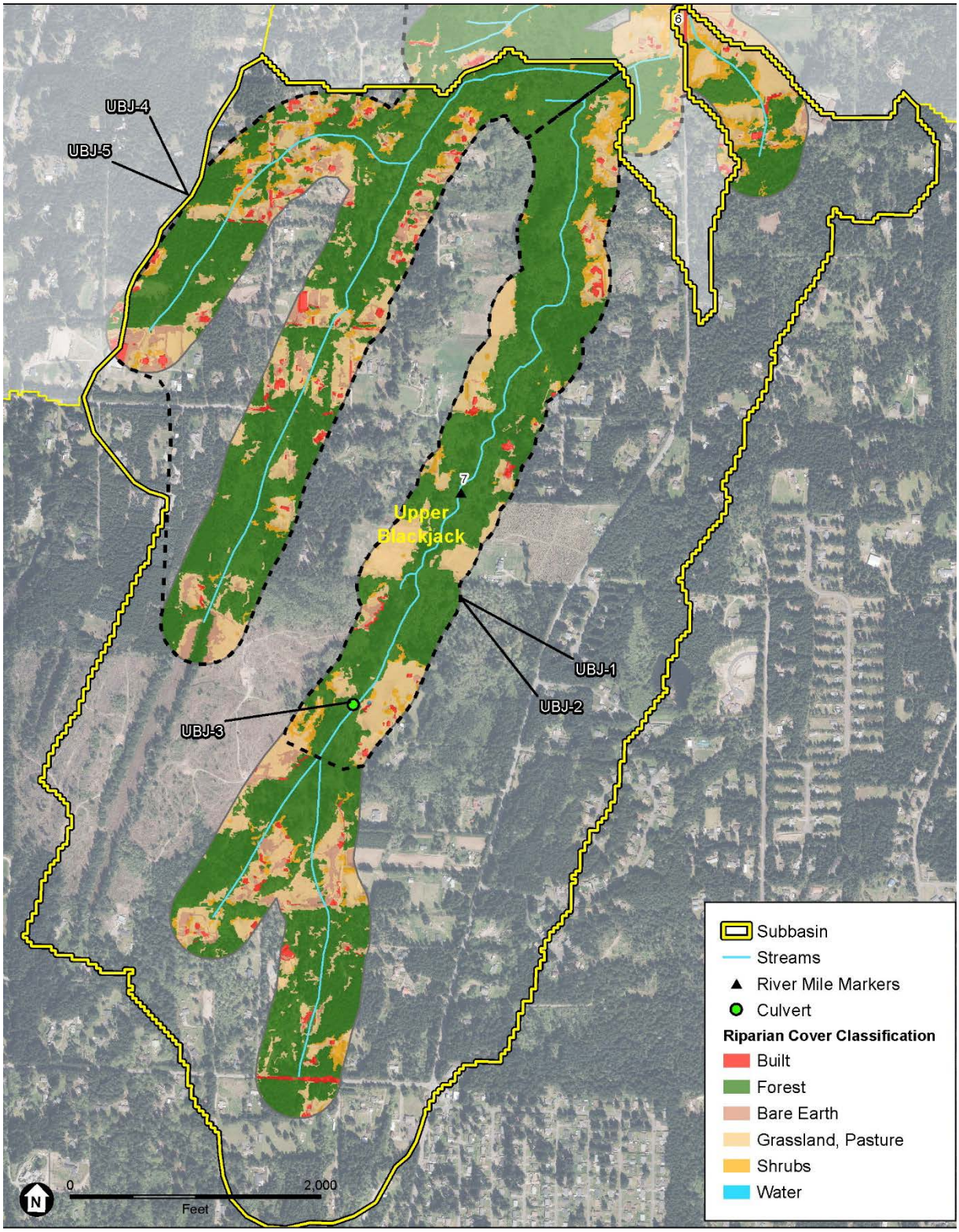
The upper Blackjack Creek subbasin is characterized by rural residential land uses, timber harvest activities and current and historic agricultural activities. Hydrology from groundwater springs and wetlands is a major contributor to headwater tributary flows. Overall, riparian conditions throughout the Upper Blackjack Creek subbasin are considered functioning with forested riparian habitat extending the full width of the riparian zone along both the mainstem and several tributaries. Similar to Ruby Creek (described below), the primary impairments to riparian function (LWD recruitment and stream shading) are from historic and current land use such as rural residential development, timber harvest, and agricultural activities.

However, even with such land use pressures, overall stream habitat is of relatively good quality and provides some of the key spawning and rearing habitat in the watershed. Acquiring and/or protecting this high quality habitat through purchase, easements, or strengthened land use development standards would be appropriate in this portion of the watershed.

Five (5) actions (UBJ1 through UBJ5) are identified for the Upper Blackjack Creek subbasin (Table 9 and Figure 5).

Table 9. Recommended Actions – Upper Blackjack Creek Subbasin

Reach	River Mile or Location	Action
Mainstem	RM 6.0–7.5	UBJ1–Protect Riparian Habitat UBJ2–Maintain or Expand Protective Zoning UBJ3–Fish Passage Improvements
Tributaries	West (2)	UBJ4–Protect Riparian Habitat UBJ5–Maintain or Expand Protective Zoning



SOURCE: NAIP, 2015; ESA, 2016; Open Street Maps, 2016; Kitsap County, 2016
FEMA, 2007

160024 - Blackjack Creek Watershed Assessmen

Figure 5.
Protection and Restoration Actions – Upper Blackjack Creek Subbasin

Action	*UBJ1–Protect Riparian Habitat - mainstem*
Description	Develop an acquisition and conservation plan to protect high quality habitat (i.e., intact riparian areas, headwater wetlands and groundwater that help maintain cool stream temperatures) along mainstem.
Outcome	Addresses riparian and floodplain processes by protecting peak and base streamflow, sediment loading, in-stream wood, channel and floodplain complexity, water temperature, and food chain support.
Strategies Addressed	P1.1 Acquisitions and conservation easements

Action	*UBJ2–Maintain or Expand Protective Zoning - mainstem*
Description	Maintain existing zoning (1 dwelling per 5 acres) to ensure protection of Upper Blackjack Creek, minimize potential for additional subdivision and impacts from development and redevelopment of existing rural parcels. Encourage the County to implement tree retention requirements and impervious surface limits within rural zoning districts. Encourage stewardship and conservation by rural property owners, especially along riparian corridors.
Outcome	Protects watershed functions and upland, wetland, and riparian habitats through strengthened regulations. This action would improve riparian processes by protecting and restoring riparian functions such as shade, wood recruitment, and natural bank stabilization.
Strategies Addressed	P1.2 Improve compliance and/or strengthen land use regulations R7. Improve stormwater attenuation capacity within and adjacent to residential areas

Action	*UBJ3–Fish Passage Improvements*
Description	Investigate fish passage at culvert west of Sidney Road and develop strategy to address findings. Site ID 931770, Passability: 67%; Total PI Not scored.
Outcome	Improves fish passage by addressing barriers to longitudinal migration. Also reconnects isolated habitats and restores continuous corridors essential for fish movement, food, shelter, and reproduction. This action also addresses the supply and downstream transport of sediment, organic material (e.g., wood and detritus) and nutrients.
Strategies Addressed	R1. Reconnect isolated habitats and remove barriers to fish passage

UBJ3 Photograph: Partial barrier culvert west of Sidney Road SW

Action	***UBJ4–Protect Riparian Habitat - tributaries***
Description	Develop an acquisition and conservation plan to protect high quality habitat (i.e., intact riparian areas, headwater wetlands and groundwater that help maintain cool stream temperatures) along tributaries in upper watershed.
Outcome	Addresses riparian and floodplain processes by protecting peak and base streamflow, sediment loading, in-stream wood, channel and floodplain complexity, water temperature, and food chain support.
Strategies Addressed	P1.1 Acquisitions and conservation easements

Action	***UBJ5–Maintain or Expand Protective Zoning - tributaries***
Description	Maintain existing zoning (1 dwelling per 5 acres) to ensure protection of Upper Blackjack Creek, minimize potential for additional subdivision and impacts from development and redevelopment of existing rural parcels. Encourage the County to implement tree retention requirements and impervious surface limits within rural zoning districts. Encourage stewardship and conservation by rural property owners, especially along riparian corridors.
Outcome	Protects watershed functions and upland, wetland, and riparian habitats through strengthened protections. This action would improve riparian processes by protecting and restoring riparian functions such as shade, wood recruitment, and natural bank stabilization.
Strategies Addressed	P1.2 Improve compliance and/or strengthen land use regulations R7. Improve stormwater attenuation capacity within and adjacent to residential areas

5.4 Ruby Creek

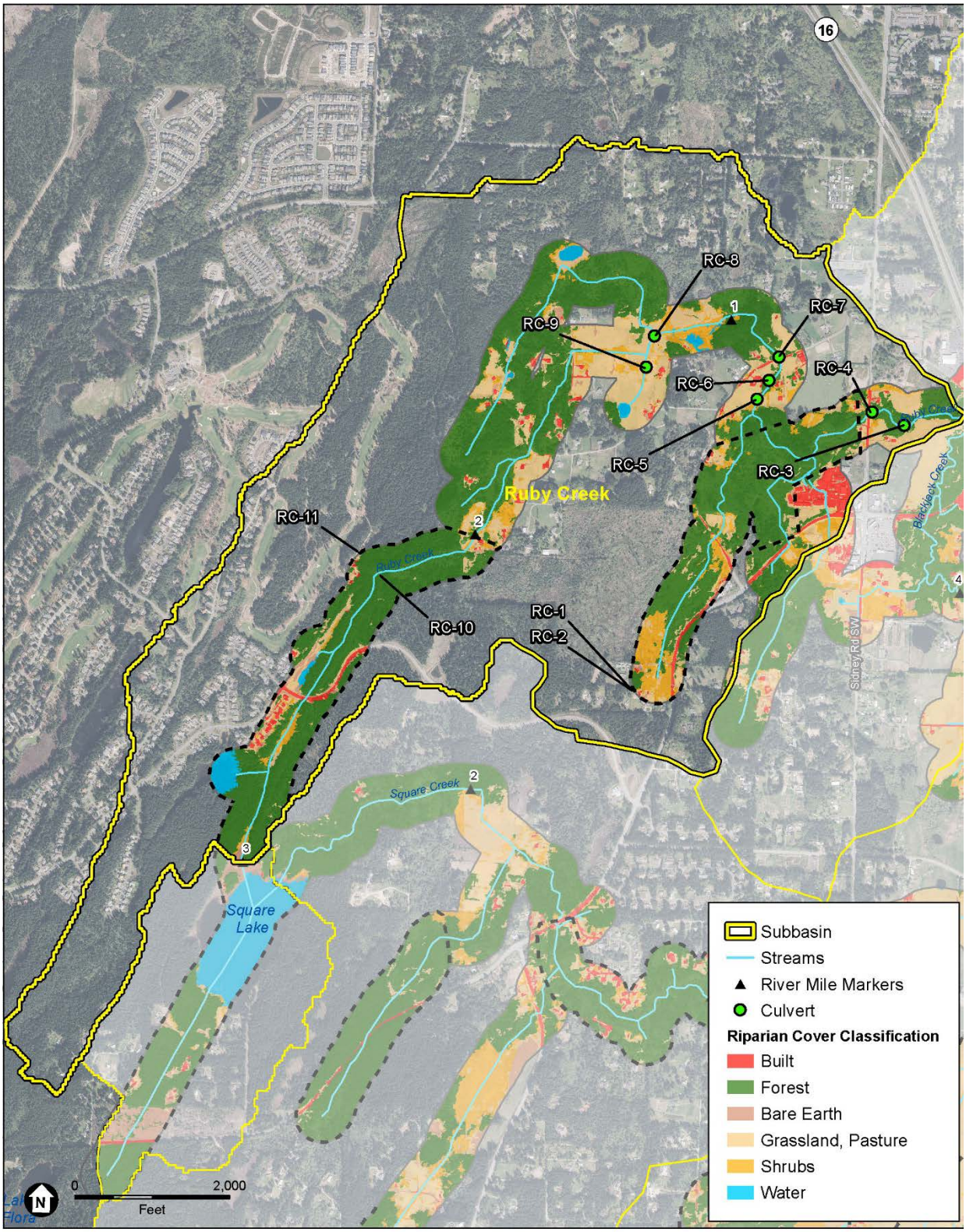
The Ruby Creek subbasin is characterized by rural residential land uses, and current and historic agricultural activities. The mainstem of Ruby Creek is a primary tributary of Blackjack Creek and flows through a mostly unconfined floodplain. Riparian conditions in the Ruby Creek subbasin range from moderately impaired to functioning, in its lower and upper reaches, to impaired in the middle portion of the subbasin. Where riparian forests are present, large woody debris recruited into Ruby Creek is likely retained within the subbasin and not exported downstream to the mainstem of Blackjack Creek. Similar to the Middle Blackjack Creek subbasin, the Ruby Creek subbasin supports agricultural land uses (with more extensive agricultural use in the recent past) that have impacted riparian vegetation and impaired floodplain connectivity and water quality. Due to recent expansion of the UGA and commercial zoning west of SR16, the lower reaches are at risk of additional commercial and residential development, which may further reduce riparian function through clearing and conversion of forest to built environment and impervious surfaces.

The subbasin also provides important flow, sediment, and temperature functions that support fish spawning and rearing. That said, recent stream temperatures for portions of Ruby Creek have been warmer and above Ecology 303(D) water temperature standard (7-Day Average Daily Maximum (7-DADmax) of 16°Celsius for "Core Summer Salmonid Habitat"). In addition, the greatest numbers of complete barriers to fish passage for the watershed are found in reaches of Ruby Creek. Therefore, fish passage improvement actions may be particularly important for this subbasin. In addition, stream channelization has occurred along sections of Ruby Creek in the middle and upper reaches. Riparian conditions would benefit from restoration in the lower and upper reaches, and re-meandering of streams along with placement of LWD would also be appropriate in the middle and upper reaches. In the upper reaches, high quality habitat should be targeted for protection.

Eleven (11) actions (RC1 through RC11) are identified for the Ruby Creek subbasin (Table 10 and Figure 6).

Table 10. Recommended Actions – Ruby Creek Subbasin

Reach	River Mile or Location	Action
Lower Reaches	RM 0.0–0.7	RC1-Protect Riparian Habitat RC2-Review Existing Zoning RC3-Restoration of Ruby Creek Upstream of Wildlife Preserve RC4- Fish Passage Improvements @ Sidney Road RC5-Fish Passage Improvements and Restoration downstream of Glenwood Road RC6-Fish Passage Improvements and Restoration downstream of Glenwood Road RC7-Fish Passage Improvements @ Glenwood Road RC8-Fish Passage Improvements and Restoration upstream of Glenwood Road
Middle Reaches	RM 0.7–2.0	RC9-Restoration of Ruby Creek north of SW Harper Road
Upper Reaches	RM 2.0–Square Lake	RC10-Protect Riparian Habitat RC11-Maintain or Expand Protective Zoning



SOURCE: NAIP, 2015; ESA, 2016; Open Street Maps, 2016; Kitsap County, 2016
FEMA, 2007

160024 - Blackjack Creek Watershed Assessment

Figure 6.
Protection and Restoration Actions – Ruby Creek Subbasin

Action	***RC1–Protect Riparian Habitat***
Description	Develop an acquisition and conservation plan to protect high quality habitat on Ruby Creek upstream of Sidney Road. [this action is modified from Aquascape II Project 70]
Outcome	Addresses riparian and floodplain processes by protecting peak and base streamflow, sediment loading, in-stream wood, channel and floodplain complexity, water temperature, and food chain support.
Strategies Addressed	P1.1 Acquisitions and conservation easements

Action	***RC2–Review Existing Zoning***
Description	Review Port Orchard Land Use and Zoning Designations in areas currently designated Commercial and Residential High Density/R-20 along Ruby Creek above (west of) Blackjack Creek to determine if Land Use and Zoning changes should be proposed in the area to ensure protection of the stream and to reduce the potential impacts from development and redevelopment; maintain County Rural Protection designation further upstream. Review adequacy and ensure enforcement of critical areas and stormwater requirements for commercial and residential areas in lower reach of Ruby Creek. Review should be informed by and consistent with the spatial information developed as part of this watershed assessment.
Outcome	Protects watershed functions and upland, wetland, and riparian habitats through strengthened protections and enforcement. This action would address riparian and floodplain processes by protecting headwater and floodplain wetlands, and protecting and restoring riparian functions such as shade, wood recruitment, and natural bank stabilization.
Strategies Addressed	P1.2 Improve compliance and/or strengthen land use regulations

Action	***RC3–Restoration of Ruby Creek Upstream of Wildlife Preserve***
Description	Construct naturalized channel, place LWD, and restore riparian vegetation east of Sidney Road and upstream of Ruby Creek Marsh Wildlife Preserve (WFC Project F). WFC Description: Ruby Creek is ditched through a field with some riparian trees and shrubs. Where the ditch line ends the flows disperse into 450’ of field without a defined channel. There is standing water in the field but it is choked by grasses without a defined surface connection. The Ruby Creek Marsh Wildlife Preserve is immediately downstream; here, the old ditched pasture has been replaced with a beaver dam wetland complex. Constructing a naturalized, sinuous channel with LWD and a riparian corridor through the flooded section of pasture would tie surface flows into the downstream Preserve. Restoration may also consider allowing for the presence of beaver and/or designing beaver dam analogs as an element where appropriate.

Action	***RC3–Restoration of Ruby Creek Upstream of Wildlife Preserve***
Outcome	Improves wetland floodplain storage to buffer against increased bank erosion from peak flows that occur downstream in steeper portions of the stream that have erodible deposits. Improves instream habitat conditions (specifically, groundwater recharge functions) of summer base flows, dissolved oxygen, and temperature. This action would also restore lateral connectivity of riparian and floodplain areas, allowing lateral channel migration, promotion of side channel and off-channel habitat formation, floodplain connectivity, and decreasing stream energy during peak flow events. Planting of native riparian vegetation would result in long-term wood recruitment, stream shading, bank and floodplain complexity, and food chain support. This action would also prevent further channel incision and improve habitat through placement of in-channel LWD. It would increase the amount of instream wood to increase hydraulic roughness and help restore channel complexity in the intermediate period while riparian forests are developing. Wood placement promotes scour and deposition processes that form complex substrate, pools and bars, and secondary channel formation.
Strategies Addressed	R2. Restore wetland and floodplain storage processes R3.1 Remove constraints to lateral connectivity (Riverine) R4. Restore riparian processes R5. Place in-channel large woody debris R6. Improve habitat conditions within and adjacent to agricultural lands

Action	***RC4–Fish Passage Improvements @ Sidney Road***
Description	Ruby Creek crosses Sidney Road in a partial barrier culvert with a 1’ perch and no substrate throughout. WFC documented many juvenile coho above the culvert, but it meets the state criteria for a partial barrier. This partial barrier was identified as a high priority by the watershed assessment (ESA, 2017a). Site ID 1320082, Passability: 67%; Total PI 29.35. [this action is WFC Project J]
Outcome	Improves fish passage by addressing barriers to longitudinal migration. Also reconnects isolated habitats and restores continuous corridors essential for fish movement, food, shelter, and reproduction. This action also addresses the supply and downstream transport of sediment, organic material (e.g., wood and detritus) and nutrients.
Strategies Addressed	R1. Reconnect isolated habitats and remove barriers to fish passage

RC4 Photograph: Partial barrier culvert under Sidney Road.

Action	***RC5–Fish Passage Improvements Downstream of Glenwood Road (#931608)***
Description	Ruby Creek flows through a complete barrier culvert just south of Glenwood Road crossing. Downstream supports functioning rearing habitat and upstream supports available habitat including Ruby Marsh and Square Lake. This total fish passage barrier was identified as a high priority by the watershed assessment (ESA, 2017a). Action proposes fish passage improvements, riparian restoration, and LWD placement. Site ID 931608, Passability: 0%; Total PI 42.53). [this action is modified from Aquascape II Project 72; also Kitsap Conservation District action with Gingrey Property]
Outcome	Improves fish passage by addressing barriers to longitudinal migration. Also reconnects isolated habitats and restores continuous corridors essential for fish movement, food, shelter, and reproduction. This action also addresses the supply and downstream transport of sediment, organic material (e.g., wood and detritus) and nutrients. Riparian restoration (i.e. native plantings, removal of non-native plants) would address riparian processes of long-term wood recruitment, stream shading, bank and floodplain complexity, and food chain support. This action would also prevent further channel incision and improve habitat through placement of in-channel LWD. It would increase the amount of instream wood to increase hydraulic roughness and help restore channel complexity in the intermediate period while riparian forests are developing. Wood placement promotes scour and deposition processes that form complex substrate, pools and bars, and secondary channel formation.
Strategies Addressed	R1. Reconnect isolated habitats and remove barriers to fish passage R4. Restore riparian processes R5. Place in-channel large woody debris

RC5 Photograph: Complete barrier culvert south of Glenwood Road crossing.

Action	***RC6–Fish Passage Improvements Downstream of Glenwood Road (#1320084)***
Description	Ruby Creek flows through a partial barrier culvert just south of Glenwood Road crossing. Downstream supports functioning rearing habitat and upstream supports available habitat including Ruby Marsh and Square Lake. Action proposes Fish passage improvements, riparian restoration, and LWD placement. Site ID 1320084, Passability: 67%; Total PI 31.78) [this action is modified from Aquascape II Project 72; also Kitsap Conservation District action with Silvernale Gingrey Property]
Outcome	Improves fish passage by addressing barriers to longitudinal migration. Also reconnects isolated habitats and restores continuous corridors essential for fish movement, food, shelter, and reproduction. This action also addresses the supply and downstream transport of sediment, organic material (e.g., wood and detritus) and nutrients. Riparian restoration (i.e. native plantings, removal of non-native plants) would address riparian processes of long-term wood recruitment, stream shading, bank and floodplain complexity, and food chain support. This action would also prevent further channel incision and improve habitat through placement of in-channel LWD. It would increase the amount of instream wood to increase hydraulic roughness and help restore channel complexity in the intermediate period while riparian forests are developing. Wood placement promotes scour and deposition processes that form complex substrate, pools and bars, and secondary channel formation.
Strategies Addressed	R1. Reconnect isolated habitats and remove barriers to fish passage R4. Restore riparian processes R5. Place in-channel large woody debris

RC6 Photograph: Partial barrier culvert south of Glenwood Road crossing.

Action	***RC7–Fish Passage Improvements @ Glenwood Road***
Description	Ruby Creek crosses Glenwood Road in a partial barrier culvert due to velocity. Downstream supports functioning rearing habitat and upstream supports available habitat including Ruby Marsh and Square Lake. This partial fish passage barrier was identified as a high priority by the watershed assessment (ESA, 2017a). Site ID 1320083, Passability: 33%; Total PI 34.26). [this action is modified from Aquascape II Project 74]
Outcome	Improves fish passage by addressing barriers to longitudinal migration. Also reconnects isolated habitats and restores continuous corridors essential for fish movement, food, shelter, and reproduction. This action also addresses the supply and downstream transport of sediment, organic material (e.g., wood and detritus) and nutrients.
Strategies Addressed	R1. Reconnect isolated habitats and remove barriers to fish passage

RC7 Photograph: Partial barrier culvert under Glenwood Road.

Action	***RC8–Fish Passage Improvements Upstream of Glenwood Road and North of Harper Road***
Description	Ruby Creek flows through three culverts upstream of the Glenwood Road crossing and north of Harper Road. Downstream supports functioning rearing habitat and upstream supports available habitat including Ruby Marsh and Square Lake. Beaver activity has been observed downstream of the culverts. Based on a WDFW survey in 2017, Ruby Creek is not mapped correctly and DNR stream data underestimates the available habitat gain. The length of habitat gain was extended based on WDFW physically walking the stream to the end of fish use for a 2010 Washington Department of Transportation survey. Action proposes Fish passage improvements, riparian restoration, and LWD placement. Site ID 931777, Passability: 67%; Total PI 14.23; Site ID 931776, Passability: 67%; Total PI 14.26; Site ID 931751, Passability: 67%; Total PI N/A (Kitsap Conservation District action with Dow and Brown Properties)
Outcome	Improves fish passage by addressing barriers to longitudinal migration. Also reconnects isolated habitats and restores continuous corridors essential for fish movement, food, shelter, and reproduction. This action also addresses the supply and downstream transport of sediment, organic material (e.g., wood and detritus) and nutrients. Riparian restoration (i.e. native plantings, removal of non-native plants) would address riparian processes of long-term wood recruitment, stream shading, bank and floodplain complexity, and food chain support. This action would also prevent further channel incision and improve habitat through placement of in-channel LWD. It would increase the amount of instream wood to increase hydraulic roughness and help restore channel complexity in the intermediate period while riparian forests are developing. Wood placement promotes scour and deposition processes that form complex substrate, pools and bars, and secondary channel formation.
Strategies Addressed	R1. Reconnect isolated habitats and remove barriers to fish passage R4. Restore riparian processes R5. Place in-channel large woody debris

RC8 Photographs: Left: Culvert # 931777. Center: Culvert #931776. Right: Culvert #931751.

Action	***RC9–Restoration of Ruby Creek north of SW Harper Road***
Description	Restore wetlands and re-meander channel, reconnect to floodplain, create off-channel habitat, and LWD placement along 2,000 feet of mainstem, north of SW Harper Road (Kitsap Conservation District action with Brown property). Restoration may also consider allowing for the presence of beaver and/or designing beaver dam analogs as an element where appropriate.
Outcome	Restores lateral connectivity of riparian and floodplain, allowing for lateral channel migration, restoration of sediment and organic material supply, storage, and transport, promoting or restoring the formation of side channels and off-channel habitats, floodplain connectivity, and decreasing stream energy during peak flow events. Planting of native riparian vegetation would result in long-term wood recruitment, stream shading, bank and floodplain complexity, and food chain support. Placement of in-channel LWD would prevent further channel incision and improve habitat. It would increase the amount of instream wood to increase hydraulic roughness and restore channel complexity in the intermediate period while riparian forests are developing. Wood placement promotes scour and deposition processes that form complex substrate, pools and bars, and secondary channel formation.
Strategies Addressed	R2. Restore wetland and floodplain storage processes R3.1 Remove constraints to lateral connectivity (Riverine) R4. Restore riparian processes R5. Place in-channel large woody debris R6. Improve habitat conditions within and adjacent to agricultural lands

Action	***RC10–Protect Riparian Habitat***
Description	Develop an acquisition and conservation plan to protect high quality habitat north of McCormick Woods Road (i.e., forest, wetlands, and beaver dams) and maintain current City Residential 12 (R12) zoning designation in this area.
Outcome	Addresses riparian and floodplain processes by protecting peak and base streamflow, sediment loading, in-stream wood, channel and floodplain complexity, water temperature, and food chain support.
Strategies Addressed	P1.1 Acquisitions and conservation easements

RC10 Photographs: Riparian habitat in upper reaches of Ruby Creek subbasin.

