Skagit Watershed Council

Sauk River Habitat Protection and Restoration Assessment and Plan

Reach and Habitat Action Priorities

29 December 2023

Key Findings

- The Sauk River is one of the most important spawning and rearing areas for Chinook salmon in the Skagit Watershed and thus the range of Puget Sound Chinook salmon.
- Rearing habitat has been identified as the key factor limiting the Skagit's six independent Chinook salmon populations, with some indications that incubation conditions also limit the Lower Sauk population. While spring chinook salmon passing through the Sauk River to spawn in the upper Suiattle and Sauk Rivers are faring better than all other populations in Puget Sound, the Lower Sauk summer Chinook population is the most imperiled in the Skagit Watershed, only meeting its low abundance threshold of 400 fish in 7 of the last 14 years.
- The low velocity habitats required for juvenile Chinook salmon rearing have been diminished in quantity and quality by human actions that sought to constrain river channel and floodplain extent. Further, we hypothesize that increased sediments from historic watershed management and ongoing climate change, as well as destabilization of mainstem response reaches, have impacted incubation success.
- The Sauk River is relatively natural still compared to the Middle Skagit River with no dams impacting hydrologic and sediment functions (except at the confluence with the Skagit River); a larger percentage of the watershed forested and in long-term protected status; a relatively small percentage of shoreline hardened with bank riprap; and a relatively well-connected floodplain. For example, the floodplains of the lower 24 miles of the Sauk River exhibit 21.2% impairment (isolation or shadowing) compared to a total of 36.4% in the Middle Skagit River, and 12% non-forested conditions compared to 35% in the Middle Skagit River.
- The Sauk River floodplain reaches exhibit a wide range of total floodplain impairment, from nearly 0% in the Rinker Creek reach (SA030) to 66% in the Darrington reach (SA060D).
- 58% of all Sauk River mainstem floodplain areas through river mile 24 currently benefit from long-term protected status.
- Floodplain extent, flood inundation area, and off-channel habitat area are tightly correlated and clustered in the Sauk River mainstem, with the vast majority occurring in 3 of the 9 reaches.
- Using the same conceptual models for rating reaches as used in the Middle Skagit Plan in 2011, these highest geomorphic potential reaches are those that provide the greatest habitat capacity for juvenile Chinook salmon, specifically the Sauk Prairie (SA050), Confluence (SA010), and Rinker Creek (SA030) reaches.
    - These three are also the reaches that are rated highest for <u>protection</u> of aquatic resources.
    - Reaches with high geomorphic potential but also high floodplain impairments were rated highest for <u>restoration</u> of aquatic resources, specifically the Confluence and Sauk Prairie reaches, followed by the Rinker Creek reach, Suiattle reach (SA040), and portions of the Upper Sauk reaches above Darrington (SA060A and SA060B).
    - Several naturally or artificially confined reaches with low habitat potential ranked low in both protection and restoration, though <u>stewardship</u> remains an important strategy in all reaches.
- A total of 35 discrete, stressor-based restoration ideas were conceptualized in the Sauk River mainstem as part of this planning process to show the range of benefits and impacts in implementing proposed habitat strategies. These concepts were analysed and filtered based primarily on a set of estimated habitat benefits. Specifically, high priority restoration concepts need to be able to implement the right strategies in the right geomorphic reaches and provide the biggest benefits possible while most easily accommodating community interests.
    - Together these 35 concepts could restore over 800 acres of floodplain processes and over 17 miles of channel formation or improvement.
    - About 13 sites with 15 discrete ideas are considered high priority restoration concepts and would restore about 75% of the identified, restorable floodplain rearing habitat in the lower Sauk River.
    - Some additional restoration concepts associated with Seattle City light, Snohomish County, Skagit County and Washington State public roads and infrastructure should be strategically reconsidered as that infrastructure is routinely replaced or vacated in future years. This

increases the likelihood of avoiding emergency construction measures and restores habitat most cost effectively. SWC prioritizes strategic relocation and setback of infrastructure over bank remediation.

- A total of 14 discrete, strategic enhancement ideas were conceptualized in the Sauk River mainstem to strategically enhance the connectivity to and habitat quality in existing side-channels. These enhancement concepts typically involve strategic placement of stable wood jams to increase connectivity between the main channel and existing side channels or high flow channels in the floodplain.
- Some Sauk River floodplain areas have shown increased reach-level channel instability, which is hypothesized to impact priority habitat, connectivity, and successful rearing. Additional biologic and geomorphic studies are recommended, including an approach for considering updates to the Skagit Chinook Salmon Recovery Plan (2005).
- Fourteen large-scale, discrete sites were identified via land cover data as lacking priority riparian forests in the study area on both public and private lands. These areas account for 177 acres in the Sauk floodplain and adjacent areas.
- Spatial data collected and analyzed for this project can be used to further develop priority restoration concepts and identify smaller scale restoration and remediation sites. Updated hydraulic modeling and geomorphic analysis more accurately characterizing benefit and risk, in addition to expanded landowner and stakeholder dialogue, are required to move recommended concepts to feasible projects in the future.

Recommended Citation

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1 INTRODUCTION

The Skagit Watershed Council (Watershed Council) developed this Sauk River Habitat Protection and Restoration Assessment and Plan ("Plan") as a framework for implementing voluntary, ecologically meaningful restoration and protection actions that minimize impacts on local communities (Figure 1). The Plan is intended to develop and communicate the need, goals, technical foundation, and reach and site-scale priorities that benefit Endangered Species Act (ESA)-listed Chinook salmon in this area of the watershed to those who will be participating in or affected by the design and implementation phases of habitat protection and restoration.

This effort helps to fill a gap in our knowledge between understanding the problem and knowing where to invest in actions that will best meet the recovery goals for Skagit Chinook populations. The strategies presented here integrate limiting habitat factors and restoration potential of the landscape to provide a framework for broad-scale, ecosystem-based restoration in the Sauk River. Although the actions prescribed here are directed at addressing limiting factors for Chinook, benefits also will be realized for other floodplain dependent species and public infrastructure in need of better resiliency.

While the priorities identified will be updated as work is accomplished and new information becomes available, the strategies and actions prescribed here will continue to inform and guide that future, voluntary work.

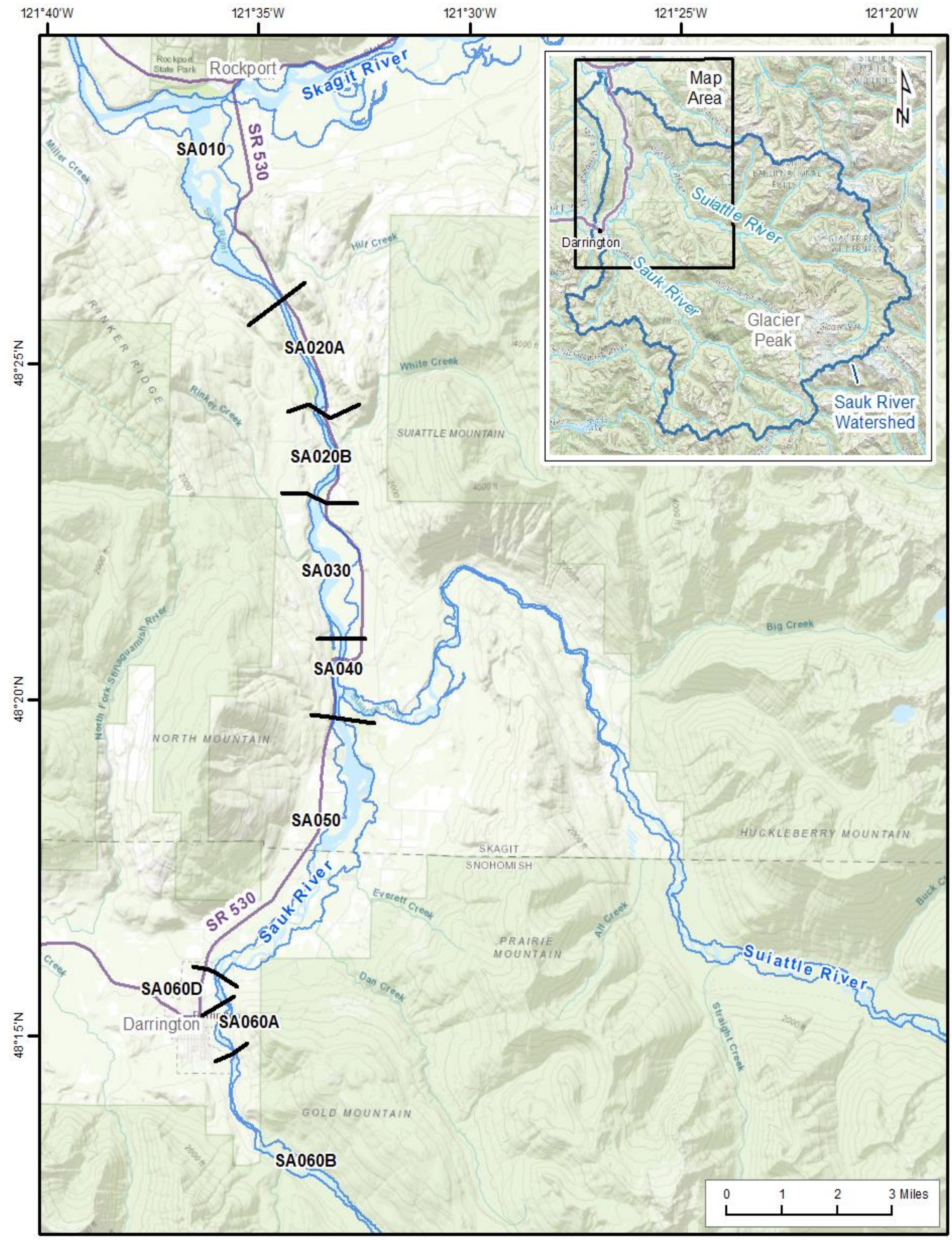

Figure 1. Location of the Sauk River project area and geomorphic reaches.