Action	***RC11–Maintain or Expand Protective Zoning***
Description	Maintain existing zoning (1 dwelling per 8 acres; 1 dwelling per 12 acres) to ensure protection of upper Ruby Creek functions, continuing to limit potential impacts from development and redevelopment of rural parcels; encourage the City to implement tree retention requirements and impervious surface limits within residential zoning districts. Ensure ongoing protection of open space areas associated with McCormick Woods Planned Urban Development (PUD).
Outcome	Protects watershed functions and upland, wetland, and riparian habitats through strengthened protections. This action would improve riparian processes by protecting and restoring riparian functions such as shade, wood recruitment, and natural bank stabilization.
Strategies Addressed	P1.2 Improve compliance and/or strengthen land use regulations R7. Improve stormwater attenuation capacity within and adjacent to residential areas

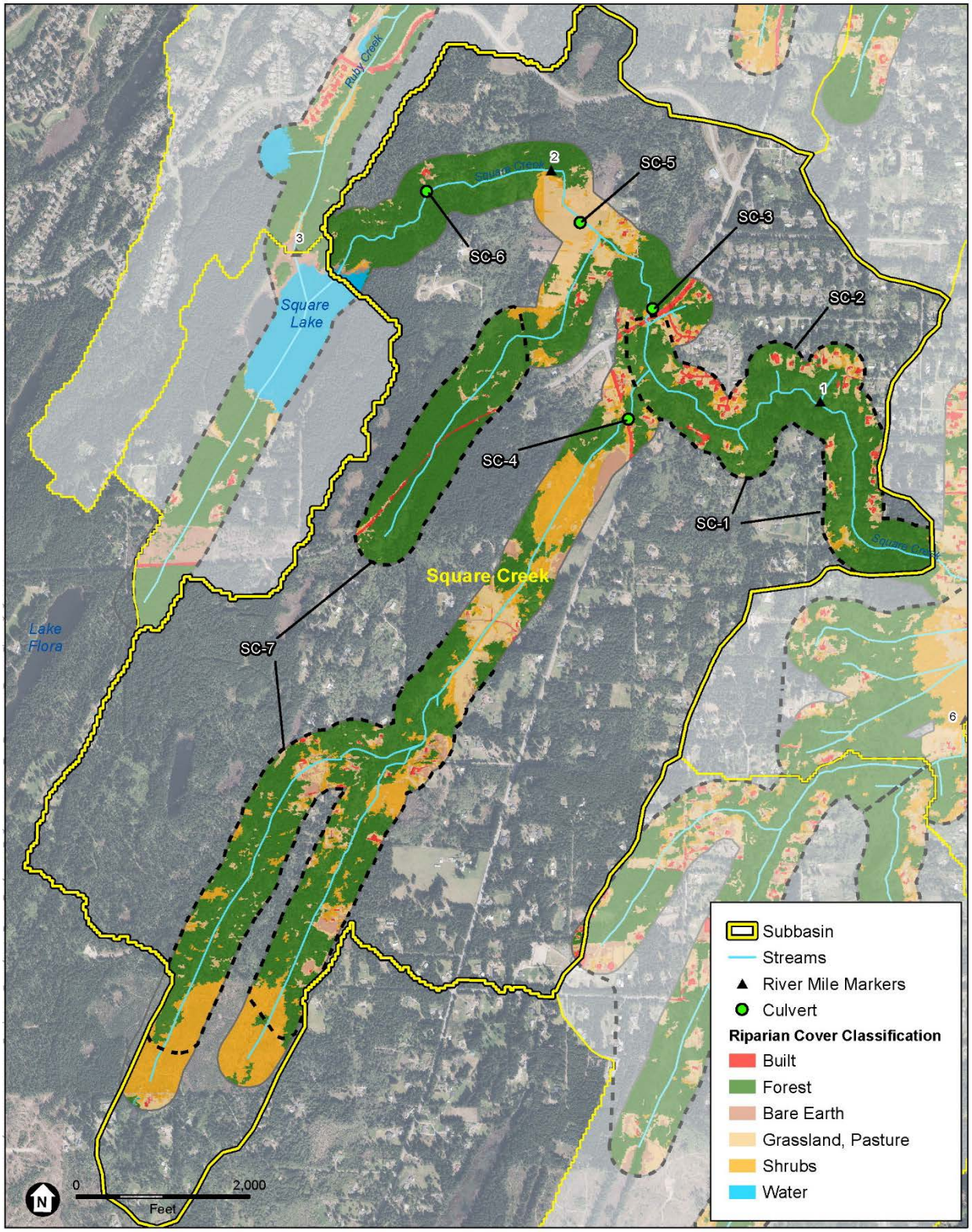
5.5 Square Creek

The Square Creek subbasin includes the mainstem of Square Creek and two tributaries. It is characterized by rural residential land uses, timber harvest activities, and current and historic agricultural activities. Riparian conditions in the Square Creek subbasin are moderately impaired as the mainstem has a relatively intact forested riparian buffer for most of its length. Riparian habitat is only impaired for a limited area along a 1,200-foot-long reach where the stream flows through ditched agricultural fields (approximately 800 feet upstream of the Glenwood Road crossing). Stream functions, such as LWD recruitment, stream shading, and sediment and nutrient filtration are impaired in this portion of the subbasin, which could affect downstream water temperatures. The Square Creek basin provides vital stream functions to support fish use despite the high number of complete barriers to fish passage. Recommended restoration needs in this subbasin are similar to the Ruby Creek subbasin.

Seven (7) actions (SC1 through SC7) are identified for the Square Creek subbasin (Table 11 and Figure 7).

Table 11. Recommended Actions – Square Creek Subbasin

Reach	River Mile or Location	Action
Mainstem	Sidney Rd – Square Lake	SC1-Protect Riparian Habitat SC2-Place In-stream Large Woody Debris SC3-Fish Passage Improvements and Restoration @ SW Lake Flora Road SC4-Fish Passage Improvements and Restoration @ Glenwood Road SC5-Restoration of Square Creek west of Glenwood Road SC6- Fish Passage Improvements upstream of Schweitzer Place
Tributaries	East & West	SC7-Maintain or Expand Protective Zoning



SOURCE: NAIP, 2015; ESA, 2016; Open Street Maps, 2016; Kitsap County, 2016
FEMA, 2007

160024 - Blackjack Creek Watershed Assessment

Figure 7.
Protection and Restoration Actions – Square Creek Subbasin

Action	***SC1–Protect Riparian Habitat***
Description	Develop a conservation plan to protect high quality habitat upstream of Sidney Road. [this action is modified from Aquascape II Project 70]
Outcome	Addresses riparian and floodplain processes by protecting peak and base streamflow, sediment loading, in-stream wood, channel and floodplain complexity, water temperature, and food chain support.
Strategies Addressed	P1.1 Acquisitions and conservation easements

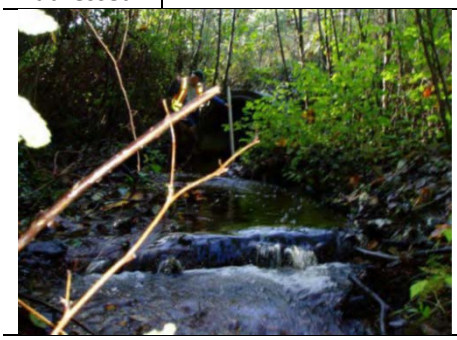
SC1 Photograph: Riparian habitat in Square Creek subbasin.

Action	***SC2–Large Woody Debris Placement***
Description	Investigate conditions and develop strategy for LWD placement, if deemed necessary, in lower reach of Square Creek. This action would involve LWD placement until full riparian function is restored and would specifically target salmonid habitats that would benefit most from acceleration of forest succession. [this action is modified from Aquascape II Project 77]
Outcome	Prevents further channel incision and improves habitat through placement of in-channel large woody material. This action focuses on increasing the amount of instream wood to increase hydraulic roughness and restore channel complexity in the intermediate period while riparian forests are developing. Wood placement promotes scour and deposition processes that form complex substrate, pools and bars, and secondary channel formation to improve stream spawning habitat.
Strategies Addressed	R5. Place in-channel large woody debris

Action	*SC3–Fish Passage Improvements and Habitat Restoration @ SW Lake Flora Road*
Description	Ruby Creek flows under SW Lake Flora Road through partial barrier culvert. Recent work at this location attempted to improve flooding and habitat conditions, but may not be operating as designed. This action would investigate conditions and develop strategy for providing fish passage improvements, channel and riparian restoration at crossing of SW Lake Flora Road and east of Glenwood Road. Site ID 931602, Passability: 67%; Total PI 23.93
Outcome	Improves fish passage by addressing barriers to longitudinal migration. Also reconnects isolated habitats and restores continuous corridors essential for fish movement, food, shelter, and reproduction. This action also addresses the supply and downstream transport of sediment, organic material (e.g., wood and detritus) and nutrients.
Strategies Addressed	R1. Reconnect isolated habitats and remove barriers to fish passage R3.1 Remove constraints to lateral connectivity (Riverine) R4. Restore riparian processes

SC3 Photograph: Partial barrier culvert under SW Lake Flora Road.

Action	*SC4–Fish Passage Improvements and Restoration @ Glenwood Road*
Description	Right bank tributary to Square Creek flows through a passable culvert under Glenwood Road. A single, man-placed log control is downstream of the culvert with a <0.2 meter drop in water surface elevation. Action proposes fish passage improvements, potential log weir removal, riparian restoration, and LWD placement on right bank tributary at crossing. Site ID 931603, Passability: 100%; Total PI N/A.
Outcome	Improves fish passage by addressing barriers to longitudinal migration. Also reconnects isolated habitats and restores continuous corridors essential for fish movement, food, shelter, and reproduction. This action also addresses the supply and downstream transport of sediment, organic material (e.g., wood and detritus) and nutrients.
Strategies Addressed	R1. Reconnect isolated habitats and remove barriers to fish passage

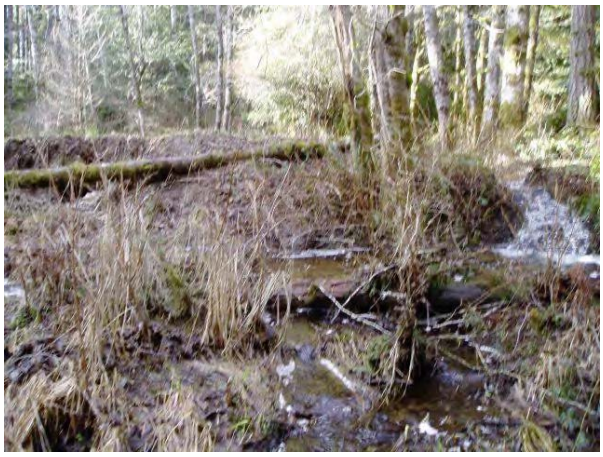


SC4 Photograph: Log weir on Square Creek.

Action	***SC5–Restoration of Square Creek West of Glenwood Road***
Description	Re-meander channel, reconnect to floodplain, create off-channel habitat, riparian restoration, and targeted LWD placement in the 1,200-foot-long reach west of Glenwood Road SW. Restoration may also consider allowing for the presence of beaver and/or designing beaver dam analogs as an element where appropriate.
Outcome	Improves wetland floodplain storage to buffer against increased bank erosion from peak flows that occur downstream in steeper portions of the stream that have erodible deposits. Improves instream habitat conditions (specifically, groundwater recharge functions) of summer base flows, dissolved oxygen, and temperature. This action would also restore lateral connectivity of riparian and floodplain areas, allowing lateral channel migration, promotion of side channel and off-channel habitat formation, floodplain connectivity, and decreasing stream energy during peak flow events. Planting of native riparian vegetation would result in long-term wood recruitment, stream shading, bank and floodplain complexity, and food chain support. This action would also prevent further channel incision and improve habitat through placement of in-channel LWD. It would increase the amount of instream wood to increase hydraulic roughness and help restore channel complexity in the intermediate period while riparian forests are developing. Wood placement promotes scour and deposition processes that form complex substrate, pools and bars, and secondary channel formation.
Strategies Addressed	R2. Restore wetland and floodplain storage processes R3.1 Remove constraints to lateral connectivity (Riverine) R4. Restore riparian processes R5. Place in-channel large woody debris

SC5 Photograph: Square Creek west of Glenwood Road.

Action	*SC6–Fish Passage Improvements Upstream of Schweitzer Place*
Description	Square Creek flows through a complete barrier with a >1m water surface drop over an earthen dam with culvert. The culvert inlet is blocked with steel plate and flows over the top of the dam. Dam is for unknown purpose. Wetlands are present downstream and rearing habitat is available upstream, including Square Lake. This total fish passage barrier was identified as a high priority by the watershed assessment (ESA, 2017a). Site ID 931754, Passability: 0%; Total PI 24.90 (Kitsap Conservation District action with Sweeney Property)
Outcome	Improves fish passage by addressing barriers to longitudinal migration. Also reconnects isolated habitats and restores continuous corridors essential for fish movement, food, shelter, and reproduction. This action also addresses the supply and downstream transport of sediment, organic material (e.g., wood and detritus) and nutrients.
Strategies Addressed	R1. Reconnect isolated habitats and remove barriers to fish passage



SC6 Photograph: Earthen dam with 0% Passability on Square Creek.

Action	*SC7–Maintain or Expand Protective Zoning - tributaries*
Description	Maintain existing zoning (Rural Residential: 1 dwelling per 5 acres) to ensure protection of southern tributaries, minimizing potential for additional subdivision and impacts from development and redevelopment of existing rural parcels. Encourage stewardship and conservation by rural property owners, especially along riparian corridors
Outcome	Protects watershed functions and upland, wetland, and riparian habitats through strengthened protections. This action would improve riparian processes by protecting and restoring riparian functions such as shade, wood recruitment, and natural bank stabilization.
Strategies Addressed	P1.2 Improve compliance and/or strengthen land use regulations R7. Improve stormwater attenuation capacity within and adjacent to residential areas

5.6 Square Lake

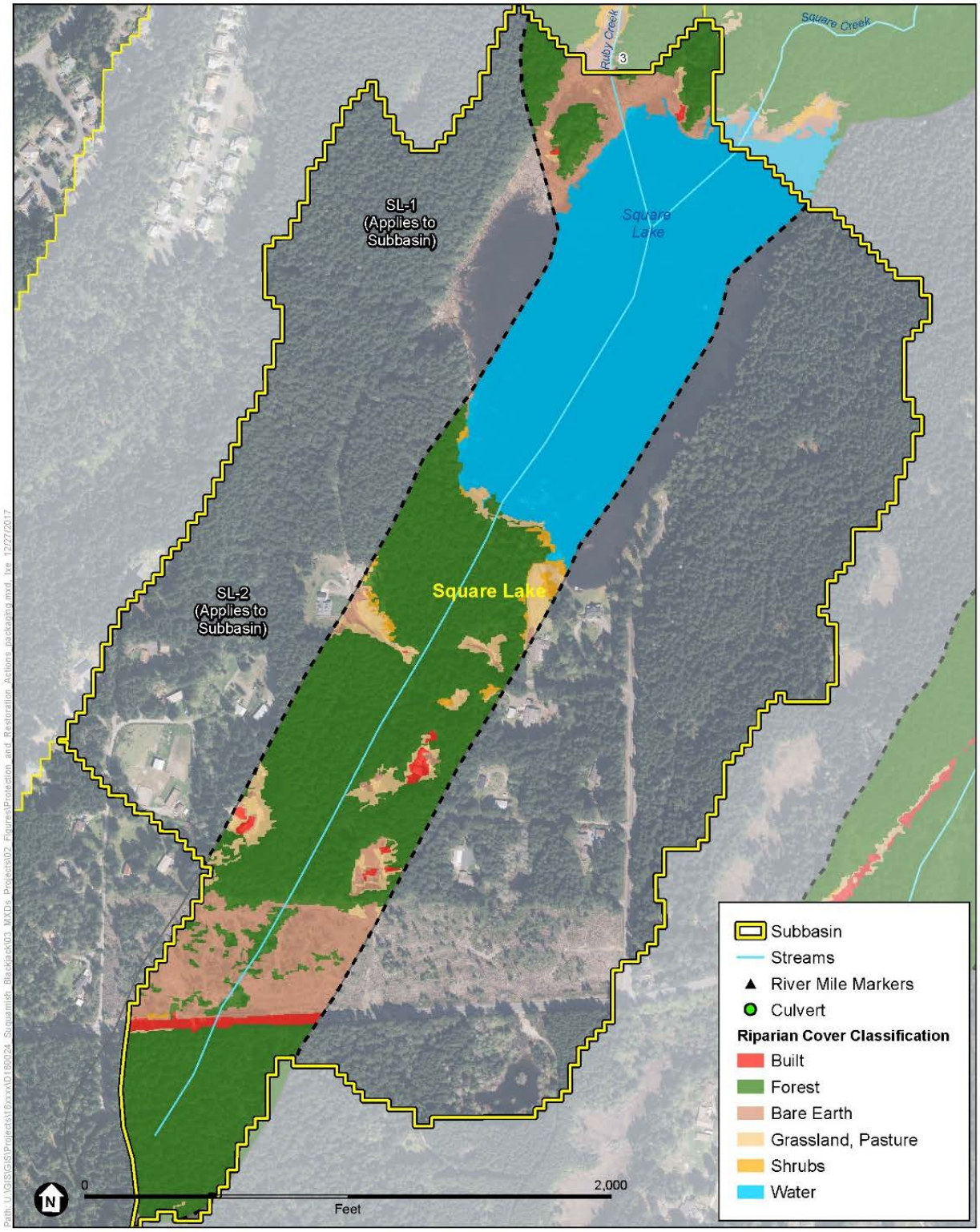
The Square Lake subbasin is the smallest subbasin (201 acres) in the watershed and contains Square Lake and the surrounding area. The subbasin is largely characterized by County Park (day use only, no overnight camping) and rural residential land uses and limited timber harvest activities. In contrast to many parts of the other subbasins in the watershed, the riparian conditions, stream functions and processes in the Square Lake subbasin are relatively intact and considered functioning. Maintaining current protections from potential future development should be a priority for the Square Lake subbasin.

Two (2) actions (SL1 through SL2) are identified for the Square Lake subbasin (Figure 8).

Action	***SL1–Protect Riparian Habitat & Maintain Public Ownership***
Description	Maintain county ownership of land surrounding Square Lake, and protect existing forested and wetland conditions, including presence of beaver
Outcome	Addresses riparian and floodplain processes by protecting peak and base streamflow, sediment loading, in-stream wood, channel and floodplain complexity, water temperature, and food chain support.
Strategies Addressed	P1. Protect Blackjack Creek habitat conditions

SL1 Photographs: Square Lake.

Action	***SL2–Protect Open Space***
Description	Ensure ongoing protection of open space areas surrounding north end of Square Lake, associated with McCormick Woods PUD (City jurisdiction)
Outcome	Addresses riparian and floodplain processes by protecting headwater and floodplain wetlands, and protecting and restoring riparian functions such as shade, wood recruitment, and natural bank stabilization.
Strategies Addressed	P1. Protect Blackjack Creek habitat conditions



SOURCE: NAIP, 2015; ESA, 2016; Open Street Maps, 2016; Kitsap County, 2016
FEMA, 2007

160024 - Blackjack Creek Watershed Assessment

Note: The channel shown flowing into Square Lake from the SW was recently mapped by WFC as "NOCH", indicating no channel exists.

Figure 8.
Protection and Restoration Actions – Square Lake Subbasin

6 PRIORITIZATION FRAMEWORK FOR ACTIONS

This section presents a framework for prioritizing the recommended protection and restoration actions. The main elements of the framework are based on the available literature of process-based restoration in watersheds, that is widely published and accepted by the restoration community in the Pacific Northwest (e.g., Roni and Beechie, 2013; Roni et al. 2002; Beechie et al. 2010; and Beechie and Bolton, 1999). Additional input and considerations for the prioritization of actions was gathered from project partners and stakeholders including specific contributions from the Department of Ecology.

6.1 Process-based Principles

Process-based restoration aims to reestablish the normal rates and magnitudes of physical, chemical, and biological processes that sustain river and floodplain ecosystems (Beechie et al. 2010). Through the application of the principles for process-based restoration, it is possible to assign a hierarchy of general priorities to watershed restoration actions. The priorities follow those suggested by Roni et al. (2002) and are based on three elements: 1) principles of watershed processes, 2) protecting existing high-quality habitats, and 3) current knowledge of the effectiveness of specific techniques.

For the Blackjack Creek watershed, an overarching framework for prioritizing site-specific actions includes:

- **First, protect intact watershed processes.** This applies where human degradation of processes has been minimal, resulting in conditions that maintain natural ecological functions and habitats.
- **Second, reconnect isolated high-quality habitats.** As the focus of this plan is salmonids, actions that link existing functioning habitats allow for adequate access to those habitats which support the broad spectrum of life history stages (e.g., spawning, rearing, and migration).
- **Third, restore disrupted or altered watershed processes.** This includes hydrology and sediment regimes, and riparian processes.
- **Fourth, enhance instream habitat with large wood.** This applies to areas where short-term improvement is immediately needed while natural watershed processes (e.g., forest re-growth) are restored.

The protection of high-quality habitat should be given priority over habitat restoration because it is typically easier, less expensive in the long-term, and more successful to maintain high quality intact habitat than to try and recreate or restore degraded habitat. Reconnecting or restoring access to habitats that are inaccessible is the next step and applies to removal of culverts or other barriers to fish passage such as levees, armoring or other structures. Reconnecting isolated off-channel habitats or blocked tributaries provides a quick biological response, is likely to last many decades or longer, and based on available evidence, has a high likelihood of success. Reconnected habitats also allow for physical and genetic refuge from both human-induced and natural stressors in the watershed.

Once the connectivity of habitats within a subbasin is restored, efforts should focus on the restoration of disrupted or altered processes that form and sustain habitats, such as the supply and movement of sediment, woody debris recruitment, shading of the stream by riparian forest, and delivery of water to the

stream channel (i.e., runoff). Riparian restoration may not produce results for many years and indeed decades for some functions. However, because of this delay, planting riparian areas should be conducted in tandem with other strategies such as reconnecting habitats or restoring altered hydrologic regimes. Lastly, the framework puts techniques that manipulate instream habitat as the lesser priority because they tend to be short-lived, the results are highly variable among techniques and species, and when not combined with other elements such as riparian restoration, they do not by itself restore processes. Even techniques that appear to be well studied, such as instream LWD placement, need more thorough evaluation and long-term monitoring (Roni et al., 2002).

Figure 9 presents a schematic diagram of the potential decision-making process for prioritizing the recommended actions in this Watershed Plan.

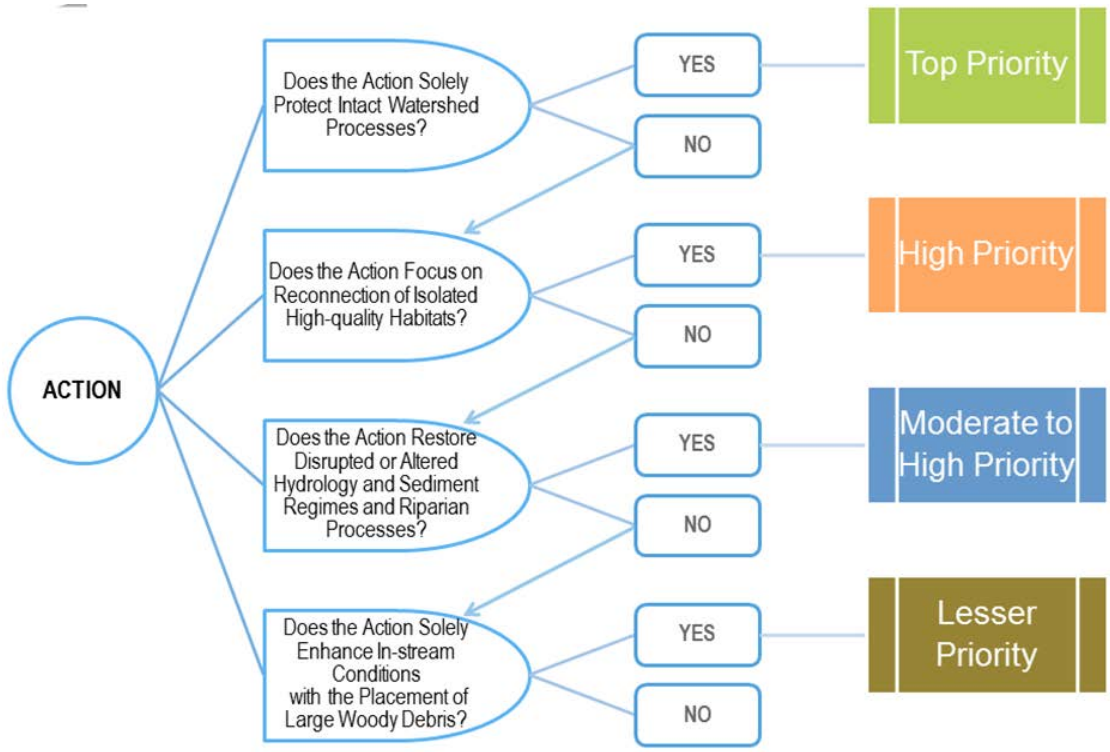


Figure 9. Schematic Diagram of a Process-based Decision-making Process for Prioritizing Actions in the Blackjack Creek Watershed.

6.2 Additional Considerations

The prioritization of restoration actions should also consider the watershed context (i.e., landscape degradation and process controls), the biological benefit, and the influence of climate change (i.e., on action effectiveness). These are suggested as additional considerations or overlays on the process-based framework above, and are meant to supplement the prioritization process. For some actions, these additional considerations may transcend the process-based principles that form the schematic in Figure 9, resulting in lesser priority actions being elevated above moderate priority actions.

Landscape Controls and Degradation

The *Key Ecological Attributes and Pressures Assessment* (ESA, 2017a) includes a landscape-scale assessment of hydrologic patterns using "down-scaled" spatial (GIS) data from Ecology's Puget Sound Watershed Characterization Project (Stanley et al., 2016). This assessment provides detailed spatial information regarding water flow processes in the subbasins of the Blackjack Creek watershed that should be considered during prioritization of both strategies and actions. In addition to evaluating ecosystem processes and functions using a hierarchal lens (as in Figure 9), it is important to assess the effects of human actions on these processes, and the resulting effects on habitat structure and ecological functions. The conceptual model in Figure 10 was developed by Stanley (2017), adapted from Beechie and Bolton (1999) and Beechie et al., (2009). The model shows the physical, chemical, and biological process drivers at multiple scales and how these drivers respond to various human-caused pressures (degradations), which in turn result in stressors on ecologic and habitat processes. The figure provides a logic model for identifying connections between observed habitat responses and degradation to watershed processes.

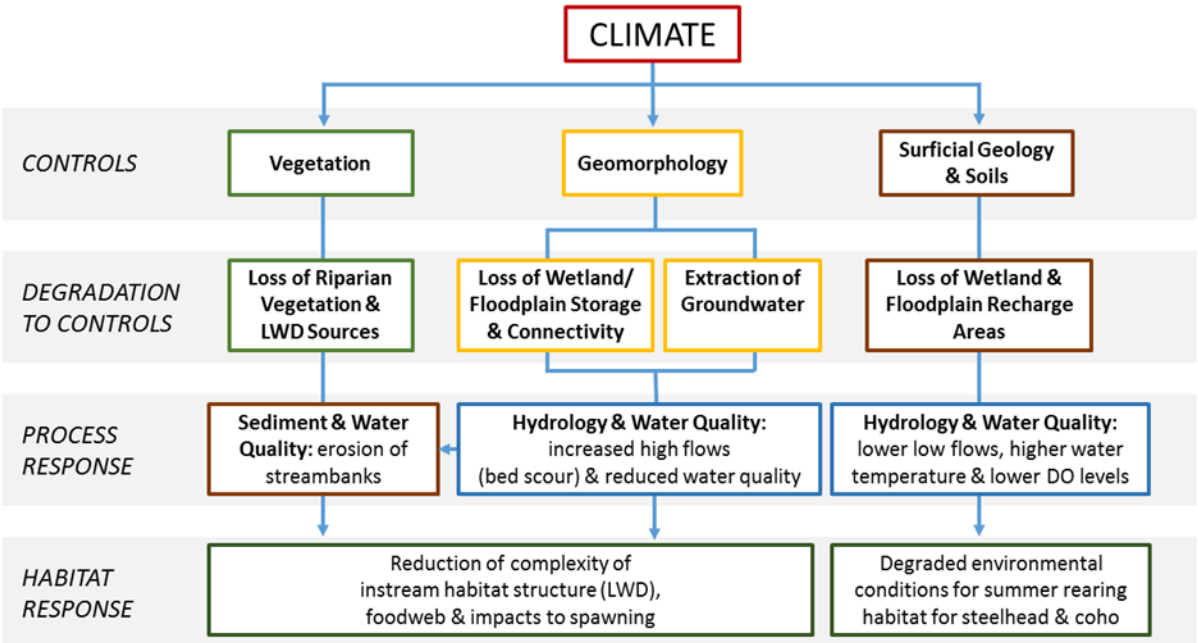


Figure 10 – Integrating Diagram of Key Ecological Attributes and Degradations for the Blackjack Creek Watershed (Stanley, 2017)

This watershed restoration model illustrates several important points. First, the interaction of controls and processes occurs at the various spatial and temporal scales. For example, vegetation controls apply primarily at the watershed and reach scales, while others such as surficial geology and soils are shaped at larger scales, including the litho-topograhic and watershed scales. The complex relationship in response to degradation of controls is also apparent, as alteration to hydrology also directly affects sediment and water quality. In addition, it becomes apparent that climate is an overarching driver that affects all controls and exerts these effects over the broad range of spatial and temporal scales.

Pertinent to the Blackjack Creek watershed, the model shows that one of the key landscape controls for sustaining the normal range of stream flows and sediment transport is wetland and floodplain storage. Spatial information from the down-scaled watershed characterization results suggest that the most important areas for wetland and floodplain storage and groundwater recharge are located in the Middle Blackjack subbasin, the Ruby Creek subbasin, and immediately west of SR16 in the upper portion of the Lower Blackjack subbasin (Figure 11). The areas shown in darker blue are considered key areas in maintaining the hydrology and aquatic ecosystem of Blackjack Creek.

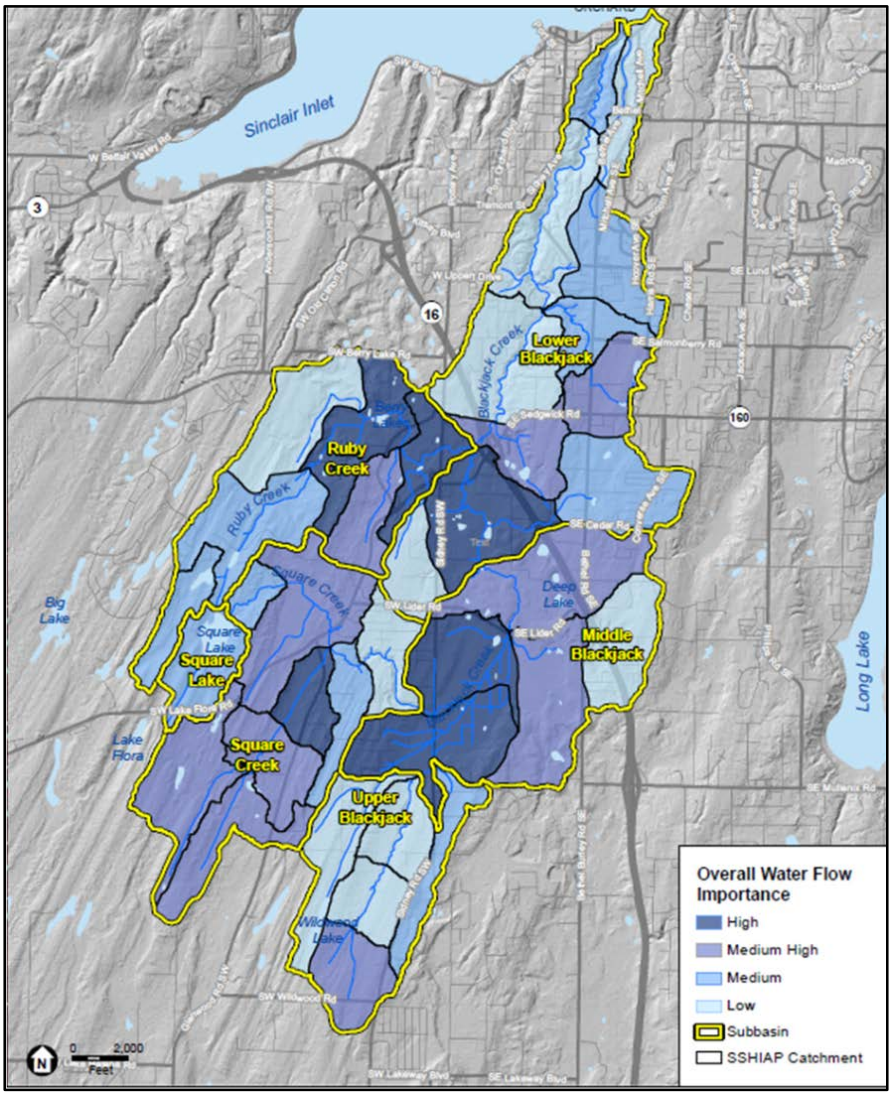


Figure 11. Watershed Characterization Results for Hydrologic Processes: Overall Water Flow Importance (ESA, 2017a)

Strategies and actions that address protecting or restoring hydrologic or sediment processes in these areas of the watershed should be prioritized above other areas since they will sustain the hydrology of Blackjack Creek. Without the normal range of flows (including peak flows and low flows), the physical structure of Blackjack Creek will degrade, which in turn will reduce the habitat complexity and food chain support critical for salmonids. These conclusions are also supported by soil mapping that shows higher levels of organic content in Middle Blackjack Creek subbasin east of Sidney Road SW, which is critical for storing water and releasing it slowly to subsurface and surface flows (see ESA, 2017a).

Biological Benefits

The relative biological benefits of an action are not specifically addressed by the process-based prioritization framework presented in Figure 9. Relative benefits to fish populations are influenced by extent of geographic area addressed by the action within the watershed. More importantly, potential benefit is influenced by the extent of influence on the populations. For example, restoration of lower watershed survival bottlenecks (e.g., barriers) that all fish might encounter would generally have a higher biological benefit than similar restoration much higher in the watershed.

Consideration of three population performance measures (productivity, capacity, and diversity) can be used to qualitatively assess the relative benefit of a given action. Actions that increase habitat quality (e.g., reduce percent fine sediment in riffles and glides, provide cooler water temperature, increase structural complexity) improve population productivity. Actions that increase habitat quantity (e.g., reestablish spawning above barriers, increase channel wetted area, provide additional life stage key habitat) increase population capacity. Increased diversity can reflect both an increase in spatial distribution and an increase in life history expression (e.g., increased use of stream segments for spawning or overwinter rearing). Population abundance is affected by both productivity and capacity; and, many actions will likely benefit all three measures.

To evaluate increases in habitat quantity, the WDFW Compilation of Fish Passage and Diversion Screening Inventory (FPDSI) can provide information on the severity of individual barriers and the potential habitat gain if the barrier were addressed, reflected in a Priority Index (PI) score. The PI score considers the type of fish in the system (resident or anadromous), the stock status, the quality of upstream habitat, and the culvert repair cost. The higher the PI Total score, the higher priority for remediating the barrier. The highest priority barriers, based on their PI scores, for the Blackjack Creek watershed are identified and listed in the *Key Ecological Attributes and Pressures Assessment* (ESA, 2017a).

Climate Change

The prioritization of protection and restoration actions should also consider the influence of climate change. Specific to restoring salmon habitats, Beechie et al. (2013) suggests there are two important considerations to help restoration actions mitigate a climate change effect or by increasing habitat diversity and biological resilience for salmonids. The first considers the predicted effect (benefit) of restoration plans or actions and whether the benefit will be altered in response to climate change (usually stream flow or stream temperature). The second considers how climate change effects would limit habitat restoration effectiveness for targeted biota (salmonids in the case of Blackjack Creek). To help determine whether restoration plans or actions should be altered to accommodate climate, Beechie et al. propose the following four questions:

Question 1: What habitats limit salmon recovery?

Question 2: Do climate change scenarios alter salmon restoration plans or priorities (or actions)?

Question 3: Does plan or action ameliorate climate effect?

Question 4: Does plan or action increase diversity and resilience?

Beechie et al. offer two simple flow charts for evaluating restoration plans or actions using these four questions. Figure 12 shows how answers to the guiding questions can be integrated to arrive at decisions

that consider the context of local climate change scenarios (note: focus should be on the flow chart on the right as it applies to the individual actions of this Watershed Plan).

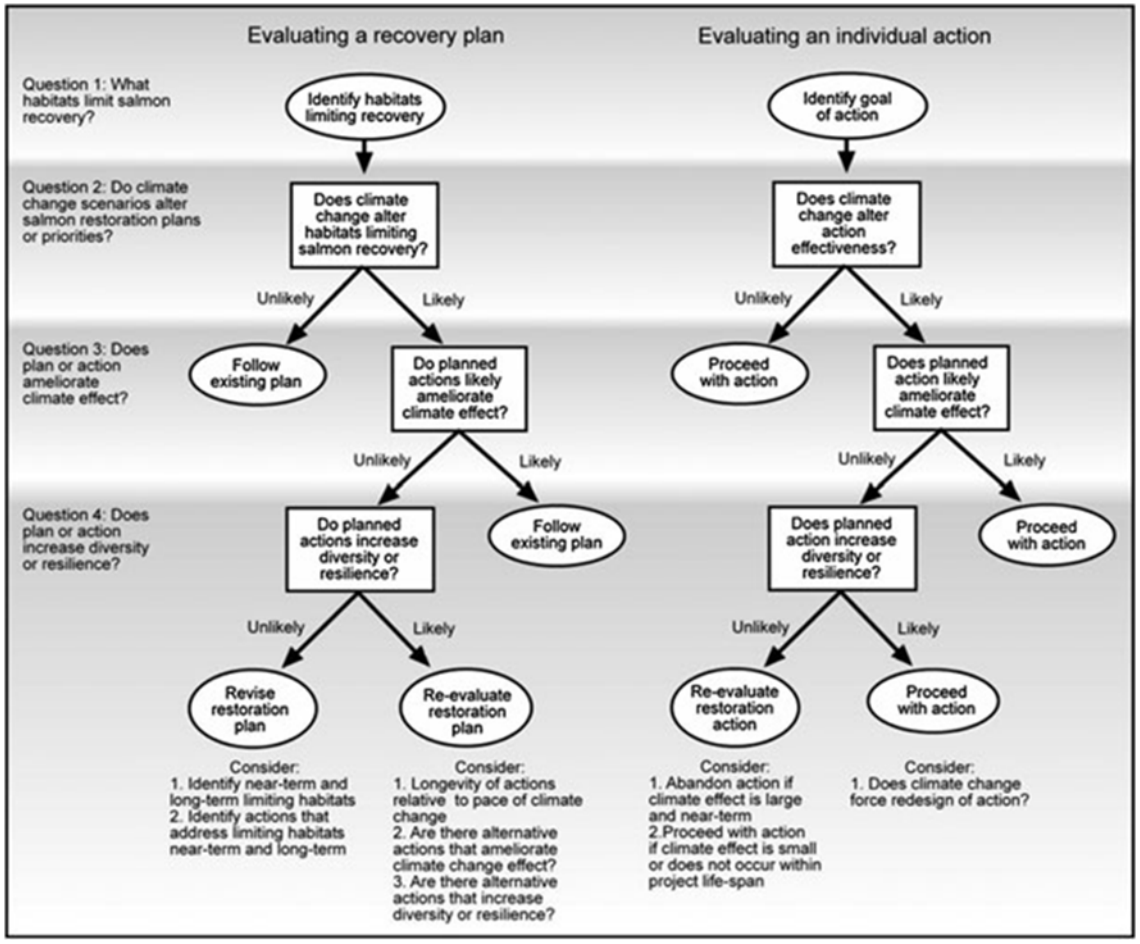


Figure 12. Flow Chart for Considering Climate Change Influence (Figure 10 from Beechie et al. 2013)

Beechie et al. (2013) also considers climate change from a different perspective, which is evaluating restoration action types and their ability to ameliorate climate change effects. This contrasts with the flow chart presented above (Figure 12), where climate change influence is an overlay or screening on top of specific actions previously identified. From this perspective, different types of restoration actions are evaluated with respect to how they address projected climate change effects on peak flow, low flow, stream temperature, and salmon population resilience (Table 12).

Table 12. Summary of Restoration Action Types and Their Ability to Ameliorate Climate Change Effects (Table III from Beechie et al. 2013)

Category	Common techniques	Ameliorates temperature increase	Ameliorates base flow decrease	Ameliorates peak flow increase	Increases salmon resilience
Longitudinal connectivity (barrier removal)					
	Removal or breaching of dam	●	●	○	●
	Barrier or culvert replacement/removal	○	○	○	●
Lateral connectivity (floodplain reconnection)					
	Levee removal	●	○	●	●
	Reconnection of floodplain features (e.g. channels, ponds)	●	○	●	●
	Creation of new floodplain habitats	●	○	●	●
Vertical connectivity (incised channel restoration)					
	Reintroduce beaver (dams increase sediment storage)	●	●	●	●
	Remove cattle (restored vegetation stores sediment)	●	●	●	○
	Install grade controls	●	●	●	○
Stream flow regimes					
	Restoration of natural flood regime	●	●	○	◒
	Reduce water withdrawals, restore summer baseflow	●	●	○	○
	Reduce upland grazing	○	◒	◒	○
	Disconnect road drainage from streams	○	○	●	○
	Natural drainage systems, retention ponds, other urban stormwater techniques	○	◒	●	○
Erosion and sediment delivery					
	Road resurfacing	○	○	○	○
	Landslide hazard reduction (sidecast removal, fill removal)	○	○	○	○
	Reduced cropland erosion (e.g. no-till seeding)	○	○	○	○
	Reduced grazing (e.g. fencing livestock away from streams)	◒	○	○	○
Riparian functions					
	Grazing removal, fencing, controlled grazing	●	○	○	○
	Planting (trees, other vegetation)	●	○	○	○
	Thinning or removal of understory	○	○	○	○
	Remove non-native plants	◒	◒	○	○
Instream rehabilitation					
	Re-meandering of straightened stream, channel realignment	◒	○	○	◒
	Addition of log structures, log jams	◒	○	○	○
	Boulder weirs and boulders	◒			
	Brush bundles, cover structures	○	○	○	○
	Gravel addition	○	○	○	○
Nutrient enrichment					
	Addition of organic and inorganic nutrients	○	○	○	○

Other Factors

This Watershed Plan focuses on a process-based approach to prioritizing protection and restoration actions. However, there are several other factors that should also be considered when prioritizing protection and restoration actions, including the complexity of the action, time to response, cost, cost effectiveness, and feasibility or opportunity to implement the actions. Prioritizing actions should be an iterative and adaptive process that seeks to gain greater understanding of all the factors. As more information becomes available on a specific action opportunity or regarding the effectiveness and cost of various techniques, it should be incorporated into the prioritization framework.

7 POTENTIAL MONITORING INDICATORS

This section provides information for use in implementing this Watershed Plan. Monitoring is critical for evaluating whether the investments in protection and restoration are meeting their objectives and providing the predicted ecological benefits (Roni and Beechie, 2013). Given the number, size, cost, and complexity of restoration actions recommended in this plan, a robust monitoring and evaluation (M&E) would be important for understanding the individual and synergistic effects of the actions and to guide future restoration efforts and priorities.

The Blackjack Creek *Key Ecological Attributes and Pressures Assessment* (ESA, 2017a) identified changes in key watershed and aquatic habitat-forming processes that have negatively affected stream and riparian habitat for salmonids in the watershed. Strategies and actions identified in this Watershed Plan are targeted to address specific degraded KEAs of habitat and salmonids and/or pressures. Guidance for using the Open Standards framework (CMP, 2013) includes a set of potential monitoring indicators for each KEA or pressure. Indicators are specific units of information measured over time that document changes in the status of a KEA or pressure. The assessment provided some guidance on potential indicators for pressures (e.g., % area covered by forest, % impervious surface area). Additional guidance on potential indicators for tracking pressures was taken from Tables 3 and 4 (Chinook KEA indicators) and Table 10 (Pressure Indicators) in PSRITT (2015) and from the Puget Sound Partnership Common Indicators (in progress). The Results Chains developed for this Watershed Plan provide additional guidance for potential indicators (Appendix C).

Table 13 lists potential KEA and pressure indicators for Blackjack Creek. Indicators are organized by pressure or KEA. Table 14 lists potential salmonid KEA indicators for Blackjack Creek.

Table 13. Potential KEA and Pressure Indicators at the Watershed Scale for Blackjack Creek.

Ecosystem Process	Key Ecological Attribute	Potential Indicators for KEA	Potential Indicators for Pressures
Hydrologic regime	High-flow hydrology regime Low-flow hydrology regime	Area/basin discharge, (e.g.,TQMean, T0.5 Yr), threshold discharge, point discharge, groundwater recharge/discharge Land cover including percentages of impervious surface area and vegetative cover Hydrographic patterns unique to each watershed will determine specific measures and the seasonal patterns most affecting Chinook (e.g., 7-day low-flow and peak-flow frequency, magnitude, and duration)	Regulated instream flow hydrograph Volume of in-basin storage Withdrawals and consumption Volume of out-of-basin transfer Volume and location of stormwater discharge and related alteration of natural hydrologic processes (e.g., infiltration, surface water and groundwater flow patterns)
Sediment regime	Sediment delivery Sediment transport and storage	Sediment budget and transport/storage regime Sediment loading (rate) Substrate composition (relevant to Chinook spawning, egg incubation, and juvenile overwintering requirements)	Road density (e.g., index of sediment loading) Loss of substrate area suitable for Chinook spawning, egg incubation, juvenile overwintering Historical frequency and volume of mass wasting (inventory) (i.e., measured loss)

Ecosystem Process	Key Ecological Attribute	Potential Indicators for KEA	Potential Indicators for Pressures
Riparian areas and wetlands	Spatial extent and continuity of riparian area Riparian community structure Riparian function	Structure (species composition and seral stage), continuity (width and length), and extent (area) of riparian vegetation (species composition and seral stage) Distribution of LWD concentrations and complexes Wood budget Recruitment rate of LWD Riparian area (extent) Riparian community species composition and structure	Area of lost depositional/floodplain areas that historically or potentially supported riparian forests Length and area of hydromodified bank (e.g., erosion, bank hardening, diking) Area and percentage of lost riparian forest cover Limits and interruptions of LWD transport Length and area of hydromodified bank (e.g., erosion, bank hardening, diking) Loss of riparian vegetation area Change and reduction in riparian and upslope vegetation community structure Loss of late seral stage component for LWD recruitment to salmon habitats Conversion of riparian area for human uses (e.g., transportation, residential, and commercial structures)
Organic matter	Organic matter —input Organic matter —retention/ processing	Structure (species composition and seral stage), continuity (width and length), and extent (area) of riparian systems Allocthonous recruitment from riparian vegetation Carbon and nitrogen cycling (flow), amount and sources of inputs; also see Nutrient process (V) below Recruitment and transport rates of instream large woody debris (LWD)	Reduction of riparian forest cover Changes in delivery of organic inputs from upslope areas Changes in delivery of organic inputs from upstream areas Type and concentration of exogenous organic inputs
Nutrient supply	Nutrient concentrations (high, low) Water quality Nutrient cycling/flux	Baseline levels of nutrients (primarily nitrogen (N), phosphorus (P), and potassium (K) Water quality metrics, including temperature, dissolved oxygen (DO), pH, conductivity/ salinity Nutrient budget (types and sources of nutrient inputs)	Inventory of anthropogenic nutrient sources (locations and load levels) Natural or artificial abundance of salmon carcasses Clean Water Act, 303d status Water quality standards exceedance Contaminants
Floodplain-channel interactions	Floodplain—connectivity Floodplain—structure and function	Length or area of potential floodplain development (gradient/confinement metrics) Hyporheic connection intact (groundwater, lakes, ponds, wetlands) Historical and current distribution of utilized habitats for holding, spawning, and rearing Distribution of habitats for rearing juveniles Distribution of habitats for prespawn holding (deep pools) and spawning (gravel riffles in main stem, side channel, and large tributaries)	Type and location of limits to juvenile and adult fish passage Area of lost natural floodplain area (historical vs. current)

Ecosystem Process	Key Ecological Attribute	Potential Indicators for KEA	Potential Indicators for Pressures
Habitat connectivity	Habitat connectivity	Availability and use of habitat patches for Chinook salmon (by life stage) Pathways (landscape) and movements (behavior) of Chinook salmon between habitat patches (i.e., for migration, rearing, feeding, etc.) Temporal (future short- and long-term) accessibility Historical vs. current connectivity patterns Correlation between abundance of Chinook salmon (by life stage) and size of required habitat types	Adult and juvenile salmon passage barriers that limit distribution (inventory and passage assessment by life stage) Access/limitations of nonindigenous species, pathogens, or contaminants Location and duration of low-flow barrier

Table 14. Potential Salmonid KEA Indicators for Blackjack Creek.

Ecosystem Process	Key Ecological Attribute	Potential Indicators
Adults	**Abundance**	Number adults to terminal area Number spawners Index counts of spawner abundance (index reaches
Juveniles	**Abundance**	Number juvenile out-migrants (total or for key subwatersheds)
Recruits per spawner	**Productivity**	Terminal area adults per spawner Spawner per spawner Out-migrants per spawner)
Adults	**Spatial Structure**	Distribution of spawners within and among subwatersheds
Adults	**Life History Diversity**	Timing of adult migration and spawning
Juveniles	**Life History Diversity**	Timing of juvenile out-migration Age structure of juvenile out-migrants (i.e., steelhead) Size of juvenile out-migrants

8 DATA GAPS AND RECOMMENDATIONS FOR FUTURE WORK

This section is a compilation of critical data gaps and uncertainties identified over the course of the project from reviews of existing data, technical reports, and other studies of the Blackjack Creek Watershed, and conversations with Suquamish tribal staff and project partners. Recommendations for filling data gaps are also included.

Hydrologic Regime

Lack of stations and continuous gauge data. The Kitsap Public Utility District (KPUD) operates a stream gauge immediately upstream of State Route (SR) 16 (approximately 3.2 miles upstream of the mouth of Blackjack Creek) with streamflow data available from 1992 to 1994 and 2000 to 2017, with some data gaps during these periods. Notably, the gauge was non-operational for most of 2010 (KPUD, 2016). This gauge is just downstream of the confluence of Ruby and Blackjack creeks and consequently does not capture flow from the full catchment area of Blackjack Creek. Because the USGS (located downstream many decades ago) and KPUD gauges are positioned at such different points in the watershed, the data are not readily comparable. The City of Port Orchard is considering reactivating the USGS gauge in the near future, making it possible to reconstruct flow data near SR 16 based on a comparison of flow between the USGS and KPUD gauge stations. This information could indicate where changes in the hydrologic regime are more pronounced or if they are consistent throughout the watershed.

Changes in peak flows. Another data gap is with respect to peak flow and flow regime affected by land use development. This flow information is needed throughout the watershed to understand hydrologic responses to land use development, climate change, and periods of drought and flood.

Low flow conditions. The low flows sub-strategy supports gaining a better understanding of the relationship between groundwater and surface water in the watershed and its effect on low flow conditions. This is currently a data gap for the watershed, and could include reviewing the amount and location of groundwater withdrawals (i.e., wells) and other out-of-stream uses and more intensive monitoring of low flow conditions in different parts of the watershed. The US Geological Survey (USGS) has been conducting modeling on this topic which should also be reviewed. Monitoring low flow conditions would also help better understand current limitations of salmonid distribution during low flow periods.

Climate Change. Projected future precipitation changes are expected to result in small increases in the total annual streamflow and a seasonal shift in flow amounts, with increases in winter but decreases in summer (Cao et al., 2016). Potential dry season hydrologic effects could include increases in evaporation from Square Lake, Wildwood Lake, Deep Lake, and wetland areas; decreased soil moisture due to increases in evapotranspiration; and increased susceptibility to drought and fire (Mote et al., 2014). Such changes are linked with an overall tendency toward a future hydrologic regime characterized by higher flood peaks and lower base flows. An assessment should be conducted that identifies watershed strategies and actions that directly address salmonid resilience to climate change in the Blackjack and potentially adjacent Kitsap Peninsula watersheds.

Square Lake. The relative contribution and seasonal dynamics of Square Lake to overall watershed hydrology are not well understood. For example, a recent survey by WFC found no channel flowing into Square Lake from the southwest as currently shown on WDFW mapping. Field investigations of Square Lake's inlets, outlets and beaver dams would aid in the understanding the lake's hydrologic relationship to downstream habitats.

Floodplain-Channel Interactions

Channel migration. Blackjack Creek appears to be relatively stable in plan form with no active meanders, but data confirming its stability and/or migration is lacking. Forthcoming LiDAR (to be collected in late 2017 and/or 2018) and high resolution imagery could be used to identify areas of past and active channel migration, slope failures along banks, etc.

Sediment regime. There is currently no record of locations of active erosion or deposition in the watershed. This information in addition to sediment transport monitoring in relation to hydrology, land use, restoration actions, etc. would be useful in informing restoration actions.

Riparian Habitat / LWD

Reach characteristics and conditions. The Limiting Factors Analysis report was mostly based on best professional judgment at the time it was written and quantitative data was usually sparse. The use of remote sensing data such as C-CAP, WDFW High Resolution Change Detection and Land Cover data, new Lidar, and drone imagery, could be relatively low cost effective alternatives for characterizing riparian conditions where current data is sparse.

In-stream characteristics and conditions. Data for reach-specific stream characteristics and habitat conditions (e.g., stream width and gradient, channel morphology, substrate conditions, riparian cover and condition, wood loading to the channel, and bank condition) in the watershed is lacking. The salmon spawning survey data may have some qualitative habitat information for the index reaches, but there is no comprehensive assessment of stream habitat parameters in the watershed. Characteristics such as pool/riffle ratios, quantification and location of LWD (see below), log jams and beaver dams, and locations of favorable spawning and rearing habitats should be targeted for use in prioritizing areas for protection and restoration. Surveys could be performed in many parts of the watershed. For the mainstem of Lower Blackjack Creek subbasin and in the Lower Ruby Creek subbasin, new surveys could be compared with limited surveys conducted by the Tribe in the late 1980s.

LWD. There is a lack of LWD data in most parts of the watershed. Large woody debris (LWD) surveys could be performed in many parts of the watershed and would aid in further prioritization and design of restoration actions. In addition to LWD surveys assessments, LWD recruitment potential in riparian corridors could combine remote sensing techniques with ground surveys, and include the current and projected (if restored) trajectories

Water Temperatures

Data collected from 2015-2017 provides some information where the Washington State temperature standard of 16ºC (7DADmax) for "Core Summer Salmonid Habitat" is being exceeded, and helps us better understand the locations of relatively warm waters and cool water refugia for salmonids in the

watershed. Continued stream temperature monitoring in the watershed is needed into the future to assess potential changes from land use and climate change. It will also useful in identifying important areas for riparian cover/planting and addressing low flow and temperature conditions.

An assessment should be made into how changes in the thermal regime due to climate and land use changes, as well as restoration actions, potentially affect habitat suitability in different parts of the watershed for salmonids.

Fish Passage

The 2016 WDFW Compilation of Fish Passage and Diversion Screening Inventory (FPDSI) reports on known City, County, State, and privately owned fish passage features for the Blackjack Creek watershed. Many of the barrier assessments are old and inaccurate. The WFC Water Type surveys (2014) were conducted recently and provide more updated information on many of the Blackjack fish barriers. Although both of these sources of fish passage information are useful tools, field verification of current barrier conditions is needed, especially if barrier replacements are to be prioritized.

Fish Distribution and Abundance. Although we have some adult abundance estimates for coho and chum salmon, there is no smolt information and very little information at all on the presence, abundance, and distribution of steelhead. There is a need to better understand the overall watershed distribution of these salmonid species, seasonal migration patterns, which habitats appear most suitable and when fish tend to occupy them. Emerging tools such as environmental DNA (e-DNA) should be considered in determining the presence, relative abundance, and distribution of salmonid species in the Blackjack watershed.

Implementation and Effectiveness Monitoring

A monitoring and evaluation (M&E) program should be developed for implementing the actions in this Watershed Plan and measuring their effectiveness. For the Blackjack Creek watershed, an interlocal agreement between the Suquamish Tribe, municipalities, agencies, and others would help support and sustain the program. This agreement along with coordination and outreach to stakeholders during implementation of actions will be important to building and maintaining support of proposed actions.

A successful M&E program would include some or all of the following elements: establishing goals and objectives; defining clear hypotheses to be tested; determining the monitoring scale; selecting an appropriate monitoring design; determining the parameters to be measured; determining the number of sites and duration of monitoring; selecting a sampling methodology (scheme); implementing the M&E program; and, finally, analysis and communicating results (see Roni and Beechie, 2013; Figure 8.1). The restoration goals established at the beginning of the process should be used to help define specific monitoring objectives and questions and guide the development of an M&E program.

9 REFERENCES

Beechie, T., H.Imaki, and J.Greene. 2013. Restoring salmon habitat for a changing climate. River Research and Applications 29: 939–960.

Beechie, T.J., D. Sear, J. Olden. 2010. Process-based principles for restoring river ecosystems. BioScience 60, 209–222.

Beechie T.J., Bolton S. 1999. An approach to restoring salmonid habitat- forming processes in Pacific Northwest watersheds. Fisheries 24: 6–15.

Booth, D.B., D. Hartley, and R. Jackson. 2002. Forest Cover, Impervious-Surface Area, and the Mitigation of Stormwater Impacts. Journal of the American Water Resources Association. Vol. 38. No. 3.

CMP (Conservation Measures Partnership). 2013. Open Standards for the Practice of Conservation. Version 3.0 (April 2013). Available: http://cmp-openstandards.org/download-os/.

ESA (Environmental Science Associates). 2017a. Blackjack Creek Key Ecological Attributes and Pressures Assessment. Prepared for the Suquamish Tribe. June 2017.