Plan Need and Goal

In 2019 the Skagit Watershed Council received funding to assess floodplain conditions and to develop a protection and restoration plan with a list of prioritized reaches and project concepts in the Sauk River. This area was chosen for this work for several reasons, including the importance of this largest tributary of the Skagit and its several Chinook populations; the relative lack of existing salmon habitat information in the Sauk River floodplain; and the important opportunity to ensure our understanding of the Sauk River keeps pace with similar efforts in other reaches of the Skagit River.

The goal of this Plan is to apply a science and community-based approach to identify and prioritize the best opportunities to protect and restore floodplain processes and functions for salmonids on a large scale in the lower 24 miles of the Sauk River. An important component of that goal is identifying both the potential benefits and impacts to private landowners, public uses and taxpayers that may be generated when these project opportunities are implemented so that public benefits can be expanded and impacts can be avoided, minimized, mitigated, or otherwise accommodated. Chinook salmon incubation and rearing habitats are the primary focus of this assessment and plan, but other floodplain-rearing species will also benefit.

The first part of this Plan seeks to identify the most important reaches for habitat protection and restoration in the Sauk River under current conditions, while the second seeks to identify specific strategies and actions that could provide abundant and high quality habitat if natural channel and floodplain processes were restored.

Development of the Sauk Plan

The Watershed Council established an advisory group referred to as the Steering Committee, composed primarily of the salmon co-managers, including the Sauk-Suiattle Indian Tribe, Skagit River System Cooperative, Upper Skagit Indian Tribe and Washington Department of Fish and Wildlife. Scientists from Seattle City Light, Skagit County, Snohomish County, United States Forest Service, and National Park Service were invited to participate given their land and infrastructure management responsibilities. The Steering Committee helped guide work planning for Watershed Council staff and their technical consultants, Natural Systems Design, Inc (NSD). As interim products were completed, they were reviewed by Watershed Council committees and the Board of Directors. Once a complete draft was available to facilitate discussion, a formal written comment period was opened to all these organizations and project concept workshops were held resulting in updates to the concepts and their evaluation approach. While this process completed the original scope of work for this Plan, the Skagit Watershed Council and its members also recognize that this is one more technical product along the path towards geomorphic floodplain protection and restoration with significantly more work to be completed in coming years. This includes implementing a broader outreach plan to share initial findings and vet recommendations to landowners and stakeholders necessary for long-term success.

This project was scoped to mirror the Watershed Council's Middle Skagit Plan to the degree possible while using only existing and available field and remote-sensed data. After collating available data, NSD completed a standalone geomorphic assessment and reach prioritization (Task 2) that is very similar to and somewhat comparable to the geomorphic assessment completed by the Middle Skagit Plan. In addition, given the dynamic character of the Sauk River compared to the Middle Skagit, NSD completed a channel migration evaluation that developed 2015 and 2022 LiDAR-derived Relative Elevation Models (REM), calculated channel migration rates and trends since 1944, and characterized geomorphic reaches (Task 3).

Significant changes in channel planform and width, particularly in Reach SA050 suggested further information was needed to evaluate relative stability and geomorphic function of wood and its relation to channel stability, leading to Task 5, also produced by NSD. To address these substantial channel impacts at an effective scale, Task 6 was scoped for NSD to conceptualize reach-scale wood placement via engineered log jams. Finally, NSD supported SWC staff with mapping and report writing.

Concurrently, SWC staff adapted habitat strategies and treatments from the Middle Skagit Plan and reviewed remote-sensed data and field conditions to conceptualize and characterize potential actions. Mapping products were collected in an online repository to benefit future outreach and learning. Floodplain stressor features such as berms and road fill were heads-up digitized with new, high resolution 2022 LiDAR and field verified when possible. Stressor-based and riparian restoration concepts were digitized and quantified for their areas of potential effect. Benefits and community impacts for each concept were analyzed via both quantitative and qualitative criteria, allowing concepts to be screened for recommended future habitat projects across several priority categories. SWC staff expanded the 2023 SWC Protection Strategy Update methods into all private, Sauk floodplain parcels in Snohomish County, quantifying habitat conditions and prioritizing parcels for their relative habitat benefit and forming the basis for protection recommendations.

Acknowledgements

We are grateful for the efforts of our many colleagues who contributed their time and expertise throughout the development of this project, significantly improving the final product. We offer special thanks to Tribal and state agency biologists and members of SWC's Technical Work Group for their continuous support and involvement in carrying out the project from its inception to its completion. Thank you to the professional staff at Natural Systems Design who provided much of the technical support for this work. We are also thankful for funding provided by the Salmon Recovery Funding Board and Seattle City Light to complete this project. Finally, thank you to those agencies who provided essential data including the Skagit River Systems Cooperative, the Upper Skagit Indian Tribe, and Snohomish County.

2 RELATIONSHIP TO OTHER RIVER PLANNING ACTIVITIES

River restoration and protection for the purpose of addressing ESA goals for threatened species also occurs within the context of other local and state planning processes that influence the future of aquatic habitats. A cohesive river restoration strategy such as presented here can serve to inform these efforts, including comprehensive flood hazard management plans, transportation improvement plans, and forest management plans, among others. Summaries of other processes and activities that inform, intersect, or complement the strategies described in this Plan are provided below.