ESA (Environmental Science Associates). 2017b. Blackjack Creek Recommended Strategies and Actions Memorandum. Prepared for the Suquamish Tribe. September 2017.

FishPro, Inc. 1987. Blackjack Creek Comprehensive Management Plan for the City of Port Orchard. June 1987.

Haring, D., 2000. Salmonid Habitat Limiting Factors, Water Resource Area 15 (East). Washington Conservation Commission. November 2000.

May, C.W., and G. Peterson. 2003. Kitsap Salmonid Refugia Report. Prepared for Kitsap County. October 2003.

Naval Facilities Engineering Command, Northwest. 2010. Sinclair Inlet Enhancement Opportunities - Aquascape II. Silverdale, WA.

McManus, E., K. Jenni, M. Clancy, K. Ghalambor, I. Logan, S. Redman, B. Labiosa, K. Currens, T. Quinn, W. Landis, K. Stiles, and J. Burke. 2014. The 2014 Puget Sound Pressures Assessment. Puget Sound Partnership. Publication # 2014-04. Tacoma, WA.

PSRITT (Puget Sound Recovery Implementation Technical Team). 2015. Puget Sound Chinook Salmon Recovery: A Framework for the Development of Monitoring and Adaptive Management Plans. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-130. September 2015.

Roni, P. and T. Beechie. 2013. Stream and Watershed Restoration: A Guide to Restoring Riverine Processes and Habitats, First Edition. Published by John Wiley & Sons, Ltd.

Roni, P., T.J. Beechie, R.E. Bilby, F.E. Leonetti, M.M. Pollock, and G.R. Pess. 2002. A Review of Stream Restoration Techniques and a Hierarchical Strategy for Prioritizing Restoration in Pacific Northwest Watersheds. North American Journal of Fisheries Management 22:1–20, 2002.

Stanley, S. 2017. Comments on Nov 1st Blackjack Creek workshop for recommended watershed protection and restoration strategies and actions. Letter dated November 7,2017 addressed to Steve Todd, Suquamish Tribe from Stephen Stanley, Washington Department of Ecology.

Stanley, S., S. Grigsby, D.B. Booth, D. Hartley, R. Horner, T. Hruby, J. Thomas, P. Bissonnette, R. Fuerstenberg, J. Lee, P. Olson, and G. Wilhere. 2016. Puget Sound Characterization. Volume 1: The Water Resources Assessments (Water Flow and Water Quality). October 2016 Update. Washington State Department of Ecology. Publication #11-06-016. Olympia, WA.

WDFW (Washington Department of Fish and Wildlife). 2016. Fish Passage and Diversion Screening Inventory: Blackjack Creek Watershed. March, 2016.

WFC (Wild Fish Conservancy). 2014. Watertype Assessment Project Summary - West Sound Watersheds Phase II. Prepared October 2014.

Appendix A

Blackjack Creek Synthesis of Existing Data and Reports Memorandum (ESA, 2016)

ESA

5309 Shilshole Avenue NW
Suite 200
Seattle, WA 98107
206.789.9658 phone
206.789.9684 fax

www.esassoc.com

memorandum

date August 29, 2016

to Steve Todd, Suquamish Tribe

from Ilon Logan, Christina Hersum, Pete Lawson, and Aaron Booy

subject Blackjack Creek Watershed Assessment and Protection and Restoration Plan:
Synthesis of Existing Data and Reports Memorandum (Task 2)

This memo is a compilation and synthesis of major findings from existing data, technical reports, and other studies of the Blackjack Creek Watershed between 1987 and 2016. The Suquamish Tribe is conducting an assessment of the watershed with support from a Shorelines National Estuary Protection (NEP) Watershed Protection and Restoration Grant from the Washington Department of Ecology (Ecology #SEANEP-2014-SuquTr-00072). The goal of the Blackjack Creek Watershed Assessment is to develop a plan for protection and restoration strategies and actions in the Blackjack Creek watershed that will protect and restore watershed, riparian, floodplain and stream processes and habitat functions for salmonids. This memo summarizes key findings of existing studies and provides an inventory of previous and ongoing restoration or protection activities in the watershed. A complete list of existing data sources and publications is attached to this memo (see Attachment A).

Key Documents

This section summarizes several documents related to salmonid habitat, stream typing, fish passage, flow regimes, stream biology, and land use in the Blackjack Creek watershed. Key documents include:

- Salmonid Habitat Limiting Factors, Water Resource Area 15 – East (Haring, 2000)
- Kitsap Salmonid Refugia Report (May and Peterson, 2003)
- West Sound Water Type Assessment – Phase II (Wild Fish Conservancy, 2014)
- Fish Passage and Diversion Screening Inventory (Washington Department of Fish and Wildlife [WDFW], 2016a)
- Blackjack Creek Comprehensive Management Plan for the City of Port Orchard (FishPro, 1987)

The *Salmonid Habitat Limiting Factors* analysis (Haring 2000) and the *Kitsap Salmonid Refugia Report* (May and Peterson 2003) provide specific characterizations of Blackjack Creek with regards to fish habitat and use. These documents provide a foundation for the watershed assessment and were used to inform West Sound Watersheds Council's priorities for projects eligible for funding in the Habitat Work Schedule. The *West Sound Water Type Assessment* (Wild Fish Conservancy, 2013) and the

WDFW Fish Passage and Diversion Screening Inventory (2016) provide current information on stream types and culvert conditions in the watershed. The *Blackjack Creek Comprehensive Management Plan* (FishPro, 1987), although dated, offers information about potential development pressures that might affect implementation strategies for salmon recovery in the watershed. This document was heavily cited during recent shoreline planning by both the City of Port Orchard and Kitsap County.

Various stream flow, water quality, and biological data (including salmon presence) have been recorded for Blackjack Creek, mostly by Kitsap County, WDFW, and the Suquamish Tribe. Each monitoring effort is also described briefly below. A more comprehensive list of existing data sources and published documents is included as Attachment A.

Salmonid Habitat Limiting Factors Water Resources Inventory Area 15 (East) Report (2000)

Report Summary

This limiting factors report compiled information for all of the drainages discharging to Puget Sound from the eastern portion of Water Resources Inventory Area (WRIA) 15 with input from a Technical Advisory Group (TAG) which consisted of individuals from resource agencies, conservation organizations, and tribal fisheries departments with expertise in the region. The report summarizes watershed characteristics, describes the distribution and condition of fish stocks, and outlines habitat limiting factors for each watershed. The report concludes with a summary of limiting factors for the area, a description of key habitats in need of protection and restoration, and a discussion of data gaps. Information on fish distribution compiled by the TAG is likely the best available source of comprehensive fish distribution data, however the report has not been comprehensively updated since 2000. However, water typing surveys completed by Wild Fish Conservancy between 2011 and 2013 provide additional fish distribution information (Wild Fish Conservancy, 2014). The report includes a map appendix highlighting the distribution of individual fish species. The section discussing habitat limiting factors for the Blackjack Creek watershed (pages 140-143) summarizes fish access, floodplain modifications, channel condition, substrate, riparian condition, water quality, water quantity, estuarine and nearshore/marine conditions. Key findings are summarized below.

Blackjack Creek supports Chinook, chum, and coho salmon, and cutthroat and steelhead trout. A summer chum stock in Blackjack Creek (South Sound-Blackjack Creek Summer Chum) is unusual to this part of Puget Sound and separate from the more common fall chum stock that also occurs in Blackjack Creek. Unlike many other area streams in the region, Blackjack Creek has not been planted annually with coho fry. Fish passage barriers are an important factor limiting salmon productivity in the watershed. Road crossings noted as potential barriers to fish passage for culvert replacement/removal in the list of action items include:

- Culvert on Unnamed tributary 15.0204 at Bethel Road;
- Two culverts on Ruby Creek; and
- Sidney Road crossing on Square Creek.

A qualitative assessment of floodplain and channel conditions is presented with ratings of good, fair, or poor. Poor habitat conditions are described for Blackjack Creek, Ruby Creek, and Square Creek. However, the report notes that wetland and stream restoration efforts completed in the late 1990s

increased floodplain connectivity along Blackjack Creek and Ruby Creek. Key limitations identified in the watershed include: low amounts of large woody debris (LWD) and lack of riparian vegetation (especially for upper tributaries, including Ruby and Square Creeks), marginal pool habitat, and garbage and debris within lower Blackjack Creek. Large wood has been added as part of restoration projects occurring in Ruby Creek. Channel substrate in each of these segments is generally fair to good. Concerns are noted in the report for increased siltation due to logging in the headwaters of Unnamed tributary 15.0207 (tributary of Square Creek).

The riparian condition of Blackjack Creek from the mouth to river mile (RM) 3.0 is characterized as fair. Riparian conditions are characterized as exceptionally good approximately 1 km upstream of the Sidney Road crossing. However, between Sedgwick and Sidney roads, Blackjack Creek is described as having poor riparian vegetation conditions in agriculturally-dominated areas. The report notes that quantitative evaluations of stream channel characteristics for Blackjack Creek and Ruby Creek are lacking and would contribute to an improved understanding of habitat conditions and restoration potential in these streams.

Haring (2000) reviewed water quality data collected by the Bremerton-Kitsap Health District at eight monitoring locations in the watershed for the period 1996-2000. Five of the locations were along Blackjack Creek, one along Ruby Creek, and two along Square Creek. The report stated that "no consistent water quality concerns were identified"; however, it was noted that Blackjack Creek was on the CWA 303(d) list for high fecal coliform levels and that there were localized observations of periodic high fecal coliform counts and low dissolved oxygen levels in several areas of the stream, as well as portions of Ruby Creek.

The report notes that development in the watershed, especially in the Urban Growth Area (UGA), has resulted in increased stormwater runoff directly entering streams and generally altered the watershed's hydrology. Quantitative information for stream flows in the watershed is only available for years 1947-1950, and 1993 and 1994. Haring (2000) suggests that more recent streamflow data would contribute a better understanding of conditions and restoration potential.

Estuarine conditions are limited in the Blackjack Creek estuary due to significant modifications and development in the intertidal area and along the banks of the estuary. Similarly, the nearshore conditions are poor due to shoreline armoring, intertidal fill, and loss of riparian vegetation and LWD.

<u>Additional Information</u>

Many of the road crossings and barriers noted for culvert replacement/removal identified by Haring (2000) have not been addressed. Only a limited number have been corrected, including a crossing at Sidney Road of two tributaries that was replaced with a bridge using a Family Forest Fish Passage Program (FFFPP) grant (Myers Property) and two culverts at the SW Harper Road crossing of Ruby Creek that were replaced with a single passable culvert (Foster/James Properties).

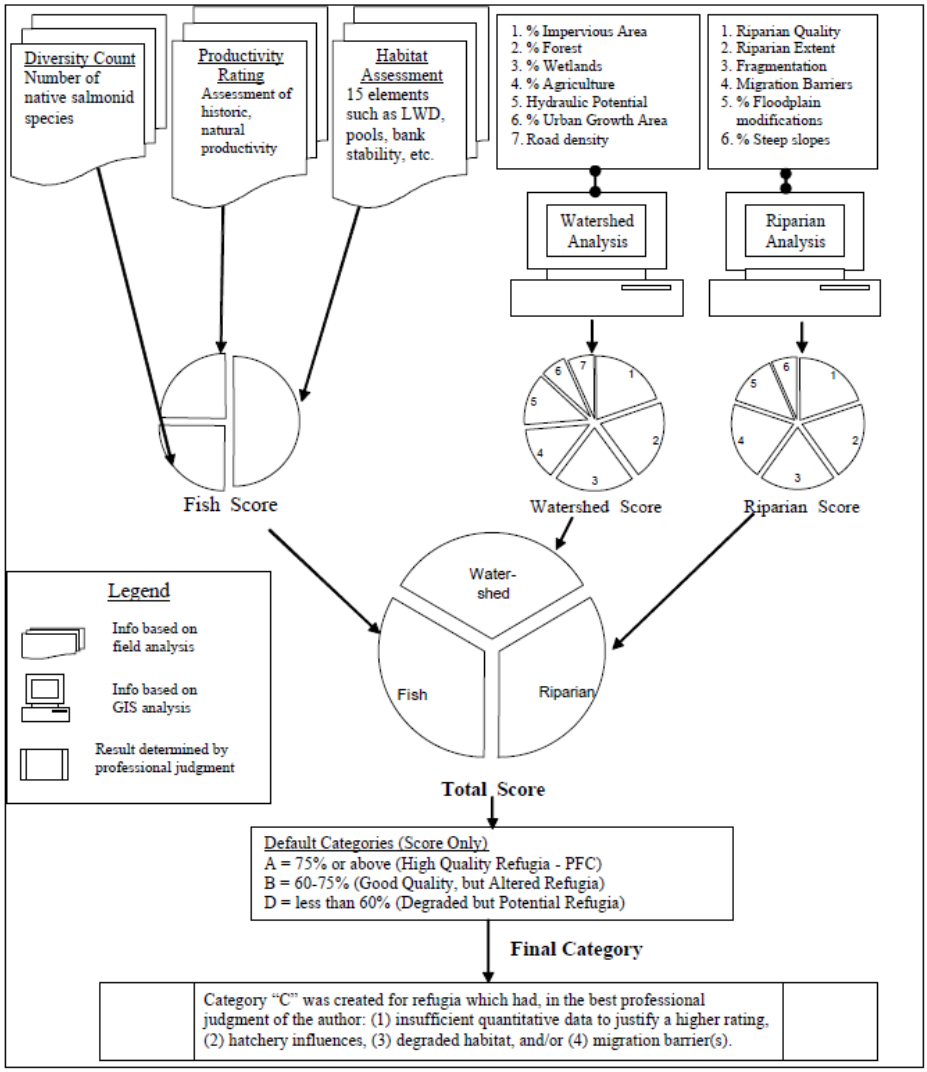
Based on several years of stream data collected by the Suquamish Tribe, water temperature in Blackjack Creek has remained cool (i.e., within the WA State water temperature standard for "Core" streams) throughout the summer, as measured by monitoring locations near the stream mouth, near Highway 16, and in the upper valley (near Dogwood Rd) (Suquamish Tribe, *in prep.*). Groundwater springs and wetland hydrology in the headwaters of the watershed are a major contributor and temperature control in the watershed.

Immediately above and downstream of the Bay Street crossing, the Blackjack Creek estuary is significantly constrained by surrounding land use and historic fill, and is heavily armored. Trash and commercial and residential land use continue to be an issue in the lower watershed and mouth.

Kitsap Salmonid Refugia Report (2003)

Report Summary

The 2003 *Kitsap Salmonid Refugia Report* was created as a landscape assessment and prioritization of freshwater salmonid habitat in Kitsap County. The report identifies and characterizes potential salmonid conservation and restoration areas or refuges based on the premise that core populations of salmon will be able to "re-seed" nearby areas if critical habitat areas or hot-spots are protected. Locations, whether stream corridors, watersheds, or shoreline areas, are identified and then weighted according to "landscape-centered" and "fish-centered" factors. "Landscape-centered" metrics, including both watershed and riparian-scale parameters, were analyzed using 30 m resolution Landsat imagery and field data and included elements such as impervious surface, overall forest cover, and the amount and quality of streamside forests and floodplains within the watershed "Fish-centered" factors combine records of salmon presence, abundance, diversity, and productivity, with field data measuring the condition of instream habitat. Landscape- and fish-centered factors were weighted to produce a "final score" that was used to assign a category to each potential refugia as shown in the model schematic below.



Freshwater Refugia Scoring and Categorization Model
(from May and Peterson, 2003)

The Kitsap Refugia study assessed all areas of the Blackjack Creek watershed as "refugia" due to importance for maintaining salmon populations, with three sub-watersheds (Ruby, Square, and Headwaters) and two riparian corridors (lower mainstem and middle reaches) assessed independently by the refugia model. The watershed was assigned an overall averaged score of 59%, with 3 of the 5 sub-watersheds receiving Category B (Good Quality) ratings, which are described as "primary refugia with altered ecological conditions." Although Category B sub-watersheds make up only 23% of all Kitsap County sub-watersheds, they represent 60% of the sub-watersheds within Blackjack Creek.

Blackjack Creek's overall score is a function of the relatively high quality of the Headwaters and Square Creek sub-watersheds, as well as along the lower mainstem of Blackjack Creek. The Headwaters sub-watershed scored 62% and Square Creek FSW scored 69%, both rated as providing Category B refugia. In the lower and middle segments of the Blackjack Creek watershed, the lower

(mainstem) sub-watershed rated as Category B refugia, while the middle mainstem rated as Category D (Potential Refugia) due to degraded habitat conditions. The Ruby Creek sub-watershed scored 57% and rated as Category C refugia because it is somewhat more degraded, but still provides important coho and cutthroat spawning and rearing habitat.

Additional Information

Blackjack Creek was categorized as a Category B stream in 2003 largely because it is one of the most productive watersheds for salmon in Kitsap County, and due to remaining intact landscape conditions (higher levels of forest and wetland cover, lower levels of impervious cover) in many portions of the watershed. Two of its main tributaries, Ruby and Square Creeks, are also relatively productive salmon streams and likely offer the best opportunities for habitat protection and restoration in the watershed.

Projected land use changes in the lower and middle watershed, based on a tour of the watershed suggest that Ruby and Blackjack Creeks may be at risk of habitat degradation from expanding development. For example, the proposed Stetson Ridge development in the Ruby Creek drainage could potentially result in further degradation of landscape conditions and functions, both along riparian corridors and across the subbasin. Loss of forest cover and increases in impervious surfaces associated with higher intensity development could result in further alteration of stream flows and water quality, potentially affecting salmonid refugia (habitat) provided by Ruby Creek.

West Sound Water Type Assessment (2013-2014)

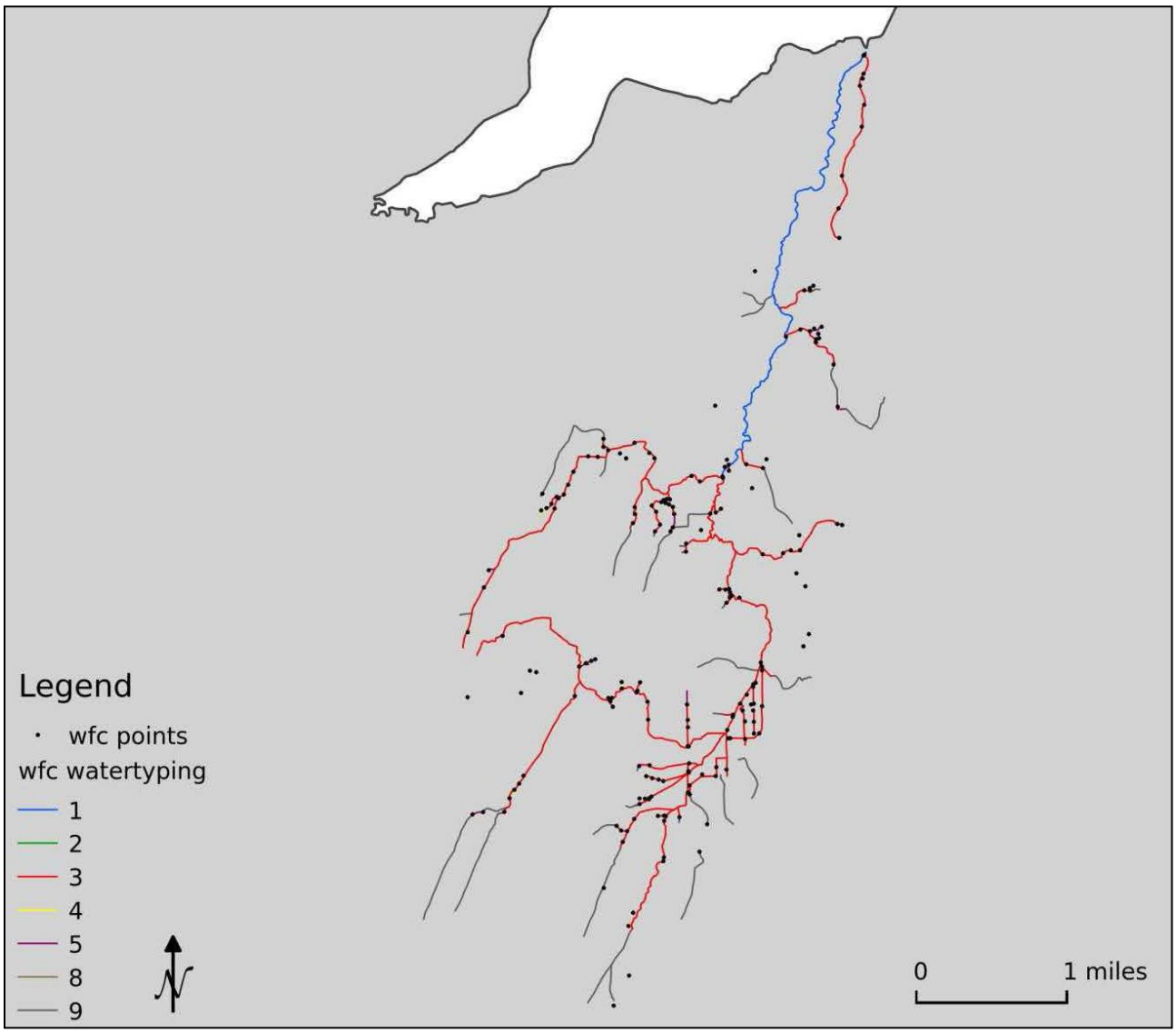
Data Summary

The Wild Fish Conservancy (WFC) performed field-based water type assessments of streams in Kitsap County in 2011 and 2013, including those in Blackjack Creek watershed. Water type assessments were limited to stream reaches where right-of-entry was granted by the property owner. WFC field staff documented stream channel locations and characteristics, fauna, riparian conditions, and restoration opportunities via GPS and photographs. Puget Sound jurisdictions, including Kitsap County and Port Orchard, regulate land use decisions adjacent to streams based on the water type of the stream, and WDFW requires water typing for projects that need a Hydraulic Project Approval. Existing water type maps are often based on modeled conditions that are not field-confirmed, and thus can misrepresent presence, location, and extent of fish habitat.

The *West Sound Water Type Assessment Phase II Summary* (WFC, 2014) found several significant discrepancies between the Washington Department of Natural Resources (WDNR) regulatory water type maps and WFC field assessments. Within the Blackjack Creek watershed, several small sections of tributaries that were either typed as non-fish bearing (Type Np or Ns) by WDNR, or didn't have a designated typing, were observed as fish-bearing (Type F) by the WFC. In other instances, the WFC found additional stream sections, which were not present on official WDNR water type maps. Also within the Blackjack Creek Watershed, WFC identified and mapped a tributary of Blackjack Creek that begins east of State Route Highway 16 and flows west under the highway and Cedar Road. This tributary was previously unmapped by WDNR.

WFC's assessment covered all of the streams and tributaries in the Blackjack Creek Watershed (see survey extent figure below). Stream wetted width, bankfull width, channel gradient, and other data were recorded at each GPS point and are visible, with photographs, by clicking on specific points of

their web-based interactive map available at: http://wildfish.beardedmaps.com/?lat=47.785&lng=-122.54&zoom=12. The *Phase II Summary* provides specific restoration opportunities, including fish passage improvements on Blackjack Creek and several tributaries (e.g., Ruby Creek crossing at Sidney Road) and wetland restoration adjacent to Blackjack Creek south of Lider Road (WFC, 2014). The field-based assessment additionally identified stream flow patterns within the upper Ruby Creek and Square Creek subbasins, with outflow from Square Lake apparently draining north to Ruby Creek as well as northeast to Square Creek. Flow characteristics of these upper subbasin connections were not reported by WFC, 2014, as these stream survey points were only visited once in April 2013. The extent and characteristics of these connections may need to be further investigated (i.e., during low flow and high flow conditions).



WFC Survey Extent Near Port Orchard and Blackjack Creek
(from WFC, 2014)

Fish Passage and Diversion Screening Inventory (2016)

Data Summary

The following table summarizes the 2016 WDFW compilation of Fish Passage and Diversion Screening Inventory (FPDSI) reports of City, County, State, and privately owned fish passage features for the Blackjack Creek watershed:

Inventory Type	#
Number of 100% Passable Features	32
Number of Barriers	31
Number of Unknown Passability	0
Number of N/A (includes non-fish bearing)	12
Total Number of FPDSI Fish Passage Features in Blackjack Creek and Tributaries	**75**

FPDSI forms include a description for culvert shape, material, and fishway type for each feature as well as additional comments. Photos of the fish passage feature are included for some reports, but not all. In total, nearly 43 percent of the total number of FPDSI features in the Blackjack Creek Watershed are fish passable, while 41 percent are considered barriers (partial or total) to fish passage. For culverts that are considered barriers, FPDSI forms include an assessment of "potential habitat gain" if the culvert barrier were to be addressed; this quantitative assessment results in a "Priority Index" (reported as PI Total) for each culvert. Several existing culverts in the lower reaches of Ruby Creek (a private crossing downstream of Glenwood Road, and the Glenwood Road) score as the highest priorities (PI Totals of 42.53 and 34.26, respectively) of all culverts in the Blackjack watershed. Three partial barrier culverts at the mainstem Blackjack Creek crossing of SR-16 also score as high priorities (PI Total scores of 32.03, 31.75, and 31.75. respectively). WDFW provides an interactive FPDSI database and map that is available at http://apps.wdfw.wa.gov/fishpassage/.

Additional Information

See 'Additional Information' under *Salmonid Habitat Limiting Factors Water Resources Inventory Area 15 (East) Report (2000)* for a description of past fish passage barrier corrections in the Blackjack Creek watershed.

Blackjack Creek Comprehensive Management Plan (1987)

Report Summary

The 1987 *Comprehensive Management Plan for Blackjack Creek Watershed* (prepared by FishPro Inc.) was developed to provide the City of Port Orchard guidance for future land use management, and addressing issues (e.g., habitat loss) in the watershed based on an environmental and land use analysis of existing conditions. It also identified public use of the watershed and opportunities for

outreach and education programs. Notably, the plan focused on the portion of the watershed within the City of Port Orchard. Using results from the environmental and land use analysis, the following recommendations were proposed for implementing the plan:

- habitat enhancement actions;
- continued water quality monitoring;
- development of a stormwater runoff input study;
- resolving land use issues related to the Shorelines Management Program (SMP) and zoning;
- initiating public outreach through education programs and volunteer efforts; and
- improving public access to Blackjack Creek.

Primary habitat enhancement actions included establishing best management practices (BMPs), debris and trash removal, and improving habitat quality. Suggested BMPs primarily related to agricultural practices (e.g. fencing) and septic system monitoring. A number of projects for improving habitat were recommended and included identifying creek sections for removal or modification of log jams[1], establishing instream log features, creating and enhancing new salmonid spawning areas, continuing a chum egg box program in Ruby Creek[2], and investigating stormwater impacts to Blackjack Creek. The "Inventory of Restoration and Protection Actions" section of this memo details projects that have been completed since 1987. One of the plan's recommendations called for developing and conducting an urban runoff study for the entire watershed to determine amounts and locations of stormwater input. Similarly, the development of a quarterly water quality monitoring program for heavy metals, nutrients, and hydrocarbons at a culvert in the upper watershed and at the mouth of Blackjack Creek was recommended.[3]

A prominent land use issue identified in the plan was the potential for commercial development along the lower three miles of Blackjack Creek and the City's ability to evaluate development proposals against possible environmental consequences for the lower reaches. At the time the plan was written, the City did not have its own Shoreline Master Program (SMP), but rather shorelines were regulated consistent with Kitsap County SMP standards, which did not designate Blackjack Creek. As a result, the plan recommended several potential environmental designations (primarily Natural, as well as Urban and Conservancy) to four shoreline segments of Blackjack Creek within the City's shoreline

---

[1] No documentation has been identified that indicates log jam removal or modification was ever implemented along Blackjack Creek; since 1987, additional research on channel structure and habitat in the Pacific Northwest streams has revealed that removing or modifying natural log jams is generally counterproductive.

[2] Available documentation shows that the Suquamish Tribe's chum egg box program continued through the early 1990s (Naval Shipyard Puget Sound, 1994; Applied Environmental Services, Inc., 2002).