US Forest Service Watershed Analyses

The 1990 Northwest Forest Plan required that watershed analyses were conducted to analyze the ecosystem at the watershed scale to provide science-based guidance for future resource management decisions. This analysis was completed for the Sauk River and Sauk River Forks watersheds in 1996 (USFS 1996) and for the Suiattle River in 2004 (USFS 2004). Both note they are designated as Tier 1 Key Watersheds in the Aquatic Conservation Strategy (USFS 1994). These processes yielded land designations for management such as riparian reserves, late successional reserves, and adaptive management areas, as well as watershed restoration recommendations, all designed to improve the health of the aquatic ecosystem while meeting broader federal forest objectives. Extensive recommendations were made to improve hydrologic and sedimentation processes such as Access and Travel Management planning, storm proofing roads, replacing fish passage barriers, removing roads from floodplains at risk of flooding and erosion, noxious weed treatments, and fire management planning, all of which have been ongoing in the Sauk Watershed for the last three decades and have improved the natural resiliency of this system. That work is essential to enable this Plan's ability to manage habitat quality more successfully in the lower watershed.

Skagit Chinook Salmon Recovery Plan

Puget Sound Chinook Salmon were listed as threatened under the Endangered Species Act in 1999. Fifteen watersheds supporting 24 populations or stocks of Chinook Salmon independently wrote salmon recovery plans in 2005, which were compiled at the Puget Sound scale with a regional chapter. This collaborative effort was adopted by the National Marine Fisheries Service in 2007 as their approach to recover Puget Sound Chinook Salmon.

The Skagit Chinook Recovery Plan (SRSC and WDFW 2005) includes all WRIAs 3 and 4 and all six of its Chinook salmon populations, including Lower Skagit Falls, Upper Skagit Summers, Cascade Springers, Lower Sauk Summers, Upper Sauk Springers, and Suiattle Springers. The Skagit Recovery Plan defined biologically based recovery goals and the factors limiting production of its Chinook populations that were known at the time. It also proposed scientifically based actions for all factors affecting the stocks, including fisheries management, artificial production, habitat protection, habitat restoration, and a monitoring, adaptive management and research program. Additional information on the most relevant Chinook populations and their habitat limitations is provided in Section 3. This Plan provides additional habitat analyses and recommendations that should be considered when updating the Skagit Chinook Plan and in implementing voluntary habitat projects.

Puget Sound Action Agenda

In 2007, the Washington State Legislature created the Puget Sound Partnership to coordinate and lead the effort to recover Puget Sound through a strategic, prioritized, science-based Action Agenda "that addresses all of the complex connections among the land, water, web of species, and human needs." http://www.psp.wa.gov/. The Action Agenda has been improved and updated multiple times since, including most recently in 2022, fulfilling the statutory mandate and purpose of the Clean Water Act's National Estuary Program.

This Plan supports one of the Action Agenda's three Strategic Initiatives: protect and restore habitat. It also helps implement three of the eight current Implementation Strategies: floodplains, land development/cover, and Chinook salmon.

Sauk River Comprehensive Flood/Erosion Control Management Plan

Efforts have been ongoing for many years to reduce flood and erosion hazards in the Lower Sauk Valley, with the most comprehensive work completed by Snohomish County and partners in 2010 known as the Sauk River Comprehensive Flood/Erosion Control Management Plan (Snohomish County 2010). This planning effort, initiated after a damaging flood in October 2003, evaluates flood and erosion hazards and identifies mitigation opportunities in the context of overlapping state and federal regulations. The effort established a mission statement to balance the need for infrastructure and property protection with the protection and restoration of natural resources and outstanding and remarkable values of the Sauk River in a manner that is acceptable to affected landowners, governments, and stakeholders.

Its objectives included describing a range of potential actions for both property protection and fish and wildlife protection and restoration, plus the areas and conditions in the corridor that justify priority consideration. Multiple structural and non-structural alternatives to achieving the mission statement were assessed and recommendations were made.

Of primary importance to this Sauk Habitat Plan is the community and agency input developed through the Management Plan's Advisory Committee. Several recommendations are incorporated into this Sauk Habitat Plan, and recommended habitat projects will not impact, and in many cases could well benefit, private property and public infrastructure.

Skagit and Snohomish County Shoreline Master Programs and Restoration Plans

The Shoreline Master Program (SMP) is a set of goals, policies and regulations consistent with the Shoreline Management Act of 1971 that includes measures to protect the environmental resources of state shorelines and promote public access and enjoyment opportunities. It must protect critical areas and ensure no net loss of ecological functions while encouraging preferred uses. Newer SMPs include restoration plans to prioritize voluntary and compensatory mitigation actions for ecological gain.

Skagit County is currently undertaking an update of their 1970's-era Shoreline Master Program (SMP). Its Shoreline Restoration Plan was developed in 2014 and amended in February 2022. Snohomish County updated their SMP in 2019. Its Restoration Element appears to be from August 2010. Both county restoration programs should be updated with many of the products from this Sauk Habitat Protection and Restoration Plan.

Skagit River Hydroelectric Project

The Sauk River is a wild river without any dams of significance currently altering its hydrology. However, the Sauk River confluence with the Skagit River is affected by changes in how water, sediment, fish, nutrients, and woody debris distribute spatially and temporally across the alluvial fan of the Sauk River caused by Seattle City Light's dams in the Upper Skagit River above Newhalem. This set of changes in habitat forming conditions is being intensely studied and considered in the Federal Energy Regulatory Commission's relicensing process for these three dams. In addition, transmission cables and the towers and road network supporting delivery of electricity to urban areas to the south do transit the Sauk River and parallel its floodplain for many miles.

While this Sauk Plan does not invest further effort into studying impacts from the Skagit River hydroelectric project, coordination of findings between the relicensing and this Sauk Plan should continue to learn across these processes and coordinate to benefit priority recommendations.

Seattle City Light also manages and funds the voluntary ESA Early Action program, which was implemented by the City of Seattle in 2000 to promote the recovery of ESA-listed fish species. The ESA Early Action Program acquires properties throughout the Skagit and Sauk Watersheds for protecting the three ESA-listed fish species: Chinook salmon, steelhead, and bull trout. The program also provides funding for habitat restoration projects on SCL conservation lands, and for conducting life history and ecological research on these species in the watershed. Funds from this program have been used to protect and restore watersheds and streams in the Skagit and Sauk, and to leverage federal and state grants for protecting and restoring the habitats required by these fish. The priorities identified in this Plan should inform where funds are applied in the lower Sauk River.

Sauk-Suiattle Indian Tribe Climate Change Assessment

The Sauk-Suiattle Indian Tribe hired Natural Systems Design to help them assess flood and erosion risks to their reservation and natural resources and how those might be impacted by climate change. Two phases described the Sauk River's hydrology and geomorphology; how climate change is likely to affect future flood flows (NSD 2014); and the short and long-term threats to tribal infrastructure and salmon habitat (NSD 2015). Regarding salmon impacts, NSD found that a 63% projected increase in the 2-year recurrence interval of bankfull flow would yield a predicted 40% increase in bankfull width and 20% increase in bankfull depth. This larger channel with a higher width-depth ratio will adversely impact riparian cover along banks, channel and bank stability, and average summer water temperatures. With summer flows projected to decrease by 40%, wetted summer and early fall channels (when Chinook are present) will be more isolated from forested, off-channel refugia. They anticipate this will continue the trend of an increasing difference between the flow areas of the bankfull and base flow channels under future conditions, worsening salmon habitat conditions and further exacerbating instream wood retention and channel complexity. The Sauk Plan builds from this analysis and recommends specific priority habitat actions.

Sauk-Suiattle State of Our Watersheds Report

In 2016 the Sauk-Suiattle Indian Tribe released the State of Our Watersheds Report for the Skagit and Sauk River Watersheds (NWIFC 2016). Ten years after adoption of the Puget Sound Salmon Recovery Plan, a review of key environmental indicators showed improvement for many important recommendations including estuary restoration, removal of forest road barriers, and ongoing floodplain restoration efforts. The State of Our Watersheds Report also noted decreasing trends in riparian forest cover throughout the Skagit and Sauk floodplains and called out the lack of action by Snohomish County to decommission the old Monte Cristo Road. This report presents findings of climate change impacts on the Sauk River, including higher predicted peak winter flows and lower predicted summer flows that will further reduce the success of salmonids. The State of Our Watersheds Report also recommends continuing to protect and restore connection to off-channel and side channel habitats. This report provides expanded and prioritized opportunities directly implementing that recommendation.

WSDOT and Skagit County Reach and Chronic Environmental Deficiencies Studies

Channel migration processes can pose a risk to property, homes, and infrastructure such as roads and bridges located within the erosion hazard area adjacent to the Sauk River. State Route (SR) 530 is an important transportation corridor that parallels the Sauk River between Darrington and the Skagit

River confluence near Rockport. Flood and erosion damages to SR 530 have necessitated Washington State Department of Transportation (WSDOT) to implement emergency maintenance activities in multiple locations along the corridor as part of the Chronic Environmental Deficiencies (CED) Program. The CED Program completed the Sauk River Corridor Study (WSDOT 2009) which analyzed six relocation/realignment options and suggested that minor realignments and armoring were the most promising strategies moving forward two larger relocation options presented fatal flaws at that time. This analysis provided a framework for developing short-term solutions that reduce impacts to fish and aquatic habitat from repetitive emergency repairs, but not necessarily long-term solutions. Since then, WSDOT has constructed six CED projects along SR 530. An approximately 3,000-foot-long segment of SR 530 was realigned in 2011 to set the roadway back from an eroding bank approximately 3.5 miles downstream of the Suiattle River confluence. Three CED projects have constructed log revetments on the right bank just upstream of the 2011 realignment to address imminent threats to the roadway where the channel is rapidly widening due to a bend cutoff avulsion. Two additional CED sites constructed log revetments to address imminent threat to the roadway on the left bank of the river at the Sauk-Suiattle confluence.