[3] The City of Port Orchard and Kitsap County comply with National Pollution Discharge Elimination System Municipal Stormwater Permit requirements, including establishment of stormwater management programs (City of Port Orchard, 2015), adopting stormwater design manuals (Kitsap County, 2010b), and submitting annual reports. In addition, Kitsap County has completed annual benthic macroinvertebrate monitoring (since 1998; see later section for details) and storm flow basin monitoring (since 2000). Storm flow basin monitoring has not included a location within the Blackjack Creek watershed (Kitsap County Public Works, 2015). Kitsap County also supports storm and surface water stewardship programs through Clean Water Kitsap. While there is overlap with these numerous programs, the specific recommendations for a watershed urban runoff study and watershed quarterly water quality monitoring have not been implemented.

jurisdiction in order to improve ecological protections and public access while allowing for limited areas of higher intensity use. Beyond the suggested shoreline environment designations, the plan recommended use of zoning and development standards to provide additional protection for lower Blackjack Creek ravine areas extending outside of the 200-foot shoreline jurisdiction. The plan presented options to implement this recommendation, including establishing a new zoning designation, applying an existing Greenbelt zoning designation, or updating existing development standards.

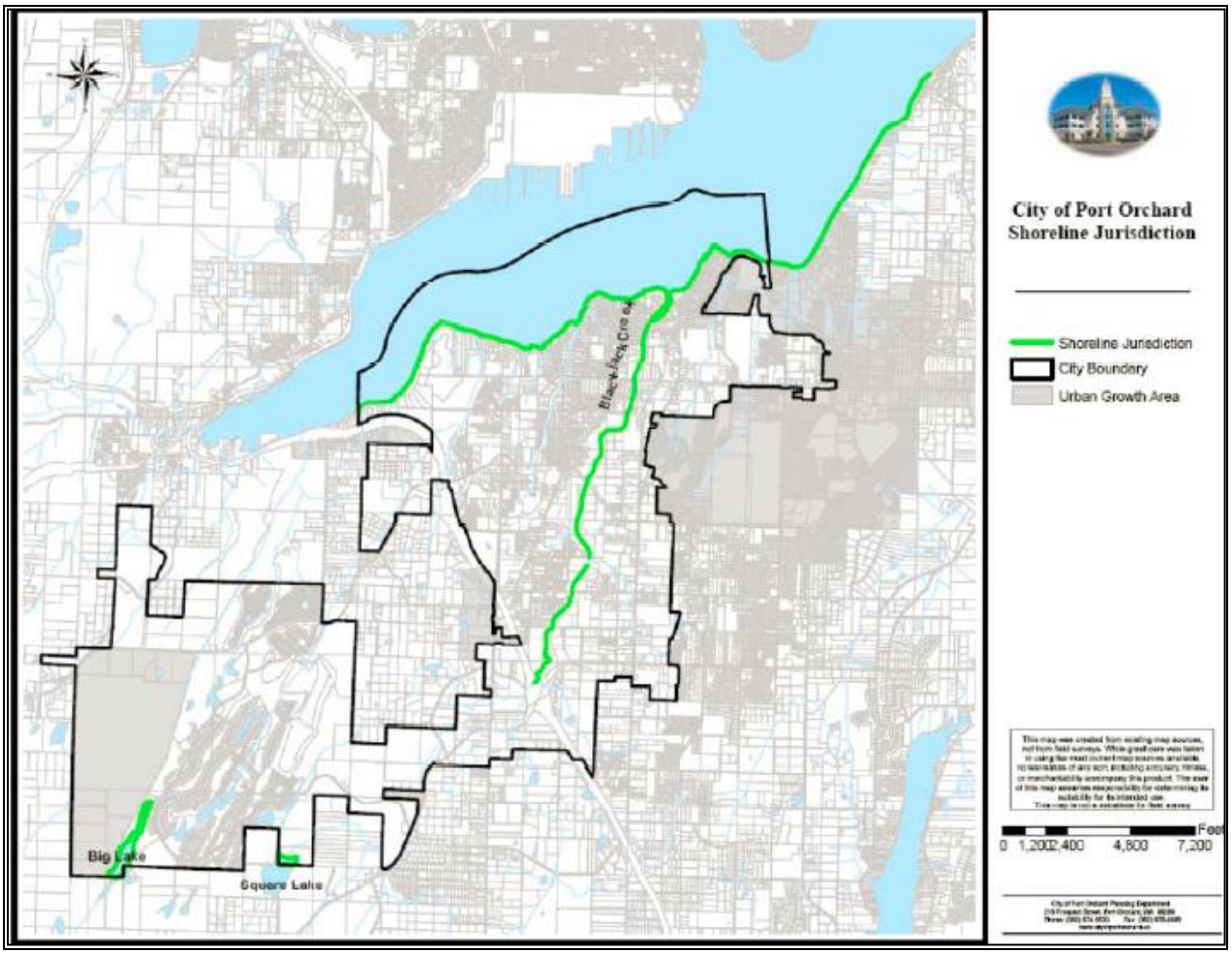
Two designs were suggested for improving public access to Blackjack Creek: a walkway/path along all or portions of the stream and an observation point. Potential sites for design were evaluated against a long list of criteria and a total of four sites were determined best suited for public access. These sites included Maple Street access behind Kentucky Fried Chicken (KFC), Kendall Street, Port Orchard bypass bridge, as well as access from the Sedgwick Interchange at State highway 16. From these four potential sites, the Maple Street access behind KFC was identified as the leading option to increase public use, enjoyment, and awareness of Blackjack Creek.

Additional Information

The City of Port Orchard updated its SMP in 2013. The City's *Shoreline Inventory and Characterization Report* (City of Port Orchard, 2013) incorporated much of the physical and biological information from the *Blackjack Creek Comprehensive Management Plan* and carried over the four shoreline segments. The portion of Blackjack Creek between the estuary mouth and SR16 is within the City's shoreline jurisdiction.

The City's 2013 SMP establishes shoreline environment designations that are generally consistent with recommendations from the 1987 Comprehensive Management Plan. The marine shoreline surrounding the stream mouth and the Blackjack Creek estuary extending just upstream of the Bay Street Bridge have an environmental designation of "High Intensity" reflecting the developed nature of these shorelines. The "High Intensity" designation also extends to the southeast of Maple Street, in the outer portion of the stream's 200-foot shoreline jurisdiction. Remaining areas of Blackjack Creek segment 1 (to the upper limits of tidal influence) are designated as "Urban Conservancy." Upstream of tidal influence, segments 2, 3 and 4 are designated as "Natural."

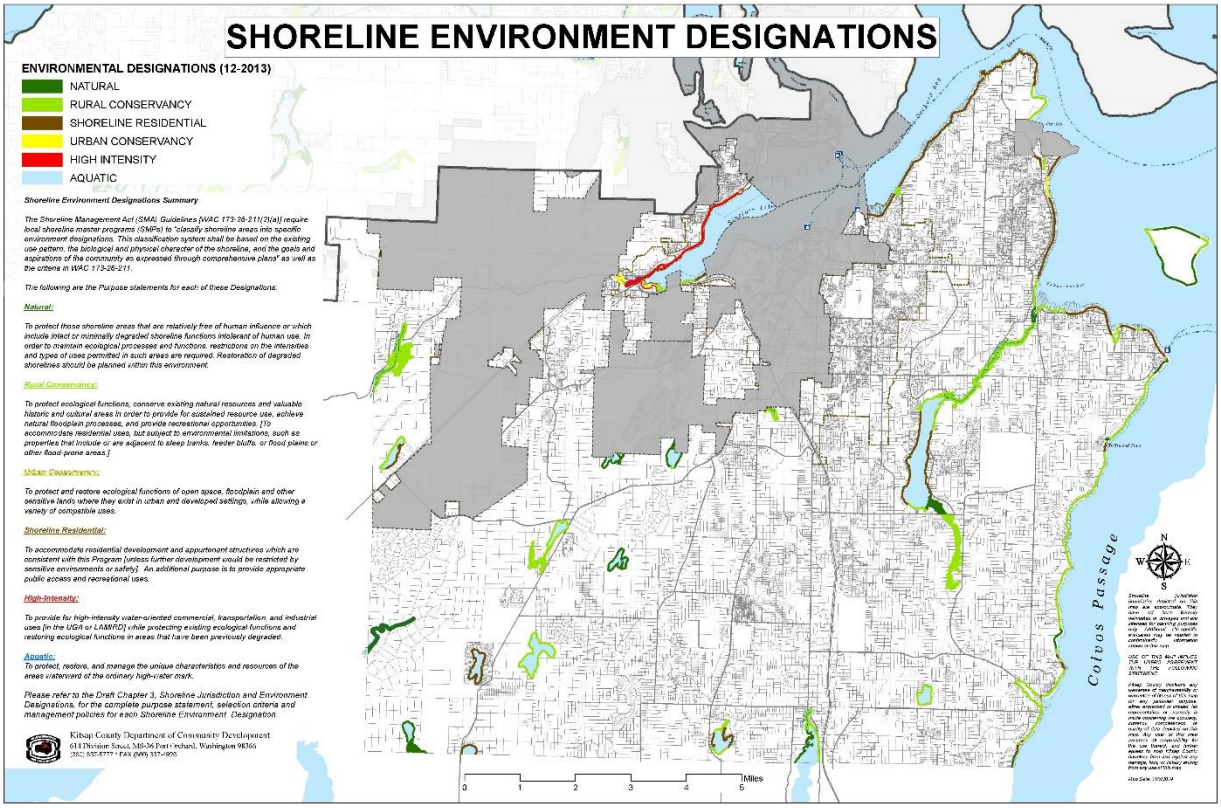
In addition, Square Lake in the southwest portion of the watershed is 35 acres in size and a designated shoreline of the state. The northeast portion of the lake shoreline (approximately 10 acres) is within the City of Port Orchard, and is designated as Urban Conservancy under the 2013 SMP. The City's lake jurisdiction includes just one property adjacent to the lake, which is currently undeveloped. The shoreline includes the lake outlet to Square Creek, and extends north to include associated wetlands and the riparian corridor of Ruby Creek immediately downstream of the outlet (the lake outlet to Ruby Creek is within Kitsap County jurisdiction). Appendix G (Lakes Inventory) of the City's 2013 SMP provides a detailed inventory and characterization of Square Lake conditions and restoration opportunities (City of Port Orchard, 2013).



Extent of City of Port Orchard Shoreline Jurisdiction (from City of Port Orchard, 2013)

The remaining approximately 20 acres of Square Lake are within Kitsap County jurisdiction, and are not within the UGA. The County's 2014 SMP designates a small portion of the southern lake shoreline as "Rural Conservancy", and all other portions of the lake shorelines as "Natural." The southern shore of the lake is moderately developed, including two shoreline residences and Square Lake State Park, all accessed from the end of Square Lake Road. Other areas of the lake within the County's shoreline jurisdiction are forested and generally undeveloped.

A small portion of Blackjack Creek that occurs outside of the City limits is also regulated under Kitsap County's SMP. This stream segment, extending south from the Port Orchard city limits to the south of SW Sedgwick Road, is designated as "Rural Conservancy."



Kitsap County Shoreline Environment Designations (from Kitsap County, 2013)

In addition to shoreline and land use protections provided through the SMP, the City also has implemented zoning districts and land use standards for areas surrounding the lower Blackjack Creek ravine. Land use designations established by the City's Comprehensive Plan (City of Port Orchard, 2008), and the corresponding Zoning districts established by Port Orchard Municipal Code (POMC) Title 16 (Land Use Regulatory Code), apply the "Greenbelt" designation along the entire lower Blackjack Creek corridor. Land use policies and standards for the Greenbelt designation are provided to significantly limit potential for new development within the lower Blackjack Creek ravine.

For other areas of the Blackjack Creek watershed, Comprehensive Plan land use designations and corresponding Zoning districts provide opportunity for higher intensity commercial and residential uses. The City is currently completing a major update of its Comprehensive Plan, with adoption anticipated by July of this year (City of Port Orchard, 2016). As part of the Comprehensive Plan update effort, the City has completed an assessment of land use capacity and buildable lands. This assessment reviews existing conditions and improvements for properties across the City and UGA, including much of the Blackjack Creek Watershed area, and considers potential for future development based on land use designations/zoning and environmental limitations (stream corridors, wetlands, floodplains, geologically hazardous areas, etc.). This information will be available as an update to the 2014 Land Use Capacity – Buildable Lands Report (Appendix G of the adopted Comprehensive Plan). Projected future development identified by the updated Buildable Lands Report will be assessed as part of consideration of pressures to landscape-scale processes that support salmon habitat.

In 2009, the City of Port Orchard received a $60,000 grant from the Washington State Recreation and Conservation Office (RCO) to build a 1.25-mile connecting trail from just behind KFC to an existing trail that crosses Blackjack Creek and leads to the end of Kendall Street (Henry, 2012). The trail planned to include a 300-foot, handicapped accessible boardwalk with two viewing platforms and educational signs. The City also planned to use staff and volunteers hours to match the grant to $120,000 (Henry, 2012). Public input, including communication with the Suquamish Tribe occurred throughout the project permitting process. However, in early 2013, RCO withdrew the grant from the City, citing the City's noncompliance with certain terms of the grant agreement. The City was unable to acquire one of several easements needed for the trail, obtain a required National Environmental Policy Act (NEPA) permit, or meet the grant deadline (Henry, 2013). There were also concerns expressed by WDFW and the Suquamish Tribe regarding potential erosion hazards and impacts to fish from construction. Currently, there are no plans to move the trail project forward.

Additional Data and Documents

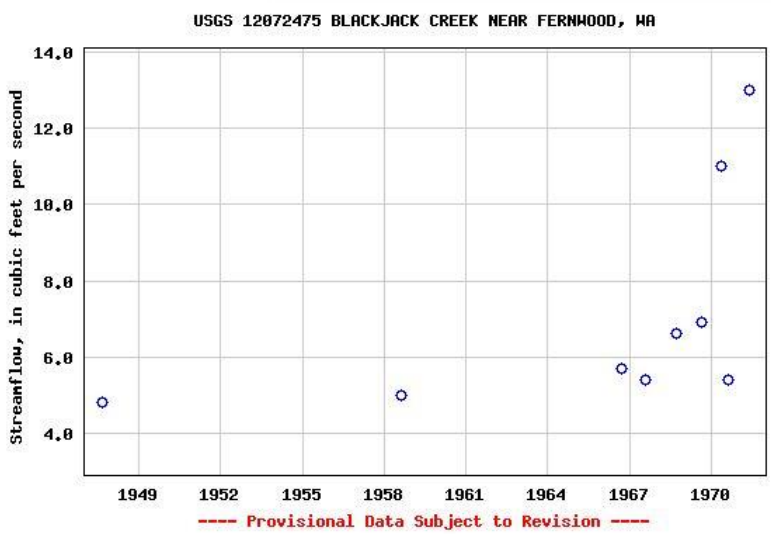
Streamflow Data for Blackjack Creek (historic and ongoing)

The US Geological Survey (USGS) historically collected streamflow data from three separate stations along Blackjack Creek that are now inactive. One station (#12072500; located on the lower mainstem Blackjack Creek approximately 1500 feet upstream of the Bay Street bridge) was used between 1947 and 1950 to measure daily streamflow (USGS, 2016). The following table provides a summary of the annual average streamflow for each water year during this time period:

Water Year	Streamflow (cfs)
1948	21.7
1949	20.2
1950	26.1

Streamflow was also measured during the months of June, July, and August of 1958 and 1959 at this station (#12072500). The average flow during these months in 1958 was 8.1 cfs, and 10.1 cfs in 1959.

A second station (#12072475) was located upstream of Hwy 16 and measured instantaneous streamflow annually during the month of August (sometimes September or May) for years 1947, 1958, and from 1966 to 1971, as depicted in the following figure (USGS, 2016).

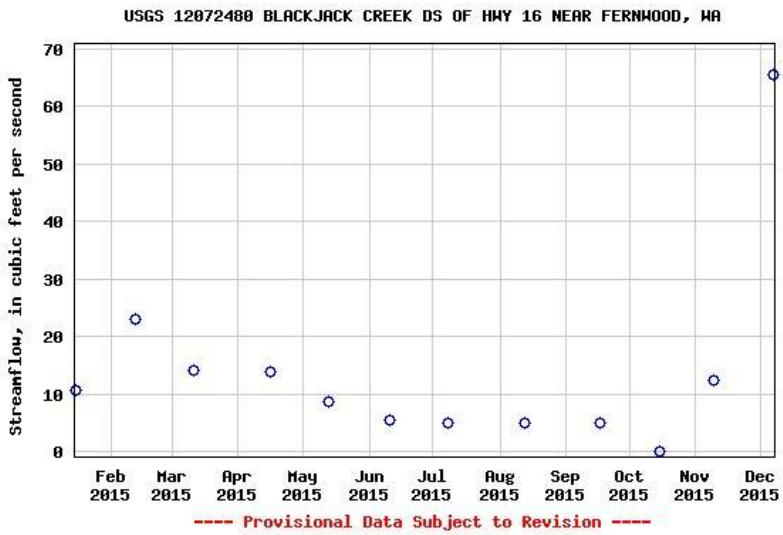


USGS Station #12072475 Streamflow Data for Blackjack Creek (USGS 2016).

A third station (#12072510) was located closer to the mouth of Blackjack Creek. This station collected streamflow data twice in 2008 (May and July) and 2012 (February and March) (USGS, 2016). The following table provides instantaneous streamflow measurements taken during these months.

Date	Streamflow (cfs)
May 7, 2008	6.6
July 14, 2008	7.0
February 29, 2012	31
March 14, 2012	71

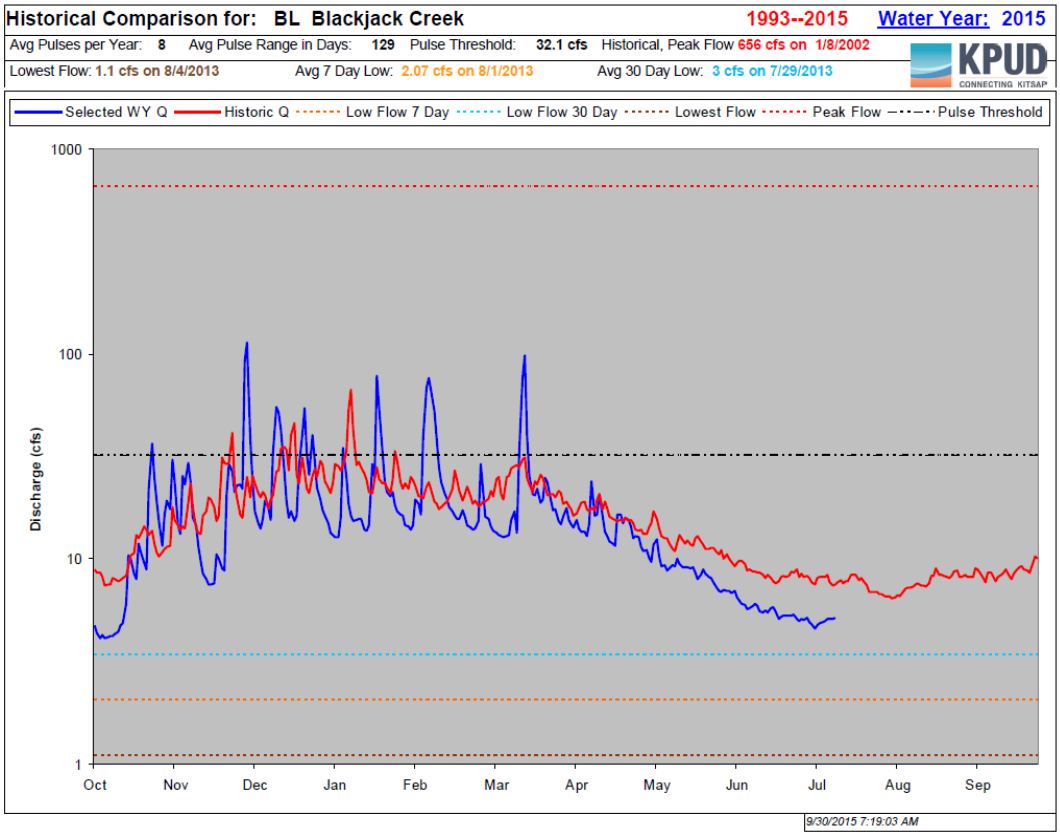
Recent (2015) instantaneous streamflow measurements have been made at an active USGS station (#12072480) located downstream of Hwy 16 (USGS, 2016). No streamflow data for 2016 is currently available. The following figure shows instantaneous streamflow data for 2015 (one measurement during each month) at this station.



USGS Station #12072480 Streamflow Data for 2015 (USGS, 2016).

All USGS measurements since 1950 (from stations #12072475#12072510, #12072480) were collected as instantaneous measurements of streamflow, limiting their usefulness in assessing historical watershed hydrologic patterns and for comparison to current conditions.

The Kitsap Public Utility District (KPUD) operates a stream gauge located approximately 3.2 miles upstream (immediately upstream of Hwy 16) from the mouth of Blackjack Creek that has collected streamflow data since October 1992. The gage is currently active; however, there was a period between August 1994 and December 2000 when it was inactive. A 2012 review of data collected at the Blackjack Creek stream gauge found that in eight complete years of data the annual average daily flow ranged from 11.2 to 21.2 cfs (Knutson and DeGaspari, 2013). The annual minimum daily flow ranged from 3.5 to 6.3 cfs while the annual maximum daily flow ranged between 61.6 and 478 cfs, and the 30-Day Low Flow averaged 5.5 cfs. Blackjack Creek had an average of eight High Pulse Counts per year and an average High Pulse Range of 119 Days[4]. The following figure shows historic and 2015 streamflow measurements for Blackjack Creek.



Blackjack Creek Stream Gauge Historical Comparisons (KPUD, 2016)

The average discharge for the current water year (October 2015-September 2016) thus far for Blackjack Creeks is 31 cfs. The following table shows the monthly average, maximum instantaneous, and average of maximum daily stream discharge levels for the 2016 water year (through May) of Blackjack Creek (KPUD, 2016).

---

[4] High pulses are events where the daily average flow is equal or greater than twice the long term daily average flow. High Pulse Count is defined as the number of times each water year that discrete high pulses occur. High Pulse Range is the days between the start of the first high pulse and the last high pulse of a water year (Knutson and DeGasperi, 2013).

Parameter	Date							
	Oct '15	Nov '15	Dec '15	Jan '16	Feb '16	Mar '16	Apr '16	May '16
Average Discharge (cfs)	6	24	55	47	37	52	19	12
Maximum Instantaneous Discharge (cfs)	25	97	290	238	68	185	28	16
Average of Maximum Daily Discharge (cfs)	20	82	235	190	63	154	25	14

Blackjack Creek Stream Gauge Recorded Observations for current Water Year (KPUD, 2016)

The City of Port Orchard is currently in the process of installing gauging and sampling stations to monitor monthly stream hydrology as well as water quality in the Blackjack Creek watershed that is within city limits for TMDL compliance.

WDFW and Suquamish Tribe Salmon Spawner Monitoring (ongoing)

The Suquamish Tribe and WDFW have been monitoring adult salmon spawning activity in the Blackjack watershed since 1968. The Tribe conducts monitoring from the mouth and throughout the lower portion of the watershed (RM 0 to RM 3.1) and WDFW surveys two index reaches upstream on the mainstem of Blackjack Creek #15.0203 (RM 5.2-5.7 and 5.7-6.3) and one reach on Little Blackjack Creek #15.0206 (RM 0.4-1.0). Monitoring is focused on coho and chum salmon spawning and is conducted in the fall. The spawner surveys include live/dead counts and characterization of carcasses. Neither redd counts or juvenile outmigration trapping have been conducted as part of the surveys.

Monitoring has documented coho and chum in each of the index reaches and Chinook have been observed in the lower mainstem of Blackjack Creek. The Tribe operates a hatchery on Gorst Creek and is likely the source of Chinook individuals. Other salmonid species include adult steelhead and searun cutthroat trout, both observed only occasionally.

No specific surveys of fish presence in Square Lake or other small lakes (e.g., Honey Lake near Ruby Creek, Deep Lake near SR-16) in the Blackjack Creek watershed have been conducted. The Tribe fisheries biologist notes that coho salmon and steelhead have been reported in Honey Lake (Oleyar pers. comm. 2016). In addition, angler forums mention bass and bluegill fish in Square Lake.

Kitsap County Stream Benthic Macroinvertebrate Monitoring (ongoing)

Since 1998, Blackjack Creek has been periodically monitored for benthic macroinvertebrates by various groups including Kitsap County Public Works, Kitsap County Stream Team, and ENVVEST. Benthic macroinvertebrate samples have been collected at five different sites in the lower, middle, and upper portions of Blackjack Creek. No other streams in the Blackjack Creek watershed have been or are currently sampled.

A 2013 monitoring summary found that Blackjack Creek had an average 15-year Benthic Index of Biotic Integrity score of 55, which is considered fair (Kitsap County Department of Public Works – Stormwater Division, 2013). In 2010, Kitsap County Public Works – Stormwater Division began collecting benthic macroinvertebrate samples on a more regular basis, once every two years. Recent samples (collected in September 2015) in lower and upper Blackjack Creek resulted in overall sample scores of 57.7 (fair) and 72.2 (good), respectively, while a sample in middle mainstem Blackjack Creek had a score of 33.5 (poor) (Puget Sound Stream Benthos, 2016).

Sinclair Inlet Fecal Pollution Reduction Project (2013)

The Sinclair Inlet Fecal Pollution Reduction project aimed to reduce fecal coliform pollution to standard levels in project area streams (including Blackjack Creek) and marine waters through shoreline and property surveys; agricultural inventory, farm planning, and BMP implementation; education and outreach; and water quality monitoring. As part of the project, the Kitsap County Health District conducted monthly trend monitoring of nine stream mouth and thirteen marine stations in the vicinity of the Sinclair Inlet Fecal Pollution Reduction project area.

Over the course of the project (2008-2013), the mouth of Blackjack Creek showed significant improvement in fecal coliform levels (Banigan et al., 2013). It met fecal coliform standards for the first three years of the project. Then in 2012 fecal coliform levels increased substantially and an investigation was initiated by the Health District in fall 2012. Several failing on-site sewage systems (OSS) were identified and subsequently corrected adjacent to the northern portion of the stream along the lower Blackjack Creek ravine. Human waste was also found near homeless encampments adjacent to the stream and the City of Port Orchard code enforcement and police addressed these areas[5]. As a result, improvements were seen in the stream the following year (Banigan et al., 2013).

Kitsap Water Pollution Identification & Correction Program: 2015 Annual Water Quality Report (2015)

This report summarized the Kitsap Public Health District's recent annual water quality data for streams, lakes, marine waters, and shoreline areas collected during the 2015 water year (October 2014-September 2015) as part of the Water Pollution Identification and Correction (PIC) program. Water quality monitoring results for Blackjack Creek indicate that the stream has low levels of bacteria and met Department of Ecology (Ecology) water quality standards. The program also evaluates streams to determine if there is a statistically significant trend in bacteria level, and includes data collected since 1996 as part of the evaluation. Results for Blackjack Creek indicate no detectable long-term trend up or down in bacteria levels (Kitsap Public Health District, 2015a and 2015b).

[5] Observations during a March 23, 2016 watershed tour, and personal communication with Suquamish Tribe staff, indicate that homeless encampments and associated human waste, refuse, and habitat disturbances continue to be an issue within the lower Blackjack Creek ravine corridor.

Summary and Identified Gaps

Based on our review of available information, we conclude that as a whole, the available information (monitoring program data, published literature, and online mapping data) on existing conditions in the Blackjack Creek watershed is generally sufficient to assess watershed function and develop recommendations. Available data sources address the geomorphological characteristics (watershed and subbasin topography, stream and wetland presence, stream flow data, fish passage barriers), chemical characteristics (water quality), and biological characteristic s (fish distribution, salmon spawning, macroinvertebrate sampling, freshwater refugia and nearshore habitats) within the watershed. Information on current and proposed land uses is available through city and county records and planning documents, augmented by aerial imagery analysis, to determine key pressures on watershed condition.

In terms of data gaps, a key area of uncertainty is the hydrologic regime of Square Lake. Field investigation of lake inlets and outlets is necessary to understand how the lake flows specifically contribute to the overall watershed hydrology and habitat connectivity. A second gap is data is in regards to reach-specific stream characteristics and habitat conditions (e.g., stream width and gradient, channel morphology, substrate conditions, riparian cover and condition, wood loading to the channel, and bank condition), for which data is lacking for streams within the watershed. The salmon spawning survey data may have some qualitative habitat information for the index reaches, but there is no comprehensive assessment of stream habitat parameters in the watershed.