Skagit County Department of Public Works is developing project actions to address erosion hazards along Concrete-Sauk Valley Road. Channel migration has resulted in the erosion of a high bank that has encroached into the road base, requiring a full lane closure of Concrete-Sauk Valley Road. In addition, the channel migration has contributed to stream bed incision on three tributary streams (Hobbit's Creek, North Osterman Creek, and South Osterman Creek) in the project area resulting in perched culverts that are fish passage barriers limiting access to tributary channel habitat.

Skagit Watershed Council Protection and Restoration Strategy

The Skagit Watershed Council Habitat Protection and Restoration Strategy (SWC 1998) was developed to ensure efficient and effective use of monies for salmon habitat recovery efforts by focusing on the causes of watershed degradation rather than the symptoms. It formed the basis in 1998 of the Watershed Council's task to rank voluntary habitat projects based on costs and benefits, and its contributions continue today with this Sauk Plan's salmon recovery priorities and project screening.

Skagit Watershed Council Strategic Approach

Five years after completion of the Skagit chapter (SRSC and WDFW 2005) of the Puget Sound Chinook Salmon Recovery Plan (Shared Strategy 2007) the Watershed Council completed the first version of its Strategic Approach to salmon recovery in the Skagit Watershed, with subsequent updates in 2015 and 2022. It refocused from a multi-species approach to one driven by the six populations of Skagit Chinook and the rearing habitats most limiting their capacity to recover. Its major guiding principles are adopted here by reference, including restoring processes that form and sustain salmon habitats; protecting functioning processes and habitats from further degradation; and focusing protection and restoration on the most biologically important areas for Chinook salmon recovery. It prioritizes target areas around rearing habitat and assigns tiers based on how many Chinook populations benefit from that habitat. It concludes with Target Area descriptions, rationale for the targets, priority objectives, and issues/challenges. This Plan anticipates strong alignment with the Strategic Approach while producing many new opportunities for continuing to implement the most important actions for Chinook salmon habitat recovery.

3 OVERVIEW OF THE SAUK WATERSHED AND ITS HUMAN AND SALMON POPULATIONS

The Plan area includes the lower 24 miles of mainstem Sauk River and its floodplain from approximately Clear Creek in Snohomish County, past the Town of Darrington, WA, to its confluence with the Skagit River at Rockport, WA in Skagit County (Figure 1). This stretch of the river represents a major transition in the physical, biological, and human landscapes. The watershed's residents live, work and play along this stretch of the river and use this valley as a major transportation corridor connecting upriver communities and recreation areas to the Skagit Valley and SR20. This is also the river corridor by which three of Skagit's six Chinook salmon populations connect to their spawning grounds as adults and then back to the Salish Sea as juveniles.

Physical Landscape

The Sauk River is the largest tributary of the Skagit River, which is in turn the largest freshwater input into the Washington State's portion of the Salish Sea. The Skagit watershed, including the Sauk watershed, is made up of high peaks and low valleys. The highest points in the basin are two volcanoes: Mount Baker (10,781 ft) and Glacier Peak (10,541 ft). The landforms of the Skagit and Sauk basins have been sculpted by repeated eruptions, glaciations and erosion. Alpine glaciations produced sharp peaks and ridges in the basin headwaters and cut deep valleys. Overriding continental glaciers rounded many of the ridges at lower elevations and scoured pre-existing drainages. A large lobe of the cordilleran ice sheet pushed up the Skagit River valley. Ice and gravel moraines repeatedly blocked the Skagit, causing it to pool into lakes and forcing it to drain south into what is now the North Fork Stillaguamish River. Sea levels were also higher at the end of the last ice age, and the Skagit River Valley up to approximately the location of the present-day town of Hamilton was likely below sea level (Riedel 2007).

After the ice retreated approximately 20,000 years ago the Skagit breached the moraine dam near Concrete, Washington and the river cut down through the glacial outwash and lacustrine sediments that had accumulated in the lakes (Tabor et al. 1999). The upper Skagit drainage above the town of Diablo formerly flowed into the Fraser River, British Columbia (Reidel 2007). The divide between the Fraser and Skagit rivers was breeched by glacial meltwater approximately 12,000 years ago, forming the Skagit River gorge above the town of Newhalem and increasing the drainage area of the Skagit by approximately 800 square miles. The Sauk and Suiattle rivers continued to drain into the North Fork Stillaguamish River until eruptions of Glacier Peak approximately 13,000 years ago deposited large amounts of sediment in an alluvial fan near present-day Darrington, Washington (Mastin and Waitt 2000). The deposited sediment forced the two rivers to the north to join the Skagit (Tabor et al. 1999).

The Sauk River is still a wild and free river without dams to alter its natural flow. The overall flow regime of the Sauk River is bimodal with the largest, short duration floods tending to occur during the late fall and winter (November through January) in response to rain-on-snow events. A secondary, and generally lower but more prolonged peak occurs during the late spring and early summer in response to seasonal snowmelt. The Sauk River basin is heavily glaciated, with glacial meltwaters maintaining relatively cold temperatures and high flows throughout the summer. However, after several decades of stability most North Cascade glaciers are in rapid retreat; from 1984 to 2006 ten glaciers lost between 20-40% of their total volume and summer streamflows correspondingly showed a 27% decline (Pelto 2008).