In conclusion, although data gaps still exist, we do not believe collection of additional quantitative data is required to complete the Blackjack Creek watershed assessment. The effort to quantitatively assess comprehensively stream habitat conditions throughout the watershed would likely be prohibitive due to time and resource constraints. We suggest that qualitative characterization of stream habitat at specific locations will be sufficient to complete the watershed assessment and will also provide an adequate basis for developing the watershed restoration and protection plan. Similarly, the lack of reach-specific data on riparian cover can be addressed by using 2000 LiDAR data and 2015 NAIP aerial coverage (including near infrared band) to develop quantitative assessments of cover conditions along project area streams.

Inventory of Restoration and Protection Actions

This section provides an inventory of watershed and stream restoration and protection actions completed or underway as of the writing of this memo. Also summarized are protected lands or parcels with conservation easements. To compile the inventory, the following sources were consulted:

- WDFW Habitat Work Schedule database http://hws.ekosystem.us/
- Washington Recreation and Conservation Office (RCO) PRISM database http://www.rco.wa.gov/prism_app/about_prism.shtml
- WDFW habitat biologists
- Kitsap Conservation District
- Great Peninsula Conservancy
- Suquamish Tribe
- Kitsap County staff
- Port Orchard staff

There are several existing reports and plans with recommendations for protection, restoration, or improvement actions in Kitsap County watersheds and Sinclair Inlet. In particular, the Wild Fish Conservancy developed a set of discrete recommendations for Blackjack Creek and tributaries as part of the *West Sound Water Typing Assessment Phase II* (WFC, 2014). The Naval Facilities Engineering Command provided recommendations for the estuary and watershed in *Sinclair Inlet Enhancement Opportunities-Aquascape II*, which was prepared in accordance with a 2008 Memorandum of Agreement between the Navy and the Suquamish Tribe (Naval Facilities, 2010). The recommendations from these and other available sources will be compiled in the next phase of the Blackjack Creek Watershed Assessment project.

Restoration Projects	
Project Name	**Myers - Tributary to Blackjack Creek R11 (#SK Blackjack 12-1945)**
Sponsor	Kitsap Conservation District
Status	Completed
Year	2014
Location	Upper Blackjack Subbasin; west side of Sidney Road
Activity	Bridge replacement
Summary	Project considered a high priority fish passage barrier on a tributary to Blackjack Creek and was funded with Family Forest Fish Passage Program funds. The crossing consisted of a very small and low bridge over a very flashy stream that builds up with streambed materials and blocks passage of fish. The structure was too small for the system and was replaced with a new 16' by 20' concrete precast bridge that allows for proper hydraulic function and will allow unimpeded fish passage. Additionally, 7

Restoration Projects	
	habitat logs were installed in the stream banks and the disturbed areas were replanted with native trees, shrubs and grasses. Correction of this barrier improves access to 2.19 miles of habitat for coho, chum, steelhead and searun cutthroat trout.
Project Name	**Blackjack Creek Mitigation Preserve**
Sponsor	Wildlands of Washington, Inc.
Status	Active/ongoing
Year	2006 (Wildlands purchased parcel #142301-3-033-2007)
Location	Upper and Middle Blackjack Subbasin; east of Sidney Road, south of Lider Road
Activity	Turnkey Mitigation Site (available for permittee-responsible mitigation)
Summary	Wildlands purchased 54.5-acre parcel with intent to restore portions as off-site mitigation for impacts to waters of the United States authorized under Sections 401 and 404 of the Clean Water Act for various development and infrastructure projects in Kitsap County. The parcel will be restored on a piece-by-piece basis, with the size of each piece dependent on the amount of compensatory mitigation area needed. Each rehabilitated area will be protected in perpetuity, with no grazing or other agricultural activities allowed after rehabilitation. In 2006, 8 acres of the site were restored as offsite mitigation for wetland impacts associated with a WSDOT transportation project (SR516 Burley-Olalla Interchange). The Wetland Rehabilitation Plan for the Blackjack Creek Mitigation Site provides rehabilitation activities proposed to re-establish a native wetland plant community and restore stream processes and function on the property. Rehabilitation will transform 54.5 acres of an existing degraded palustrine emergent wetland to a mix of palustrine scrub-shrub wetland (20.78 acres), palustrine mixed forest wetland (13.16 acres) and palustrine emergent wetland (0.19 acre), using two distinct woody plant palates appropriate for mineral soils and peat soils. In addition, approximately 18.4 acres of wetlands in the perimeter buffer will receive the same rehabilitation treatments. The segment of Blackjack Creek within the Mitigation Site will be enhanced by constructing two new meandering segments, removing a constructed berm that impedes overbanking, and installing instream habitat features (2.02 acres). In addition, infrastructure associated with the ditches and site access (culverts and bridges) will be removed, and portions of the ditches will be plugged to slow groundwater movement from the wetland into the creek and provide seasonally inundated areas for amphibian use.
Project Name	**Foster/James Culvert**
Sponsor	Kitsap Conservation District
Status	Completed

Restoration Projects	
Year	2014
Location	Ruby Creek at Harper Road Crossing
Activity	Culvert replacement
Summary	The project involved replacing two undersized culverts, identified fish passage barriers, on Ruby Creek and replacing it with a 70-foot-long culvert. The project was funded by the Family Forest Fish Passage Program. The project allows for proper hydraulic function and will allow unimpeded fish passage. Additionally, 5 habitat logs were installed in the stream banks and the disturbed areas were replanted with native trees, shrubs and grasses. Correction of this barrier improves access to approximately 2 miles of habitat for coho, chum, steelhead and searun cutthroat trout.
Project Name	**Prentice LWD Enhancement**
Sponsor	Kitsap Conservation District
Status	Completed
Year	2014
Location	Ruby Creek
Activity	Large Woody Debris installation
Summary	The Backyard Habitat Grant project involved installing 18 habitat logs along 300 feet of creek to improve channel morphology and provide habitat for fish and other aquatic organisms. The logs were successful holding back and sorting stream bed material, forming pools and providing shelter for spawning and rearing salmon.
Project Name	**Alsin Dam Removal and Enhancement**
Sponsor	Kitsap Conservation District
Status	In progress
Year	2016
Location	Ruby Creek
Activity	Small dam removal
Summary	This Backyard Habitat Grant involves removal of a small timber dam that is a fish passage barrier and placement LWD along 300 feet of stream. The purpose of the project is to improve fish passage to approximately 2 miles of upstream habitat and improve stream morphology for fish and other aquatic organisms. Riparian trees and shrubs will be planted along the stream corridor.

Conservation Projects	
Project Name	**Griebel Property**
Sponsor	Great Peninsula Conservancy
Status	Complete
Year	2015
Location	Upper Blackjack Subbasin; west side of Sidney Road
Activity	Property purchase
Summary	10 acre property containing extensive forested and shrub wetland and a tributary of Blackjack Creek. Property located immediately downstream from Myers Property.
Project Name	**Wiltermood/Nash Conservation Easement**
Sponsor	Great Peninsula Conservancy
Status	Complete
Year	unknown
Location	Ruby Creek Subbasin; northwest of Glenwood Road SW
Activity	Conservation Easement
Summary	15 acre easement that includes Ruby Creek and Ruby Marsh, an extensive open water, emergent and scrub-shrub wetland completx.

Protected Lands	
Name	**Square Lake**
Owner	Kitsap County
Type	State park
Location	Square Lake Subbasin
Summary	Minimally developed state park contains 35-acre Square Lake, a shallow lake surrounded by coniferous forest. Lake supports aquatic vegetation across most of its area and habitat for fish, amphibians, and beavers. There is a small parking area and a primitive trail along the east side of lake. The state park covers 180 acres and one-third of lake is with City of Port Orchard (northern portion). One road, Square Lake Road, accesses three residential properties and one house at the south end.

References

Applied Environmental Services, Inc. 2002. City of Port Orchard Shoreline Resource Analysis and Inventory. Prepared for the City of Port Orchard. September 2002.

Banigan, L., and S. Whitford. 2013. Sinclair Inlet Restoration Project: Final Report. Kitsap Public Health District. November 2013.

City of Port Orchard. 2016. Draft update to the Comprehensive Plan. Available at: http://www.cityofportorchard.us/2016-comp-plan-update

City of Port Orchard. 2015. 2015 Draft Stormwater Management Program. Prepared by Andrea Archer-Parsons, PE, Assistant City Engineer / Stormwater Manager, Public Works Department.

City of Port Orchard. 2013. Shoreline Master Program - Ordinance 005-13. Adopted March 2013. Available at: http://www.cityofportorchard.us/smp

City of Port Orchard. 2008. Comprehensive Plan and subsequent updates in 2011, 2012, 2013, and 2014. Available at: http://www.cityofportorchard.us/adopted-comprehensive-plan

FishPro, Inc. 1987. Blackjack Creek Comprehensive Management Plan for the City of Port Orchard. June 1987.

Haring, D., 2000. Salmonid Habitat Limiting Factors, Water Resource Area 15 (East). Washington Conservation Commission. November 2000.

Henry, C. 2012. Blackjack Creek, Urban Wilderness. Kitsap Sun. June 6, 2012.

Henry, C. 2013. Port Orchard's Blackjack Creek trial project goes off track. Kitsap Sun. March 20, 2013.

King County, Pierce County, and Snohomish County. 2016. Puget Sound Stream Benthos Biotic Integrity Map database. Available at: http://pugetsoundstreambenthos.org/Biotic-Integrity-Map.aspx?Agency-Project=Kitsap%3A%20All%20Projects . Accessed May 2016.

Kitsap County Department of Public Works Stormwater Division. 2015. Water Year 2014-15 Storm Flow Summary Report. Available: http://www.kitsapgov.com/sswm/pub_docs.htm

Kitsap County Department of Public Works Stormwater Division. 2014. Kitsap Benthic Monitoring 1998-2013. October 2014.

Kitsap County Department of Public Works Watershed Health Program. 2015. Stream Benthos Monitoring 2010-2013 Results & Future Sampling. January 2015.

Kitsap County. 2013. Final Draft Kitsap County Shoreline Master Program. Prepared by Kitsap County Department of Community Development, Environmental Programs. Port Orchard, WA.

Kitsap County. 2010a. Final Draft Shoreline Inventory and Characterization. Prepared by Kitsap County Department of Community Development, Environmental Programs. Port Orchard, WA.

Kitsap County. 2010b. Kitsap County Stormwater Design Manual. Effective February 16, 2010. Available: http://www.kitsapgov.com/dcd/documents/dev_eng/sw_design_manual/kc_stormwater_design_manual.htm

Kitsap Public Health District. 2015a. Sinclair Inlet Watershed: 2015 Water Quality Monitoring Report.

Kitsap Public Health District. 2015b. Water Pollution Identification & Correction Program: 2015 Annual Water Quality Report.

Kitsap Public Utility District (KPUD). 2016. KPUD Hydrological Data – Gage Map and continuous streamflow for Blackjack Creek. Available at http://kpudhydrodata.kpud.org/. Accessed May 2016.

Knutson, C. and C. DeGasperi. 2013. Kitsap County Stream Flow Report. Prepared for Kitsap County Public Works. Available at: http://www.kitsapgov.com/sswm/pdf/Kitsap-Stream-Flow-3-4-13.pdf. May 2013.

May, C.W., and Peterson, G. 2003. Kitsap Salmonid Refugia Report. Prepared for Kitsap County. October 2003.

Naval Shipyard Puget Sound. 1994. Draft Supplemental Environmental Impact Statement for Naval Shipyard Puget Sound Pier D Dredging. March 1994.

Naval Facilities Engineering Command, Northwest. 2010. Sinclair Inlet Enhancement Opportunities - Aquascape II. Silverdale, WA.

Northwest Indian Fisheries Commission (NWIFC) and WDFW (Washington Department of Fish and Wildlife). Statewide Integrated Fish Distribution Database. Available at: http://maps.nwifc.org/swifd/

Puget Sound Stream Benthos. 2016. Biotic Integrity database. Available at: http://www.pugetsoundstreambenthos.org/. Accessed May 2016.

Suquamish Tribe. In prep. Water Temperature Monitoring – Summary Report.

USGS (U.S. Geological Survey). 2016. National Water Information System: Mapper. Available at: http://maps.waterdata.usgs.gov/mapper/index.html. Accessed June 2016.

WDFW (Washington Department of Fish and Wildlife). 2016. Fish Passage and Diversion Screening Inventory: Blackjack Creek Watershed. March, 2016.

WFC (Wild Fish Conservancy). 2014. Watertype Assessment Project Summary - West Sound Watersheds Phase II. Prepared October 2014.

WFC (Wild Fish Conservancy). 2013. Watertype Assessment Project Summary - West Sound Watersheds Phase I. Prepared May 2013.

ATTACHMENT A

List of Existing Data Sources and Publications

1. Watershed Boundary and Drainage Network

Washington Department of Fish and Wildlife, 1975. Catalog of Washington Streams and Salmon Utilization.

- Map with inventory of streams
- Web portal http://www.arcgis.com/home/webmap/viewer.html?webmap=e89edcdf56874f969312ee1497811b89&extent=-122.3966,48.263,-122.2284,48.3527

U.S Geological Survey (USGS). National Hydrography Dataset (NHD).

- GIS data with watershed boundary, stream segments and water bodies.

Northwest Indian Fisheries Commission and Washington Department of Fish and Wildlife, 2002. Stream segments. Salmon and Steelhead Habitat and Inventory and Assessment Program (SSHIAP).

- Stream segments classified by gradient and valley confinement.

2. Topography

USGS. 7.5 minute map series

- Bremerton West Quadrangle (revised 2014)
- Burley Quadrangle (revised 2014)
- Bremerton East Quadrangle (revised 2014)
- Ollala Quadrangle (revised 2014)

Puget Sound LiDAR Consortium, 2000. LiDAR data for Kitsap County.

- Bare Earth DEM - topographic surface with all man-made structures and vegetation removed;
- Top Surface DEM - surface including man-made features and vegetation.

3. Hydrology

National Weather Service (NWS) Cooperative Observer Program. Precipitation data at Bremerton, which is the closest station to Port Orchard. http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wabrem

- Period of record 1948-present.
- Mean annual precipitation at Bremerton is 56.4 inches.

PRISM Climate Group, Oregon State University. Average annual precipitation 1981-2010. http://prism.oregonstate.edu.

- GIS data (grid) interpolated from monitoring stations.

Kitsap Public Utility District (KPUD). Continuous streamflow data for Blackjack Creek at http://64.146.148.103/BL_Recorded_Conditions.aspx

- Period of record is October 1992-August 1994, December 2000-present.
- Map and list of KPUD gages http://www.kitsapgov.com/sswm/flow.htm

Knutson, C. and C. DeGasperi. 2013. Kitsap County Stream Flow Report. Prepared for Kitsap County Public Works. Available at: http://www.kitsapgov.com/sswm/pdf/Kitsap-Stream-Flow-3-4-13.pdf. May 2013.

US Geological Survey. Continuous and/or discrete streamflow measurements.

- One active stream gages in Blackjack watershed located downstream of SR16 (station #12072480) collected monthly streamflow data in 2015. Data for 2016 is currently unavailable.
- Historic collections:
  - Daily streamflow 1947-1950 (station #12072500)
  - Flow during June, July, August 1958-1959 (station#12072500)
  - Flow during August 1947, 1958, 1966-1971 (station #12072745)
  - Flow during May and July 2008 and February and March 2-12 (#12072510)
- http://maps.waterdata.usgs.gov/mapper/index.html.

Cummans, JE. 1977. Low-flow characteristics of streams on the Kitsap Peninsula and selected adjacent islands, Washington. USGS Open File Report 76-704. Prepared in cooperation with the State of Washington Dept. of Fisheries.

Sceva, J.E., 1957. Geology and ground-water resources of Kitsap County, Washington. U.S. Geological Survey Water-Supply Paper 1413. Prepared in cooperation with the State of Washington, Department of Conservation and Development, Water Resources Division.

- Presents an overview of groundwater resources in the region based on field data collected in 1949-50.

Garling, M., Molenaar, D., 1965. Water Resources and Geology of the Kitsap Peninsula and Certain Adjacent Islands, State of Washington, Department of Conservation, Division of Water Resources, Water Supply Bulletiun No. 18.

- Extends the work from Sceva (1957) with additional field data and revised mapping.

Kitsap County Ground Water Advisory Committee, 1991. Kitsap County Ground Water Management Plan. http://www.kpud.org/groundWaterManagementPlan.php

- Do any of the 27 principle aquifers identified in the groundwater management plan underlie any substantial portion of the Blackjack Creek watershed?

Kitsap Public Utility District, 1997. Kitsap County Initial Basin Assessment, Open File Technical Report No. 97-04. Prepared in association with Economic and Engineering Services, Inc., Pacific Groundwater Group, Inc. Robinson & Noble, Inc., and KCM, Inc.

- Assessment compiles existing information to characterize the overall condition of water resources in Kitsap County including: ground water, surface water, climatic, hydrogeology, water demand, allocated water (rights and claims), and water quality, as well as the relative health of aquatic ecosystems.
- Characteristics are summarized for 18 subareas in the county. Blackjack Creek is discussed as part of the Manchester subarea.

Golder Associates with Engineering & Economic Services, 2002. Kitsap Basin (WRIA 15) Phase II – Level 1 Assessment Data Compilation and Preliminary Assessment, Prepared for WRIA 15 Planning Unit.

- Compiles and analyzes sub-areas in WRIA 15 outside of the area covered by the Initial Basin Assessment (KPUD, 1997) and provides a WRIA-wide comparison of sub-areas to quantify key parameters for use in prioritizing sub-areas and topics for in-depth analysis in a Level 2 Assessment.

Kitsap County, 2006. Critical Aquifer Recharge Areas.

- GIS data identifying land areas that contain hydrogeologic conditions that facilitate aquifer recharge and/or transmit contaminants to an underlying aquifer.
- Category I areas have high potential for land use activities to adversely affect groundwater and include areas inside the five-year time of travel zone for Group A water system wells (or 10-year time of travel zone when the well is at or above sea level and the aquifer does not have an overlying confining layer).
- Category II areas provide recharge effects to aquifers that are current or potentially will become potable water supplies and are vulnerable to contamination.

Welch, W.B., Frans, L.M., Olsen, T.D., 2014. Hydrogeologic Framework, Groundwater Movement, and Water Budget of the Kitsap Peninsula, West-Central Washington. US Geological Survey Scientific Investigations Report 2014-5106.

- Characterizes the groundwater-flow system on the Kitsap Peninsula including descriptions of the geology and hydrogeologic framework, groundwater recharge and discharge, groundwater levels and flow directions, seasonal groundwater-level fluctuations, interactions between aquifers and the surface-water system, and a water budget.
- Describe hydrogeology for Blackjack Creek watershed.
- Describe how geology affects groundwater recharge within Blackjack watershed.

U.S. Geological Survey, 2014. NLCD 2011 Percent Developed Imperviousness. http://www.mrlc.gov/nlcd2011.php.

- GIS data from NLCD estimating percent area of impervious surface within a 30 m grid cell.
- Provides an indicator of hydrologic alteration (e.g., Booth et al., 1993).

Washington State Department of Ecology. Well Logs.
https://fortress.wa.gov/ecy/waterresources/map/WCLSWebMap/

- Describes the location, ownership, construction details and lithology of completed wells.
- Approximately 60 permitted wells (primarily water-supply) located in Blackjack Creek watershed.

KPUD, 2015. Water level data from monitoring wells.

- Appear to be 3 monitoring wells in watershed area, http://64.146.148.103/wells/AAA639.aspx (period of record 9/12/1969-11/4/2015); http://64.146.148.103/wells/ACK457.aspx (period of record 2/25/1997-11/4/2015); http://64.146.148.103/wells/AAC825.aspx (period of record 7/17/1979-11/4/2015)

- Describe any trends in water level records.

Washington Administrative Code 173-515, Instream Resources Protection Program – Kitsap Water Resource Inventory Area 15. http://apps.leg.wa.gov/wac/default.aspx?cite=173-515.

- Minimum instream flows have apparently not been applied to Blackjack Creek and tributaries.
- Blackjack Creek and tributaries are closed to additional consumptive appropriations since 4/5/1960;

4. Geology and Soils

Sceva, J.E., 1957. Geology and ground-water resources of Kitsap County, Washington. U.S. Geological Survey Water-Supply Paper 1413. Prepared in cooperation with the State of Washington, Department of Conservation and Development, Water Resources Division.

- Presents a geologic sequence and map

Garling, M., Molenaar, D., 1965. Water Resources and Geology of the Kitsap Peninsula and Certain Adjacent Islands, State of Washington, Department of Conservation, Division of Water Resources, Water Supply Bulletiun No. 18.

- Modifies geologic sequence from Sceva (1957) with additional field data. Not sure if mapping is changed in area of Blackjack Creek.

Deeter, J.D., 1979. Quaternary Geology and Stratigraphy of Kitsap County, Washington. MS Thesis, Western Washington University.

- Includes map of surficial geology, on-site sewage feasibility map and a slope stability map for the county.
- Digital data from slope stability map available from Kitsap County GIS

McMurphy, C.J., 1980. Soil Survey of Kitsap County Area, Washington. US Department of Agriculture, Soil Conservation Service.

- Soil characteristics and properties (e.g., hydrologic soil group, hydric soils)
- GIS Data available online at http://websoilsurvey.nrcs.usda.gov

Booth, D.B., Troost, K.G., 2005. Geologic map of the Olalla 7.5' quadrangle, King, Kitsap, and Pierce Counties, Washington. U.S. Geological Survey Scientific Investigations Map SIM-2005-2902.

- Updated geologic map for southern part of watershed.

McKenna, J.P., Lidke, D.J., Coe, J.A., 2008. Landslides Mapped from LIDAR Imagery, Kitsap County, Washington, U. S. Geological Survey Open-File Report 2008-1292.

- Includes delineation of landslide deposits in Blackjack Watershed.

Haugerud, R.A., 2009. Preliminary Geomorphic Map of the Kitsap Peninsula, Washington, U.S. Geological Survey Open-File Report 2009-1033.

- Map of morphologic units interpreted from LiDAR DEM.

Washington Department of Natural Resources, 2010. Digital Geology of Washington State at 1:100,000 Scale, version 3.0

- GIS database of geologic units.

Tabor, R.W., Haugerud, R.A., Booth, D.B., Troost, K.G., 2013. Lidar-revised geologic map of the Olalla 7.5' quadrangle, King, Kitsap, and Pierce Counties, Washington. U.S. Geological Survey Scientific Investigations Map 3277.

- Revised interpretation of surficial geology from Booth and Troost (2005) using LiDAR DEM

Haeussler, P.J., in preparation, Geologic map of the Bremerton E. 7.5' quadrangle, Kitsap County, Washington, U.S. Geological Survey Open-File Report, scale 1:24,000.

Hauessler, P.J., in preparation, Geologic map of the Bremerton W. 7.5' quadrangle, Kitsap County, Washington, U.S. Geological Survey Open-File Report, scale 1:24,000.

Yount, J.C. and Gower, H.D., 1991, Bedrock geologic map of the Seattle 30' by 60' quadrangle, Washington: U.S. Geological Survey, Open-File Report OF-91-147, scale 1:100000.

Yount, J.C., Minard, J.P., and Dembroff, G.R., 1993, Geologic map of surficial deposits in the Seattle 30' by 60' quadrangle, Washington: U.S. Geological Survey, Open-File Report OF-93-233, scale 1:100000.

GRI, 2014. Geologically Hazardous Areas Map Update, Memorandum to Kitsap County Department of Community Development.

- Updates the Kitsap County Geologically Hazardous Areas Maps in support of the 2016 Comprehensive Plan update and the Critical Areas Ordinance update

Kitsap County, 2004. Geologic Hazard Areas.

- GIS data produced as union of NRCS soil survey units (McMurphy, 1980) and the soil stability classification from Deeter (1979).

5. Vegetation and Wetlands

US Fish and Wildlife Service, 2014. National Wetlands Inventory. http://www.fws.gov/wetlands.

- Polygons delineated from 1973 and 1981 aerial imagery.
- Wetlands classified with definitions from Cowardin et al. (1979).

Kitsap County. 2006. Kitsap County Wetlands Mosaic.

- GIS data combining various wetland data sources into one comprehensive data layer.
- Includes primarily NWI data for Blackjack Creek watershed with addition of a few survey delineated wetlands extracted from parcel map sections.

Multi-Resolution Land Characteristics (MRLC) Consortium, 2015. National Land Cover Database 2011 (NLCD 2011). http://www.mrlc.gov/nlcd2011.php.

- Land cover classification derived from the analysis of multiple dates of remotely sensed Landsat imagery (30 meter grid cell resolution).

National Oceanic and Atmospheric Administration, 2013. Coastal Change Analysis Program (C-CAP) 2010 Regional Land Cover Data.

- Land cover classification derived from the analysis of multiple dates of remotely sensed Landsat imagery (30 meter grid cell resolution).
- Available datasets include: 1992, 1996, 2001, 2006, 2010.

Washington State Department of Ecology, 2011. Modeled Wetlands Inventory. http://www.ecy.wa.gov/services/gis/data/biota/wetlands.htm

- Ecology extracted wetlands land cover classifications from the overall land cover layer from C-CAP.
- More accurate than NWI, especially in agricultural/pasture, forests, and stream corridors.
- It includes a "Potentially Disturbed Wetlands" category for areas that have a high potential to be wetland, but have an observed land cover of "pasture/hay" or "cultivated".

Pearce, K. 2015. Puget Sound High Resolution Change Detection (HRCD). Washington Department of Fish and Wildlife. http://arcg.is/1GbByjX

- Land Cover Change by Change Agent: 2006 to 2009, 2009 to 2011, 2011 to 2013.
- 2013 to 2015 analysis is underway.
- Should also have 2006 to 2013 (and later 2015) change analysis.
- GIS dataset with polygons representing areas that have significantly lost vegetation or have been converted to quasi-permanent use (i.e. roads, buildings).
- Dataset represents modeled change polygons derived from NAIP imagery (1 m resolution).

6. Land Use Planning

Applied Environmental Services, Inc. 2002. City of Port Orchard Shoreline Resource Analysis and Inventory. Prepared for the City of Port Orchard. September 2002.

Kitsap County Department of Community Development, 2005. Kitsap County Critical Areas Ordinance, Title 19 Kitsap County Code. http://www.kitsapgov.com/dcd/lu_env/cao/cao.htm.

- Supplements development regulations to protect critical areas including:
  - Wetlands,
  - Fish and Wildlife Habitat Conservation Areas,
  - Geologically Hazardous Areas,
  - Frequently Flooded Areas, and
  - Aquifer Recharge Areas.

Kitsap County, 2006. Port Orchard/South Kitsap Final Sub-Area Plan/Preliminary Final Environmental Impact Statement.

- Included as part of Kitsap County Comprehensive Plan adopted in 2012.
- Environmental assessment of Port Orchard UGA and adjoining lands.

Kitsap County, 2012. Kitsap County Comprehensive Plan.

- Volume I: Comprehensive Plan Policy Document
- Volume II: Final Supplemental Environmental Impact Statement
- Includes GIS data of land use, zoning, and UGA boundary.

Kitsap County, 2014. Buildable Lands Report.

- Measures both the growth that has occurred under the existing comprehensive plan (using time period 2006-2012) and evaluates whether there is sufficient suitable land within UGAs to accommodate the projected residential, commercial and industrial growth for the coming planning horizon.

Kitsap County, 2015. Working Draft for the Kitsap County Comprehensive Plan Update 2016-2036.

- Working Draft released November 2015 concurrently with Draft Supplemental Environmental Impact Statement
- Final Drafts anticipated in Spring 2016

Kitsap County, 2014. Kitsap County Shoreline Master Program.

- Guides the future development of the shorelines in a manner consistent with the Shoreline Management Act of 1971.
- Jurisdiction applies to very short stretch of Blackjack Creek north of SR16 where it flows outside City of Port Orchard limits.
- http://www.kitsapshoreline.org/

Kitsap County, 2015. Tax Parcels.

- GIS data showing parcel boundaries.
- https://psearch.kitsapgov.com/webappa/

FishPro, Inc. 1987. Blackjack Creek Comprehensive Management Plan for the City of Port Orchard.

Great Peninsula Conservancy. Map of parcels with conservation easements or ownerships established in the Blackjack Creek Watershed.

- Greibel property (10 acres) (adjacent to Myers property)
- Conservation easement on Ruby Creek (15 acres)

Port Orchard, 2013. City of Port Orchard Shoreline Master Program.