The Sauk River is also a federally recognized Wild and Scenic River System, as designated by Congress in 1978. This includes the entire study area and extends up past the confluence with the North Fork Sauk, up into the Suiattle and North Fork Sauk Rivers to their boundaries with the Glacier Peak Wilderness Area. This program is meant to preserve rivers with outstanding natural, cultural, and recreational values in their natural and free-flowing condition for present and future generations.

Across the study area, the river transitions from a mountainous, semi-constrained river to a wide, complex channel that occupies a broad floodplain. Several large tributaries flow into the mainstem above and within the study area, including the North Fork Sauk River, the Whitechuck River, and the Suiattle River, plus many smaller but important tributaries including Dan Creek.

It is the wider, more unconstrained alluvial channels that have the greatest capacity to build floodplains and migrate laterally back and forth across the floodplain, leaving a mosaic of active channels, side channels, oxbow lakes and wetlands. Floodplain water bodies such as these are collectively referred to as “off-channel habitats,” and provide prime rearing and feeding areas for juvenile salmonids. The channels develop this island-bar pattern because of the large sediment load carried by the river, the large-scale transport and storage of woody debris, and the effective resistance provided by dense stream-bank vegetation (Reidel 2008).

In contrast, channels constrained by steep mountain sideslopes or bedrock tend to be steeper and straighter, with limited floodplain development and relatively fewer off channel habitats. Transitional channels between the alluvial and constrained generally have coarser gravel beds, less sinuosity, and relatively little, large wood accumulations. These relatively straight channels function as large wood and sediment transport zones. They tend to exhibit relatively stable floodplain features over many decades or centuries.

Land ownership and management also define the physical landscape. As noted in the Sauk River Comprehensive Flood/Erosion Control Management Plan (Snohomish County 2010), the chief land use in the Sauk River watershed is forest management with minor areas used for non-forest commercial, rural residential, mining, and agriculture. Forest management goals and ownership is diverse, with a wide range of federal, state, county, municipal, and private entities owning these lands. Different forest management goals include income, ecological services, recreation, and aesthetics.

The largest landowner at 46% of the entire watershed is the US Forest Service, including parts of both Glacier Peak and Henry M. Jackson Wilderness Areas. These lands are within the Mount Baker-Snoqualmie National Forest, with a district ranger station located in Darrington. Federal land use in this area has focused on ecological and recreational services since the Northwest Forest Plan was adopted in 1994 though pre-commercial and commercial timber harvest continues at low levels. The next largest landowner is Washington State Department of Natural Resources (DNR) with 24% of the watershed’s area, mostly around the Suiattle River confluence and lower Sauk River. Their forest management prescriptions have wider objectives than federal forest lands such as producing sustainable income for schools and junior taxing districts, though timber harvest in channel migration zones is tightly managed. Private timberlands managed primarily for income compose much of the rest of the watershed’s forest lands and are an important source of local jobs. Finally, a significant percentage of floodplain and riparian forests in the Sauk River Valley have been conserved in the last few decades for aquatic conservation purposes by groups such as the Sauk-Suiattle Indian Tribe and Seattle City Light, bringing the total conservation ownership in the lower 24 miles of the Sauk geomorphic floodplain to about 58% (see Section 5).

Human History

The Sauk River and adjacent areas have been home to indigenous people for many thousands of years. Their descendants today include members of several tribes, particularly the Sauk-Suiattle Indian Tribe, Upper Skagit Indian Tribe, Swinomish Indian Tribal Community, and Samish Indian Nation. The Sauk-Suiattle Indian Tribe and its predecessors established a large village in the Sauk Prairie consisting of at least eight traditional cedar longhouses in addition to many smaller camps in the watershed. Their population numbered around 4000 people before European contact. They traveled local rivers by canoe and around the mountains and valleys by local and regional trails. They lived on abundant natural resources such as saltwater fish, shellfish, salmon, wildlife, and plants gathered in their usual and accustomed manner and traded freely between the Salish Sea and Eastern Washington.

Early settlers of European heritage began to move into the valley in the mid to late 1800's. Many Salish Sea Tribes signed the Treaty of Point Elliot in 1855, including the Sauk-Suiattle. While hunting and fishing rights were reserved, the loss of property rights heavily impacted tribal communities and their way of life. Conflicts with the new settlers continued and the Sauk-Suiattle Indian Tribe's village was burned to the ground in the 1880s. By 1924 their population had dwindled to 18. Since then, the Tribe has reclaimed land as the base of their current reservation along the Sauk River and their 350+ members now maintain their identity and hope for the future through their tribal identity, social structure, tribal government, and co-management of natural resources with Washington State.