- Guides the future development of the shorelines in a manner consistent with the Shoreline Management Act of 1971.
- Jurisdiction applies to lower 3.0 miles of Blackjack Creek (north of SR16) and along shoreline in Sinclair Inlet.
- http://www.cityofportorchard.us/smp

U.S. Endowment for Forestry and Communities, 2015. National Conservation Easement Database. 2015. http://www.conservationeasement.us.

- Shows no easements in Blackjack Creek watershed.
- Does not include areas protected by GPC.

U.S. Geological Survey, 2012. Protected Areas Database of the United States (PADUS) version 1.3. Gap Analysis Program (GAP). http://gapanalysis.usgs.gov/padus/.

- GIS data that describes public land ownership, management and conservation lands nationally, including voluntarily provided privately protected areas.
- Does not include areas protected by GPC.

7. Floodplain Characteristics

Haring, D., 2000. Salmonid Habitat Limiting Factors, Water Resource Area 15 (East). Washington Conservation Commission.

- Includes qualitative summary of floodplain modifications.

Federal Emergency Management Agency, 2010. Flood Insurance Study, Kitsap County, Washington and Incorporated Areas, Flood Insurance Study Number 5335C (Revised 11/4/2010).

- Delineates 100-year floodplain for Blackjack Creek.

8. Riparian and Large Wood

Haring, D., 2000. Salmonid Habitat Limiting Factors, Water Resource Area 15 (East). Washington Conservation Commission.

- Qualitative summary of riparian conditions.

9. Sediment

Haring, D., 2000. Salmonid Habitat Limiting Factors, Water Resource Area 15 (East). Washington Conservation Commission.

- Qualitative summary substrate, development impacts.

10. Nearshore Characteristics

Borde, A.B., Judd, C., Sather, N.K., Thom, R.M., 2009. East Kitsap County Nearshore Habitat Assessment And Restoration Prioritization Framework, Prepared for Kitsap County, Department of Community Development by Battelle Marine Sciences Laboratory.

- An ecological decision-support tool developed for Kitsap County to summarize the state of the nearshore and to identify priority areas for protection, restoration, enhancement, or creation within the nearshore.
- Study covers shoreline of Sinclair Inlet (no freshwater habitats).

Kitsap County, 2010. Shoreline Inventory and Characterization, Kitsap County Department of Community Development, Environmental Programs.

- Synthesized existing information from Borde et al. (2009) in the support of shoreline designation as part of the SMP Update
- Establishes the baseline for "no net loss" of ecological conditions and informs the policies, regulations and mitigation standards.

Washington Department of Natural Resources. 2000. The Washington State ShoreZone Inventory. http://www.dnr.wa.gov/programs-and-services/aquatics/aquatic-science/nearshore-habitat-inventory

- ShoreZone Inventory describes physical and biological characteristics of intertidal and shallow subtidal areas from aerial surveys between 1994-2000.
- Includes 50 habitat characteristics, such as shoreline type, vegetation types such as kelp and eelgrass, and anthropogenic features such as bulkheads.

11. Fish Distribution and Population Status

Haring, D., 2000. Salmonid Habitat Limiting Factors, Water Resource Area 15 (East). Washington Conservation Commission.

- Describes distribution and condition of salmon, steelhead, and cutthroat stocks.
- Includes maps of fish distribution.

Washington Department of Natural Resources, 2006. Washington State Watercourse Hydrography [Digital Data]. http://www.dnr.wa.gov/forest-practices-water-typing.

- GIS data includes water typing classification for fish-bearing and non-fish streams used by Forest Practices program to determine the amount and pattern of riparian buffer protection required during forest practices activities.

Wild Fish Conservancy. Watertype Assessment Project Summary - West Sound Watersheds Phase I. Prepared May 2013. Phase II. Prepared October 2014. Reports available at: http://wildfishconservancy.org/resources/maps

- WFC collected field data to determine and correct water type classifications in Kitsap County streams.
- Blackjack Creek watershed was surveyed in 2013/2014 (Steve Todd sent GIS files to ESA around March 18, 2016).
- Web-based interactive map available at: http://wildfish.beardedmaps.com/?lat=47.785&lng=-122.54&zoom=12

StreamNet, 2012. Generalized Fish Distribution. http://www.streamnet.org/data/interactive-maps-and-gis-data/.

- GIS data with attributes noting fish distribution.

Penttila, D. 2007. Marine Forage Fishes in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-03. Published by Seattle District, U.W. Army Corps of Engineers, Seattle, Washington.

- Reports spawning beaches for various forage fish (2005 surveys).

Washington Department of Fish and Wildlife, 2015. http://wdfw.wa.gov/fishing/washington/583/.

- General description of fishing conditions.
- Notes habitat conditions good for warmwater species.

Suquamish Tribe Fisheries Department. Spawner Surveys.

- Fall spawner survey data collected by Suquamish Tribe and WDFW from 1968 to current.
- Includes live/dead counts for index reaches in Blackjack Creek.

Washington Department of Fish and Wildlife and Suquamish Tribe. Hatchery fish releases into Blackjack Creek.

- Includes releases of coho, steelhead, and Chinook.
- No records of any trout or other fish spp. releases into Square Lake by WDFW

Washington Department of Fish and Wildlife. Steelhead Population Model Development

- Joe Anderson (WDFW) is developing a steelhead population model to develop recovery goals for Puget Sound steelhead.

Waldo, T. C. Clark, and B. Jones. 2013. Applying the NOAA-Fisheries Threshold Intrinsic Potential Model from NHD PLUS (100K) to NHD High Resolution (24K or higher resolution). NWIFC, August 2013.

- Stream reach IP classified base on stream gradient and channel width.

Puget Sound Steelhead Technical Recovery Team (PSSTRT). 2013. Identifying Historical Populations of Steelhead within the Puget Sound Distinct Population Segment. Final Review Draft. 149 p.

- Description of steelhead population; Blackjack Creek part of the Central and South Puget Sound MPG and the East Kitsap Winter-Run Steelhead Independent population

Puget Sound Steelhead Technical Recovery Team (PSSTRT). 2013. Viability Criteria for Puget Sound Steelhead. Final Review Draft. 373 p.

- The report has limited usefulness for Blackjack Creek because of a lack of data.

12. Instream Habitat and Biological Conditions

Haring, D., 2000. Salmonid Habitat Limiting Factors, Water Resource Area 15 (East). Washington Conservation Commission.

- Brief, qualitative description of channel conditions for Blackjack Creek and tributaries.

May, C.W., Peterson, G., 2003. Kitsap Salmonid Refugia Report. Prepared for Kitsap County.

- Project identified and characterized potential salmonid conservation and restoration areas (salmonid refugia) within Kitsap County.
- Classified Blackjack in Category B (Good Quality) overall averaged score of 59%.

- Classified largely because it is one of the most productive watersheds for salmon in Kitsap County, and due to remaining intact landscape conditions (higher levels of forest and wetland cover, lower levels of impervious cover) in many portions of the watershed.
- Also the lack of data (no quantitative habitat assessments) limits support for a higher rating.

Kitsap Public Works. Macroinvertebrate Monitoring.

- Periodic monitoring since 1998. Five different sites in Blackjack watershed.
- http://www.kitsapgov.com/sswm/wq_bugs.htm

Puget Sound Stream Benthos. 2016. Biotic Integrity database. Available at: http://www.pugetsoundstreambenthos.org/ . Accessed May 2016.

13. Passage Barriers

Haring, D., 2000. Salmonid Habitat Limiting Factors, Water Resource Area 15 (East). Washington Conservation Commission.

- Lists known barriers on major stream crossings.

Washington Department of Fish and Wildlife, 2016. Fish Passage and Diversion Screening Inventory.

- Received GIS data and detailed site reports from WDFW database by email from Daniel Barrett (WDFW) on March 8, 2016.

Wild Fish Conservancy. West Sound Water Type Assessment. http://wildfishconservancy.org/projects/west-sound-watertype-assessment.

- WFC are collecting field data to determine and correct water type classifications in Kitsap County streams.
- Blackjack Creek watershed was surveyed in 2013/2014 (Steve Todd sent GIS files to ESA around March 18, 2016).

14. Water Quality

Washington Department of Ecology, 2012. Water Quality Assessment and 303(d) List. http://www.ecy.wa.gov/programs/wq/303d/

- Current, EPA-approved assessment from 2012.
- 2014 Water Quality Assessment and Candidate 303(d) List submitted for EPA review in September 2015.
- Tribe will be submitting stream temperature data to Ecology in June 2016.

Kitsap Public Health District. Fecal Bacterial Pollution Monitoring. http://www.kitsapgov.com/sswm/bacteria.htm

- Kitsap County Health District conducted monthly trend monitoring of nine stream mouth stations, and thirteen marine in the vicinity of the Sinclair Inlet Fecal Pollution Reduction project area.
- Sampling at mouth of Blackjack Creek 2008-2013.

Kitsap Public Health District, 2015. 2015 Annual Water Quality Monitoring Report.

- Blackjack Creek has low levels of bacteria and met Department of Ecology (Ecology) water quality standards.
- Also indicates stationary long-term trend in bacteria levels based on data from 1996.

Crim, E., 2014. Shellfish Restoration & Protection Project, Kitsap Public Health District.

- Implements a targeted program to clean up "Prohibited" and "Closed" shellfish growing areas, and protect "Approved" growing areas with a routine shoreline monitoring program that locates FC "hot spots" and tracks the source(s).

Suquamish Tribe. 2016. Water Temperature monitoring in Blackjack Creek. Unpublished data provided by Suquamish Tribe.

- Stream temperature data collected by the Suquamish Tribe since 2003 in lower Blackjack Creek ravine.
- Missing years when the tribe either didn't install a temperature logger or it got lost.
- One year (2015) of temperature data for Blackjack Creek just upstream of Hwy 16 and just downstream of Dogwood Road. Plan is to collect stream temperature at same sites (and potentially additional sites) in 2016 and 2017.
- Tribe is preparing report of stream temperature data for several streams including Blackjack Creek (in prep).

15. Aerial Photos

U.S. Geological Survey, 1951. Scale 1:24,000.

U.S. Geological Survey, 1968. Scale 1:30,000.

U.S. Geological Survey, 1990. Digital Orthophoto Quadrangle. Scale 1:12,000 (1 meter pixel resolution).

U.S. Department of Agriculture, National Agricultural Imagery Program Scale 1:12,000 (1 meter pixel resolution).

- 2006
- 2009
- 2011
- 2013
- 2015

U.S. Geological Survey. High Resolution Orthoimagery. (1 foot pixel resolution).

- 2002
- 2005
- 2007
- 2012
- 2015

Washington State Department of Ecology. Coastal Atlas v 6.2. https://fortress.wa.gov/ecy/coastalatlas/tools/ShorePhotos.aspx.

- Oblique aerial imagery of Yukon Harbor, Estuary, and Long Lake (various years from 1976/77, early 1990s, 2006)

16. Historical Information

U.S. Bureau of Land Management. Land Status and Cadastral Survey Records.

- General Land Office survey plats from 1858 shows channel location and width where stream intersects the section line boundaries.
- Selected GLO notes from Blackjack watershed will be put into GIS shapefile format by Steve Todd, Suquamish Tribe.

17. Other Reports/Data

Naval Facilities Engineering Command, Northwest. 2010. Sinclair Inlet Enhancement Opportunities - Aquascape II. Silverdale, WA.

URS Greiner, Inc. and Science Applications International Corporation (SAIC). 1999. Sinclair Inlet Existing Conditions Data Compilation. [Only available as appendix to NAVFAC 2010]

Washington Department of Ecology, Watershed Characterization. Volumes 1 and 2:

Stanley, S., S. Grigsby, D. B. Booth, D. Hartley, R. Horner, T. Hruby, J. Thomas, P. Bissonnette, R. Fuerstenberg, J. Lee, P. Olson, George Wilhere. 2011. Puget Sound Characterization. Volume 1: The Water Resources Assessments (Water Flow and Water Quality). Washington State Department of Ecology. Publication #11-06-016. Olympia, WA.

Wilhere, G.F., T. Quinn, D. Gombert, J. Jacobson, and A. Weiss. 2013. A Coarse-scale Assessment of the Relative Value of Small Drainage Areas and Marine Shorelines for the Conservation of Fish and Wildlife Habitats in Puget Sound Basin. Washington Department Fish and Wildlife, Habitat Program, Olympia, Washington.

Errata Sheet

December 31,2017

For the: Blackjack Creek Watershed Assessment and Protection and Restoration Plan Synthesis of Existing Data and Reports Memorandum (ESA, 2016)

Please note the following corrections to the synthesis memo:

1. Page 23, the correct date for the Griebel Property purchase by the Great Peninsula Conservancy is August 10, 2006 not 2015.
2. Page 23, the correct date for the Wiltermood/Nash Conservation Easment by the Great Peninsula Conservancy is October 1, 1991 and not unknown.

Appendix B

Blackjack Creek Strategies and Sub-Strategies

Blackjack Creek Watershed Plan: Strategies and Sub-strategies

Strategy	Sub-strategies	Description	Application	Expected Benefits to Salmonids	Expected Ecosystem Process Benefits
P1. Protect Blackjack Creek habitat conditions	**P1.1. Acquisitions and conservation easements**	Protect upland, wetland, and riparian habitats that are minimally impaired by floodplain modifications and have an intact riparian forested corridor through acquisition or conservation easements. This strategy addresses the most critical stressor on ecosystem components, the conversion of land cover for residential, commercial, and industrial uses (A1, A2, A3). By limiting conversion of land cover, this strategy addresses riparian and floodplain processes by protecting peak and base streamflow, sediment loading, in-stream wood presence and recruitment, channel and floodplain complexity, water temperature, and food chain support. This strategy may also be needed to implement certain restoration actions. Stressor(s) addressed: Land conversion (A1, A2, A3); Terrestrial habitat fragmentation (B)	Watershed Reach/Site	Improved egg to fry survival from reduced exposure to bed scour and substrate composition more suitable to spawning and egg survival (substrate size and reduced fine sediment). Improved chum fry survival from improved stream margin habitat complexity and increased side channel complexity. Improved juvenile coho and steelhead summer and overwinter survival (sediment loading, streamflow, habitat structural complexity, water temperature, and food chain). Improved adult habitat utilization from increased availability and quality.	Riparian conditions maintained. Increased stream shading and reduced solar radiation. Natural bank stabilization. Water temperatures maintained. Floodplain processes maintained. Headwater and floodplain wetlands protected. Peak streamflow protected. Sediment loading and rates maintained. Increased instream wood presence and recruitment. Channel and floodplain complexity. Food chain support.
	P1.2. Improve compliance and/or strengthen land use regulations	Improve compliance with land use regulations through better enforcement and landowner practice and also strengthen regulations to protect watershed functions and upland, wetland, and riparian habitats. This includes development standards that maintain a cumulative forest cover and effective impervious surface; planning mechanisms and incentives to use a watershed-based approach, including transfer of development rights; and locating and designing development that is informed by and consistent with spatial information developed as part of this watershed assessment. This strategy addresses riparian and floodplain processes by protecting headwater and floodplain wetlands, and protecting and restoring riparian functions such as shade, in-stream wood presence and recruitment, and natural bank stabilization. Stressor(s) addressed: Land conversion (A1, A2, A3); Terrestrial habitat fragmentation (B)	Watershed	Improved egg to fry survival from reduced exposure to bed scour and substrate composition more suitable to spawning and egg survival (substrate size and reduced fine sediment). Improved chum fry survival from improved stream margin habitat complexity and increased side channel complexity. Improved juvenile coho and steelhead summer and overwinter survival (sediment loading, streamflow, habitat structural complexity, water temperature, and food chain). Improved adult habitat utilization from increased availability and quality.	Riparian conditions maintained. Increased stream shading and reduced solar radiation. Natural bank stabilization. Floodplain processes maintained. Headwater and floodplain wetlands protected. Improved water quality (e.g., temperatures, dissolved oxygen levels, pollutants).
	P1.3 Protect (and improve understanding of) instream low flow conditions	Protect instream flow conditions important for salmonids by protecting aquifer recharge areas, implementing actions that enhance or promote groundwater exchange with surface waters, ensuring that permitted and permit-exempt uses account for instream flows, and through providing education and outreach. In addition, the strategy includes developing a better understanding of the relationship between groundwater and surface water in the watershed, including groundwater extraction (abstraction), and its effect on low flow conditions by evaluating existing data, modeling, and other information. This strategy addresses both a near-term action and an important data gap regarding groundwater-surface water continuity, the type and amount of out-of-stream water uses (i.e., exempt or permitted groundwater wells and surface water withdrawals), and the effect on summer low flows in the watershed. Stressor(s) addressed: Altered low flows from land cover change (K1); Altered low flows from climate change (K2); Altered low flows from withdrawals (K3)	Watershed	Improved juvenile coho and steelhead summer survival (streamflow, water temperature, and food chain).	Base streamflow protected.

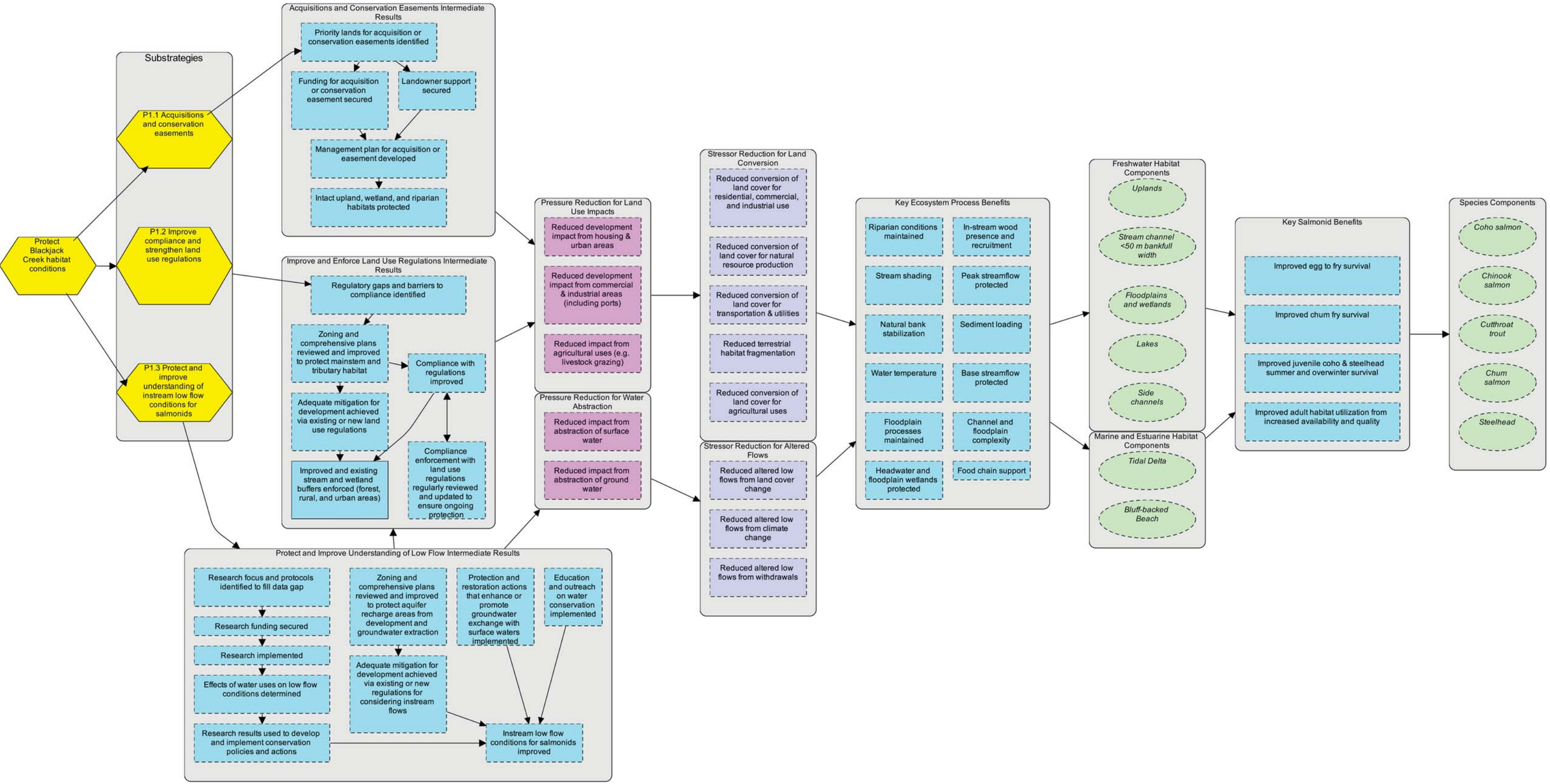
Strategy	Sub-strategies	Description	Application	Expected Benefits to Salmonids	Expected Ecosystem Process Benefits
R1. Reconnect isolated habitats and remove barriers to fish passage		Reconnect isolated habitats and improve fish passage through removal of barriers and replacement of culverts or other artificial structures. This strategy focuses on restoring longitudinal connectivity at road crossings, improving sediment and organic material supply and transport, nutrient cycling, and the timing and volume of water. Stressor(s) addressed: Culverts as fish passage barriers (E2) ; In-channel structural barriers to water, sediment, debris flows (M1)	Reach/Site	Increased adult access to spawning habitat. Increased access by juvenile coho and steelhead to moderate to high quality habitats (e.g., Upper Ruby Creek, Upper Blackjack Creek, and Square Creek). Reduced impact of partial barriers to behavior of migrating adults. Improved habitat near and downstream of barrier from restored sediment and organic material supply and transport.	Restored longitudinal connectivity at road crossings. Improved sediment and organic material supply and transport. Improved localized hydrology. Improved instream processes (nutrient cycling, food chain support, and detritus). Habitat connectivity restored.
R2. Restore wetland and floodplain storage processes		Rehabilitate, enhance, or create wetland areas and floodplains to restore natural flood storage processes. This strategy addresses the loss of storage functions in the upper and middle portions of the watershed where wetlands and stream reaches have been altered from past development or reduced beaver activity. Improving wetland and floodplain storage in upper portions of watershed would act as a buffer against increased bank erosion from peak flows that occur downstream in the steeper portions of the stream that have erodible deposits. This strategy also addresses loss of groundwater recharge functions by improving instream habitat conditions of summer base flows, dissolved oxygen, and temperature, as well as providing water quality benefits. Stressor(s) addressed: Terrestrial and freshwater species disturbance in natural landscapes (G2); Altered peak flows from land cover change (J1); Altered peak flows from climate change (J2); Changes in water temperature from local causes (X3)	Reach/Site	Improved egg to fry survival from reduced exposure to bed scour and substrate composition more suitable to spawning and egg survival (substrate size and reduced fine sediment). Improved juvenile coho and steelhead summer and overwinter survival (sediment loading, streamflow, habitat structural complexity, water temperature, and food chain). Improved adult habitat utilization from increased availability and quality of adult holding habitats (hydrologic and sediment regime and in-stream habitats). Restored hydrologic processes (stormwater retention, attenuation, and infiltration). Improved water quality.	Improved flood storage. Improved instream habitat conditions (summer base flows). Buffered bank erosion. Restored hydrologic processes (stormwater retention, attenuation, and infiltration) and reduced peak flows. Improved water quality (e.g., temperatures, dissolved oxygen levels, pollutants).
R3. Remove constraints to lateral connectivity	**R2.1 Riverine**	Restore lateral connectivity of riparian and floodplain areas through removal of constraints such as bank armor, ditches, or undersized culverts. This strategy focuses on allowing lateral channel migration, promoting or restoring the formation of side channels and off-channel habitats, floodplain connectivity, storing fine sediment, and decreasing stream energy during peak flow events. This strategy also addresses loss of groundwater recharge functions by increasing the lateral extent of the hyporheic zone thereby reducing summer water temperatures and maintaining base flows. Stressor(s) addressed: In-channel structural barriers to water, sediment, debris flows (M1); Reduced impacts from incised stream channels and disconnected side channels	Reach/Site	Improved egg to fry survival from reduced exposure to bed scour (flood flows) and substrate composition more suitable to spawning and egg survival (floodplain storage of fine sediment). Improved chum fry survival from improved stream margin habitat complexity and increased side channel complexity. Improved juvenile coho and steelhead survival during summer from increased habitat complexity, pools, side channels, and thermal refugia. Improved juvenile coho survival during winter from increased in-channel complexity, and floodplain habitat complexity and quantity. Improved juvenile steelhead survival during winter from increased in-channel habitat complexity and flood flow refuge.	Allowing lateral channel migration. Restored sediment and organic material supply, storage, and transport. Formation of side channels and off-channel habitats. Decreased stream energy during peak flow events. Improved floodplain connectivity. Increased lateral extent of hyporheic zone thereby reducing summer water temperatures and base flows.
	R2.2 Tidal	Restore lateral connectivity of estuary through removal of nearshore fill, bridge abutments, and bank armor. This strategy focuses on allowing tidal exchange, formation of distributary channels, tidal marsh, and fluvial deposition. Stressor(s) addressed: Shoreline hardening and stabilization (C) and nearshore fill	Reach/Site	Reduced impact of partial barriers to juvenile utilization of estuarine habitats. Improved adult habitat utilization from increased availability and quality of adult holding habitats.	Formation of distributary channels. Improved tidal exchange. Lateral estuarine connectivity restored. Fluvial deposition.

Strategy	Sub-strategies	Description	Application	Expected Benefits to Salmonids	Expected Ecosystem Process Benefits
R4. Restore riparian processes		Restore riparian processes through the planting of native vegetation along riparian corridors along with removal of non-native invasive vegetation. This strategy addresses riparian processes of long-term wood recruitment, stream shading, bank and floodplain stability and complexity, and food chain support. Stressor(s) addressed: Terrestrial habitat fragmentation (B); Displacement by non-native species (R2); Changes in water temperature from local causes (X3)	Reach/Site	Improved egg to fry survival from reduced exposure to bed scour and substrate composition more suitable to spawning and egg survival (substrate size and reduced fine sediment). Improved chum fry survival from improved stream margin habitat complexity and increased side channel complexity. Improved juvenile coho and steelhead survival during summer from increased habitat complexity and pools. Improved juvenile coho survival during winter from increased in-channel complexity, and floodplain habitat complexity and quantity. Improved juvenile steelhead survival during winter from increased in-channel habitat complexity and flood flow refuge. Improved adult habitat utilization from increased availability and quality of adult holding habitats.	Improved long-term recruitment of wood. Greater and improved streambank and floodplain stability and complexity. Improved stream shading. Food chain support.
R5. Place in-channel large woody debris		Prevent further channel incision and improve habitat through placement of in-channel large woody material. This strategy focuses on increasing the amount of instream wood to increase hydraulic roughness and restore channel complexity in the intermediate period while riparian forests are developing. Wood placement promotes scour and deposition processes that form complex substrate, pools and bars, and secondary channel formation. Stressor(s) addressed: Land conversion (A1, A2, A3); Terrestrial habitat fragmentation (B); Reduced impacts from incised stream channels and disconnected side channels	Reach/Site	Improved egg to fry survival from reduced exposure to bed scour and substrate composition more suitable to spawning and egg survival (substrate size and reduced fine sediment). Improved chum fry survival from improved stream margin habitat complexity and increased side channel complexity. Improved juvenile coho and steelhead survival during summer from increased habitat complexity and pools. Improved juvenile coho survival during winter from increased in-channel complexity, and floodplain habitat complexity and quantity. Improved juvenile steelhead survival during winter from increased in-channel habitat complexity and flood flow refuge. Improved adult habitat utilization from increased availability and quality of adult holding habitats.	Increased amount of instream wood. Channel complexity restored. Increased hydraulic roughness. Improved scour and deposition processes that form complex substrate, pools and bars, and secondary channels.
R6. Improve habitat conditions within and adjacent to agricultural lands		Reduce habitat impacts on agricultural lands through development and implementation of farm plans or other programs that restore riparian and floodplain functions. This strategy also focuses on reducing unrestricted livestock access to streams and the potential for damaging vegetation and bank erosion through exclusion methods. Stressor(s) addressed: Non-point source, non-persistent toxic chemicals in aquatic systems (V2); Changes in water temperature from local causes (X3) ; Terrestrial habitat fragmentation (B); Reduced impacts from incised stream channels and disconnected side channels	Watershed Reach/Site	Improved egg to fry survival from reduced exposure to bed scour and substrate composition more suitable to spawning and egg survival (substrate size and reduced fine sediment). Improved chum fry survival from improved stream margin habitat complexity and increased side channel complexity. Improved juvenile coho and steelhead survival during summer from increased habitat complexity and pools. Improved juvenile coho survival during winter from increased in-channel complexity, and floodplain habitat complexity and quantity. Improved juvenile steelhead survival during winter from increased in-channel habitat complexity and flood flow refuge. Improved adult habitat utilization from increased availability and quality of adult holding habitats.	Higher streambank and floodplain stability and complexity. Reduced erosion. Improved water quality (e.g., temperatures, dissolved oxygen levels, pollutants).

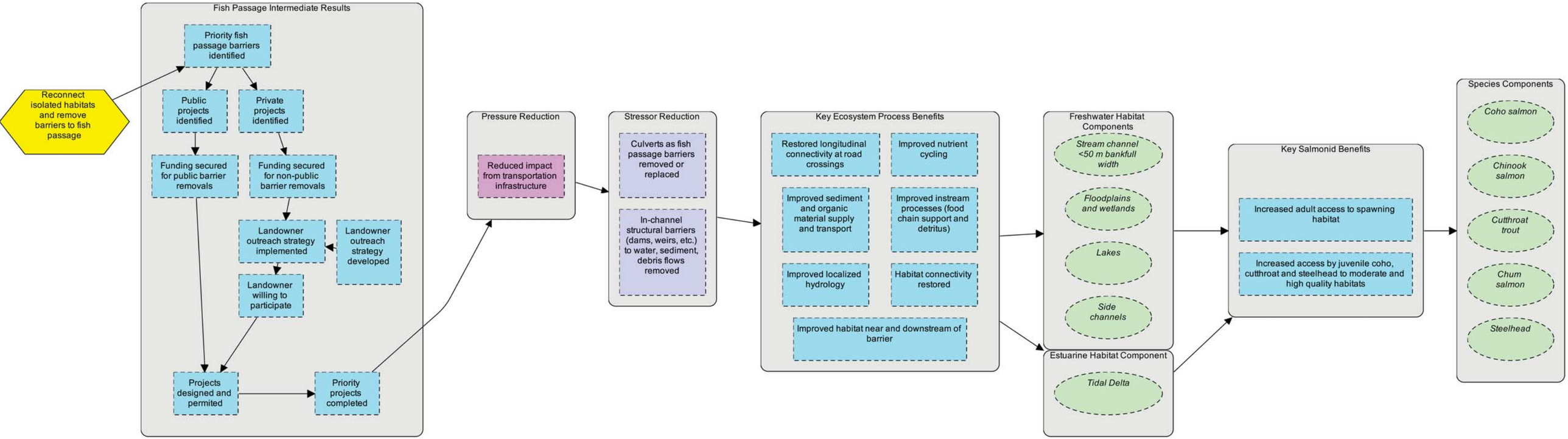
Strategy	Sub-strategies	Description	Application	Expected Benefits to Salmonids	Expected Ecosystem Process Benefits
R7. Improve stormwater attenuation capacity within and adjacent to residential areas		Improve flood storage and attenuation processes by implementing low impact development activities such as new stormwater runoff facilities, facility retrofits, flow control and water quality treatment for stormwater runoff. This strategy addresses the negative effects of altered stormwater runoff regimes associated with increased impervious surface coverage by restoring natural storage functions that protect/restore hydrologic regime. Stressor(s) addressed: Altered peak flows from land cover change (J1); Non-point source, non-persistent toxic chemicals in aquatic systems (V2); Non-point source conventional water pollutants (X2); Changes in water temperature from local causes (X3); Increased erosion/sediment transport and downstream erosion; increased stream channel capacity and flood flow that creates incised stream channels.	Watershed Reach/Site	Improved adult habitat utilization from increased availability and quality of adult holding habitats.	Improve flood storage. Restored stormwater and flood attenuation processes and reduction in peak flows. Improved water quality (e.g., temperatures, dissolved oxygen levels, pollutants). Improved groundwater recharge and protection of flow regime.
R8. Debris Prevention and Removal		Improve water quality and instream habitat structure and condition through the prevention and removal of accumulated litter and artificial debris such as rubble, riprap, and other refuse. This strategy addresses aesthetic and environmental health issues (i.e., garbage and human waste) in localized areas. In some areas, this strategy also addresses degraded habitat conditions by removing artificial impediments to habitat-forming processes that support sediment and organic material supply and transport, nutrient cycling, and localized hydrology. Stressor(s) addressed: In-channel structural barriers to water, sediment, debris flows (M1); Non-point source, non-persistent toxic chemicals in aquatic systems (V2); Non-point source conventional water pollutants (X2); Garbage and Solid Waste (i.e, rubbish and other solid materials including those that entangle wildlife) (9.4 in PSRITT); Work and Other Activities (i.e., people spending time in or traveling in natural environments for reasons other than recreation or military activities) (6.3 in PSRITT)	Watershed Reach/Site	Improved adult habitat utilization from increased availability and quality of adult holding habitats.	Restored sediment and organic material supply and transport, nutrient cycling, and localized hydrology. Improved water quality.
R9. Public Involvement		Support citizen-based watershed monitoring groups and landowner education programs about habitat protection through development, funding, or assistance. This strategy focuses on the support and promotion of community education and outreach in the watershed such as planting and weed removal events, rain garden construction and maintenance workshops, and interpretative programs. Potential focus areas for community education include: the benefits of native plant species to the ecosystem and salmonids; ecological role and benefits of beaver on the landscape; protection of native plant communities (forests, wetlands), and soils; the relationship between impervious surface and aquatic habitat conditions; the protection of natural hydrologic regimes through stormwater retention and LID techniques; the protection of salmonid habitat through stormwater treatment; and, the protection of salmonid habitat through increased water conservation and reduced groundwater extraction (abstraction). Stressor(s) addressed: Terrestrial habitat fragmentation (B); Terrestrial and freshwater species disturbance in human dominated areas (G1); Non-point source, non-persistent toxic chemicals in aquatic systems (V2); Non-point source conventional water pollutants (X2)	Watershed	Improved adult habitat utilization from increased availability and quality. Improved juvenile coho and steelhead summer survival (streamflow, water temperature, and food chain).	Greater understanding of the health of Blackjack Creek system. Broader acceptance of low impact development approaches and actions.

Appendix C
Blackjack Creek Results Chains

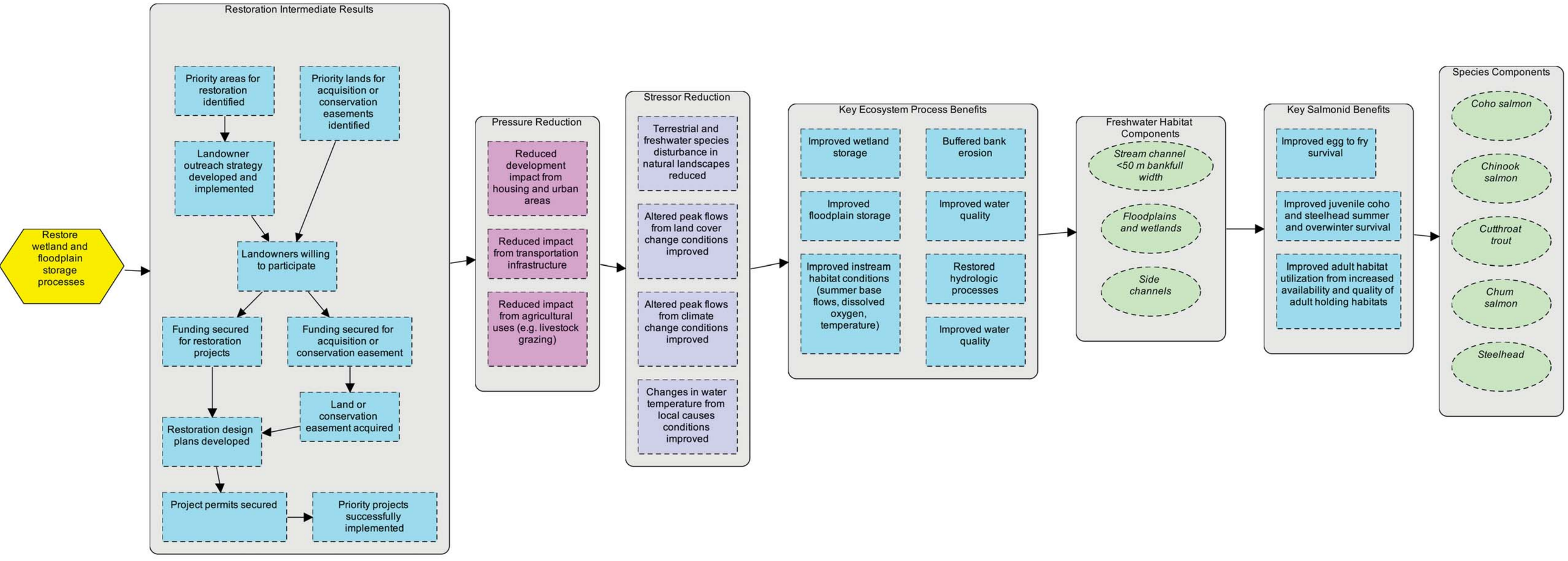
P1. Protect Blackjack Creek Habitat Conditions Results Chain



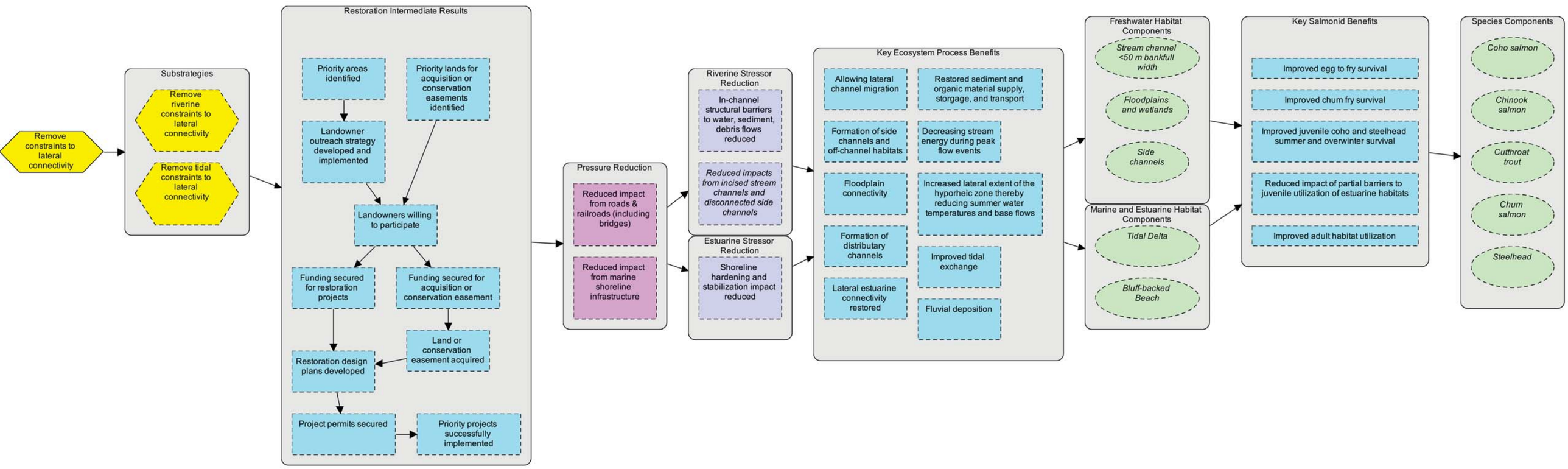
R1. Reconnect Isolated Habitats and Remove Barriers to Fish Passage Results Chain



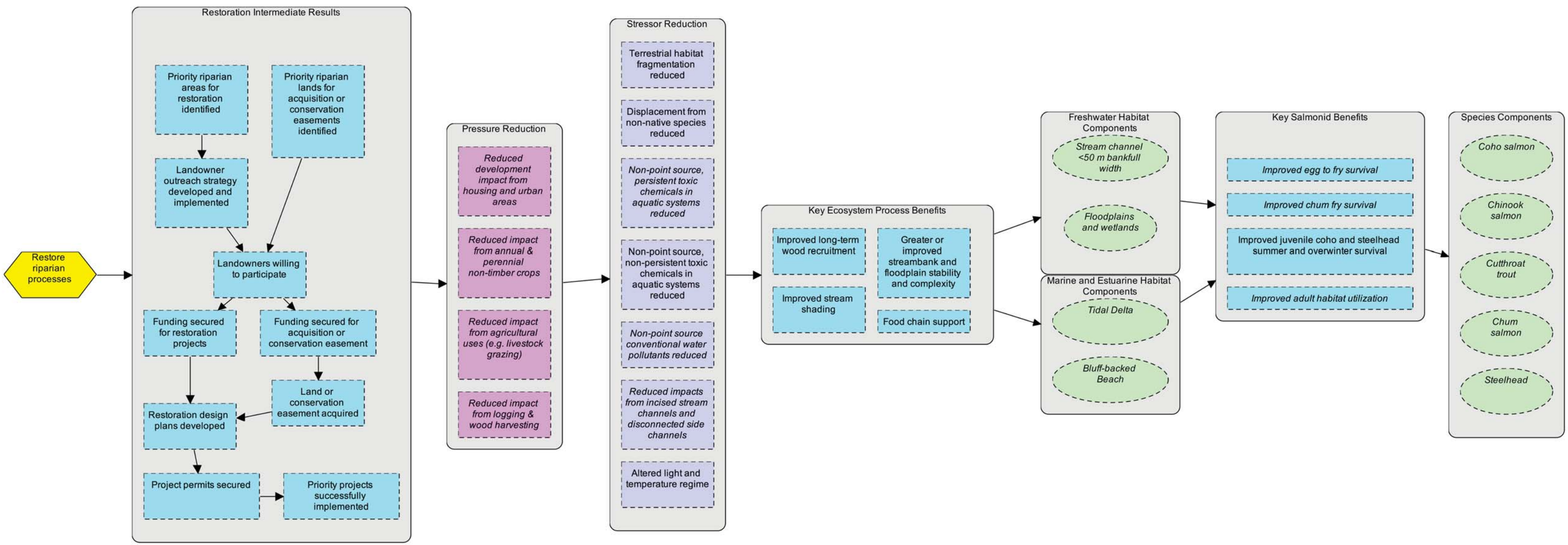
R2. Restore Wetland and Floodplain Storage Processes Results Chain



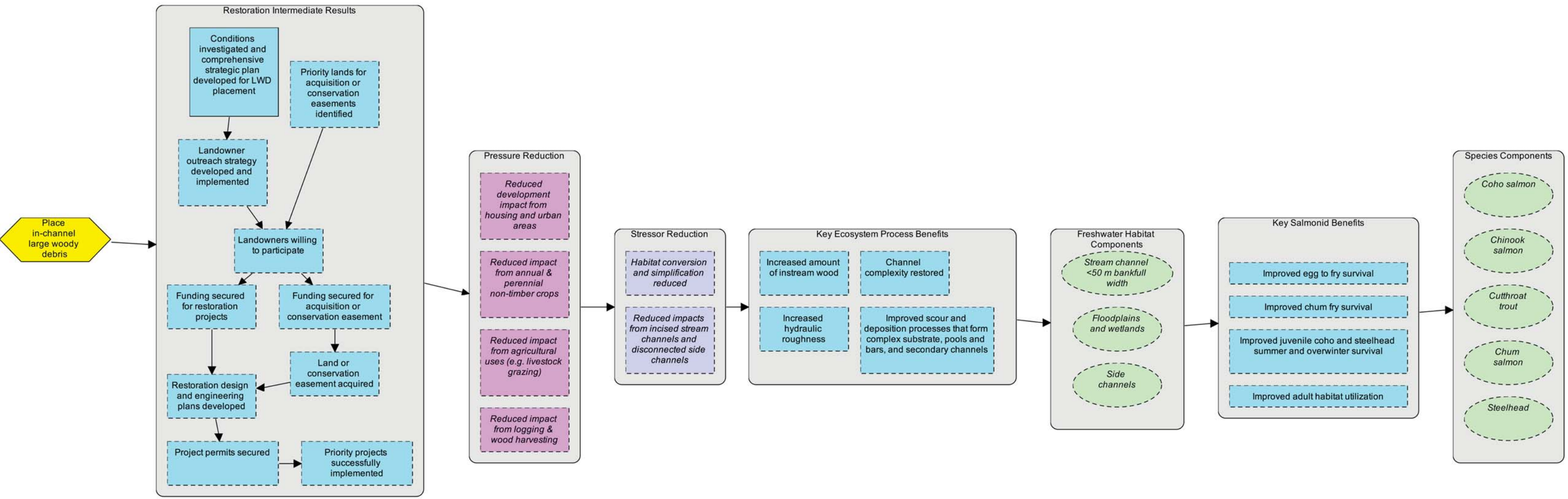
R3. Remove Constraints to Lateral Connectivity Results Chain



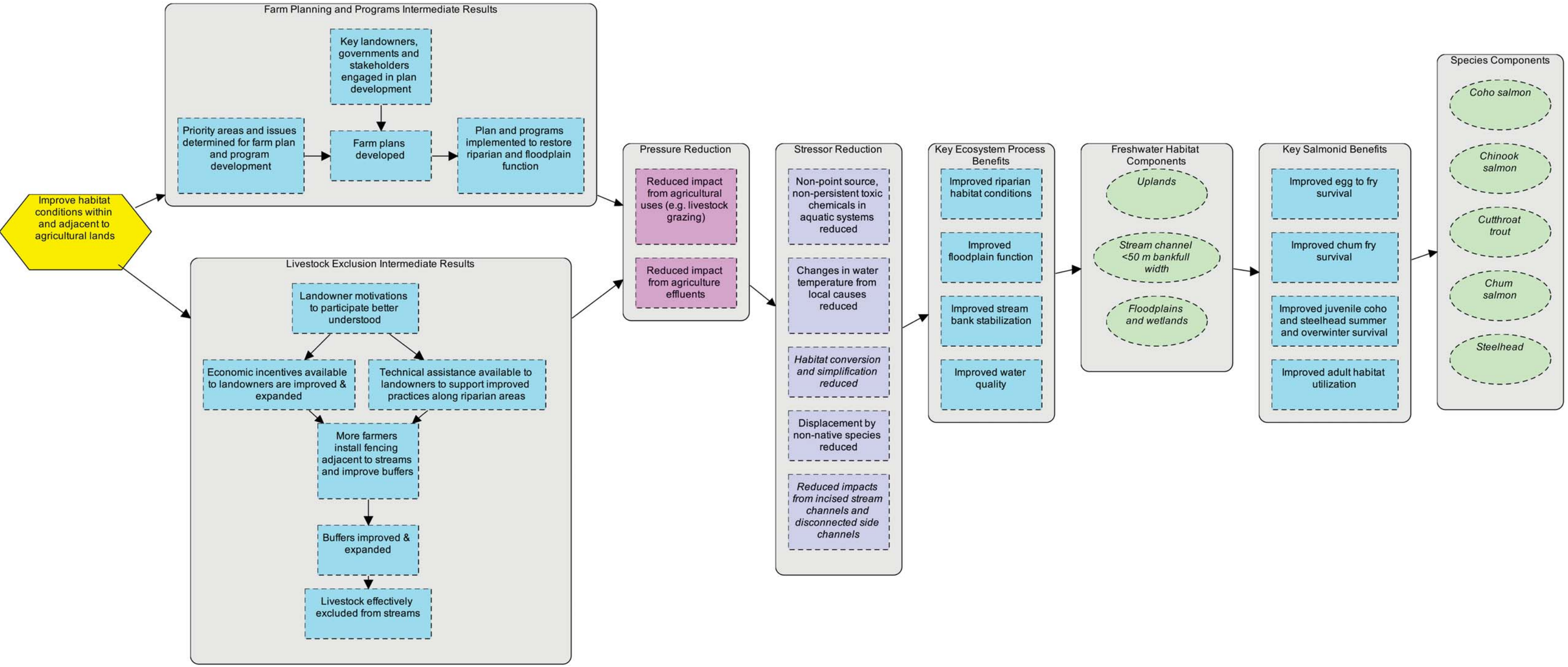
R4. Restore Riparian Processes Results Chain



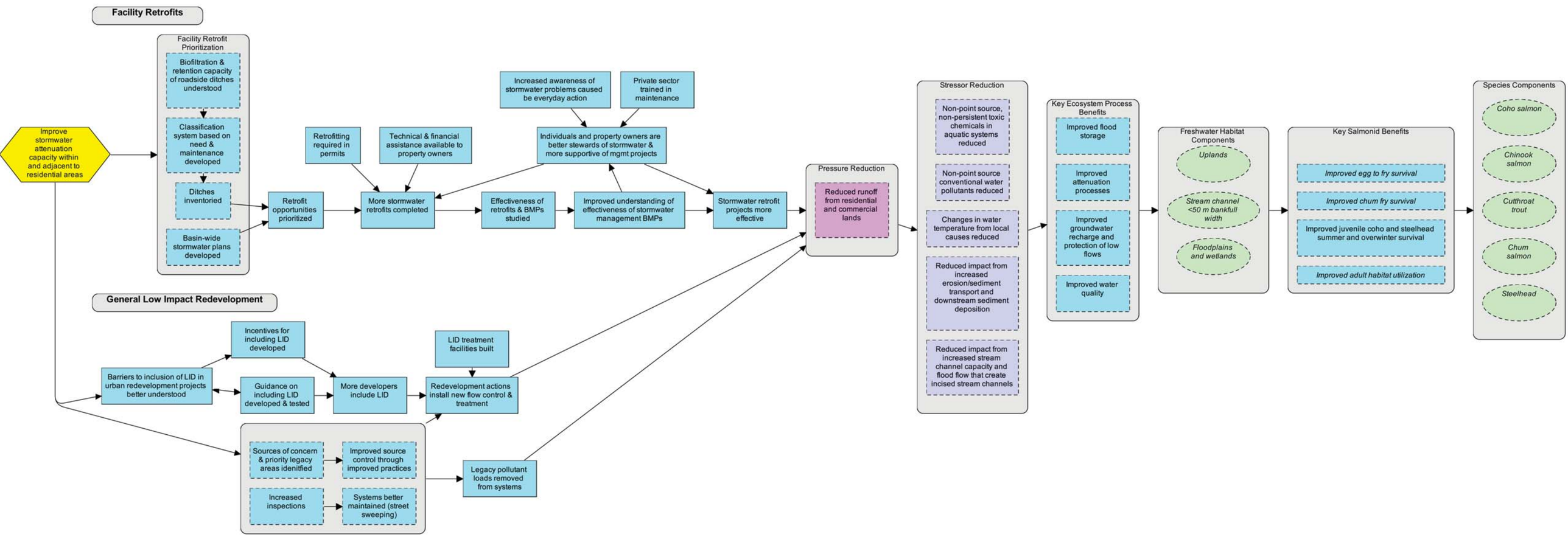
R5. Place In-Channel Large Woody Debris Results Chain



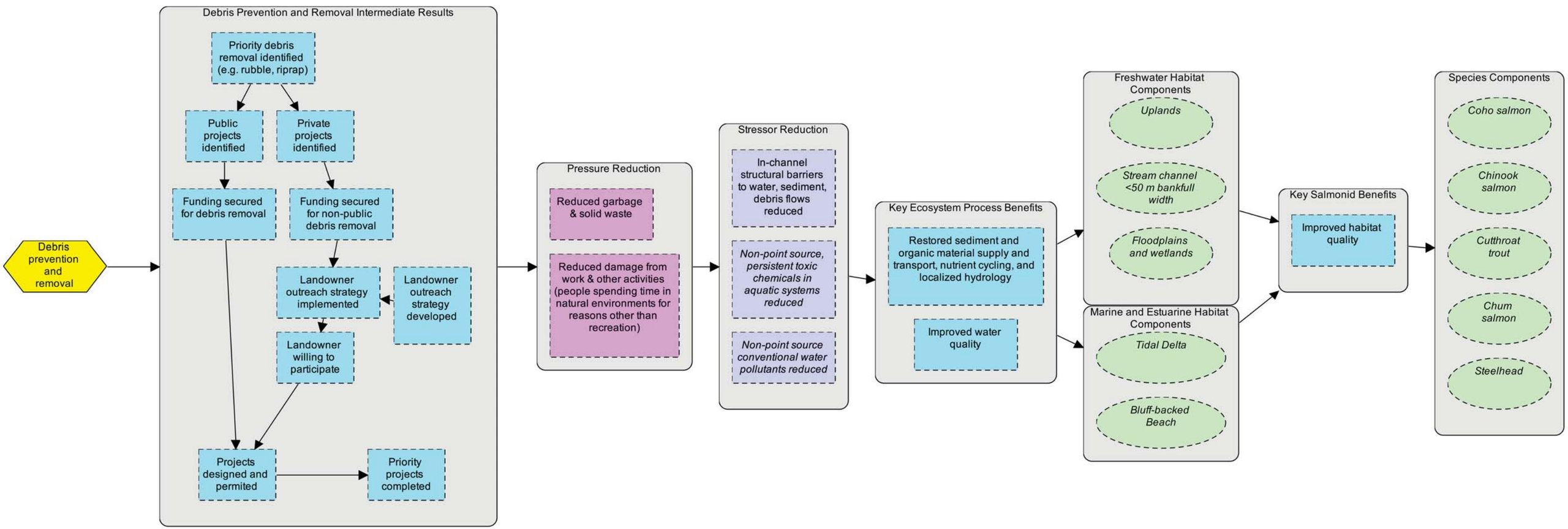
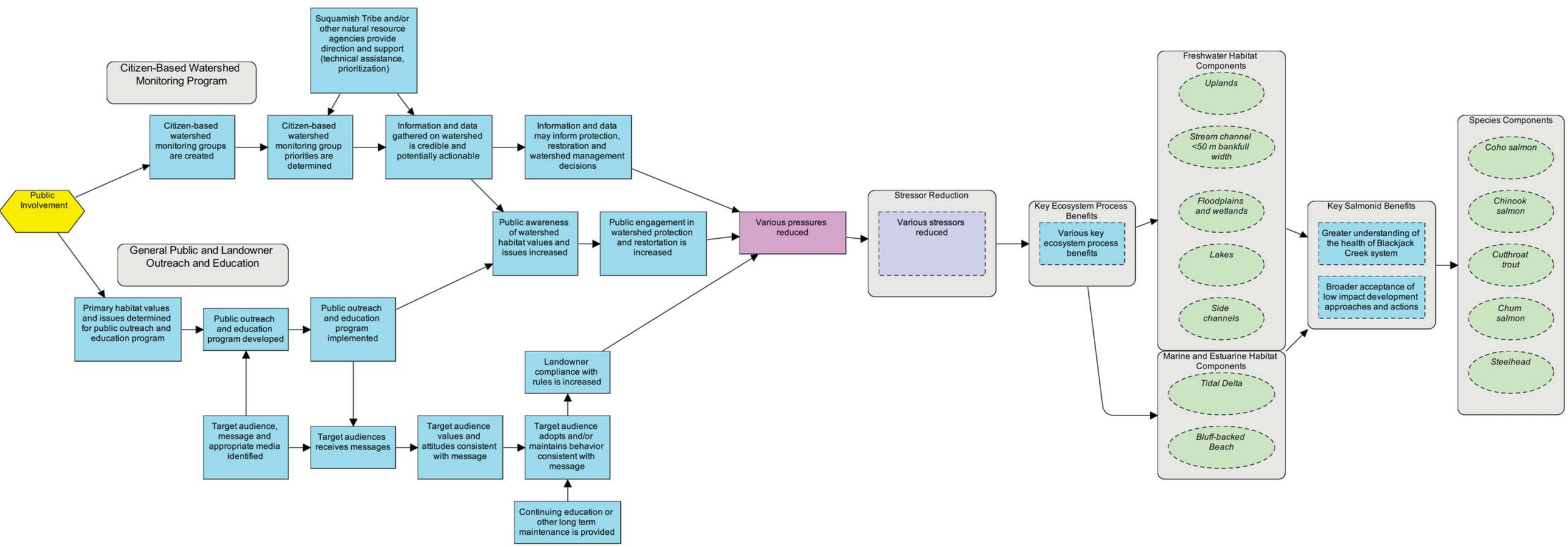
R6. Improve Habitat Conditions Within and Adjacent to Agricultural Lands Results Chain



R7. Improve Stormwater Attenuation Capacity within and Adjacent to Residential Areas Results Chain



R8. Debris Prevention and Removal Results Chain



R9. Public Involvement Results Chain