European settlement of the watershed did not begin in earnest until the 1880's, first with early settlers, trappers, and miners. The mining and forestry industry spurred road building and a new railroad line to Darrington by 1901. Automobiles could travel to the flat plains of Darrington sitting above the Sauk River in 1920, followed by electricity in 1926 (Snohomish County 2010). Soon thereafter town leaders began to market Darrington as an outdoor recreational mecca, leading to the incorporation of Darrington in 1945 following the Great Depression. Since then, mining and agriculture have slowly given way to rural residential uses and recreational tourism. Forestry is still a major commercial enterprise, including the Hamilton Lumber Mill on the banks of the Sauk River. Many old roads, bridges and buildings built in the river's floodplains in Darrington's early history have been destroyed by episodic flooding and erosion, leaving fewer roads and people in harm's way today.

Salmon Populations

Chinook Populations and Population Demographics

As noted above, the Skagit Watershed supports six of Puget Sound's 22 natural populations of Chinook salmon (Ruckelshaus 2006), with three of those six occurring in the Sauk Watershed (Figure 2). No other watershed in Puget Sound contains as many native Chinook salmon genomes, which is a key to long-term resilience. Further, most of the spring Chinook salmon populations left in Puget Sound are in the Skagit, with most of those in the Sauk Watershed.

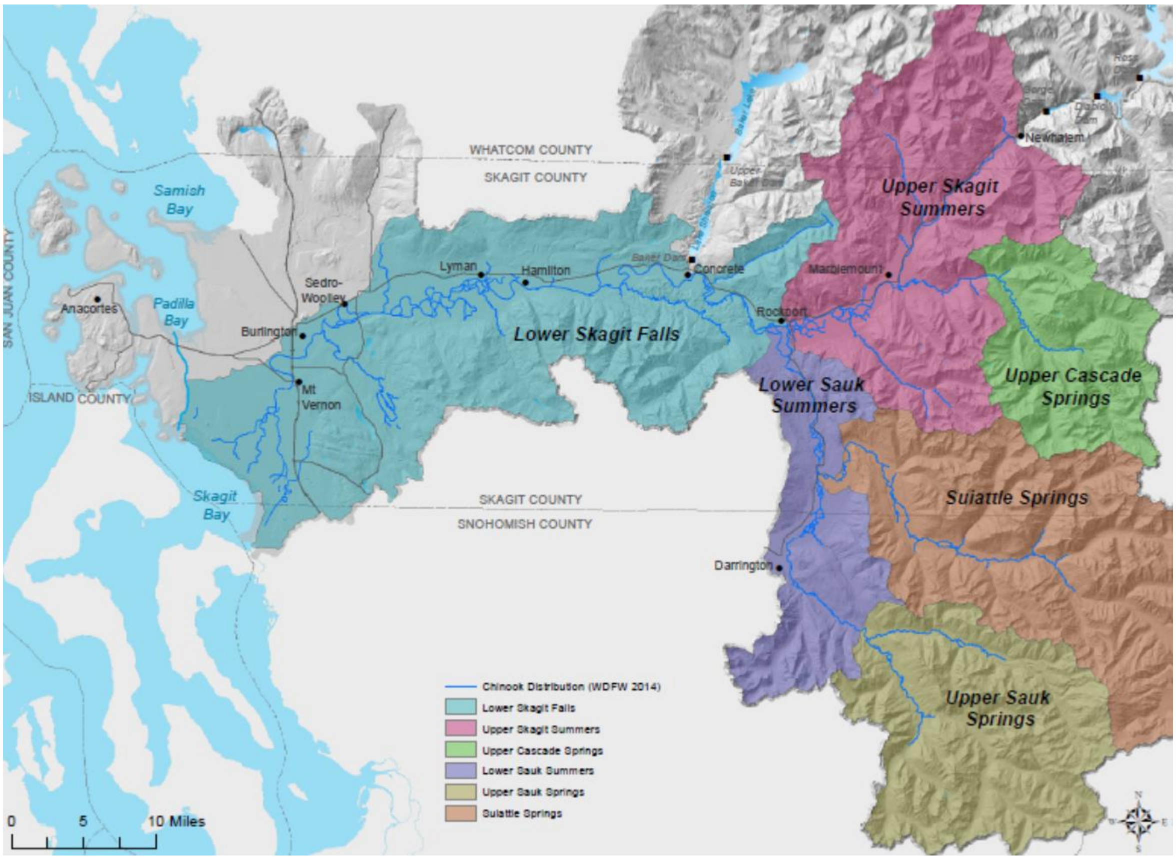

Figure 2. Chinook salmon populations in the Skagit Watershed.

In addition, no other watershed in Puget Sound displays as much abundance and productivity in their Chinook salmon populations, with more than 50% of all wild Chinook salmon in Puget Sound emanating from the Skagit Watershed. A recent analysis (WDFW, Salmon Population Indicators 2022) comparing the geomean of the last five years of Chinook salmon spawners by population to their low productivity recovery planning targets shows that while the six Skagit stocks are outperforming all other stocks in Puget Sound (Figure 3), they are still well below recovery targets in all cases except the Suiattle River spring Chinook. These facts suggest that while the remaining salmon habitat in the Skagit and Sauk Rivers is still functional and thus important to protect, it is equally important to restore habitats to further increase productivity and abundance to the point they will persist into the future (i.e. meet their recovery planning targets).

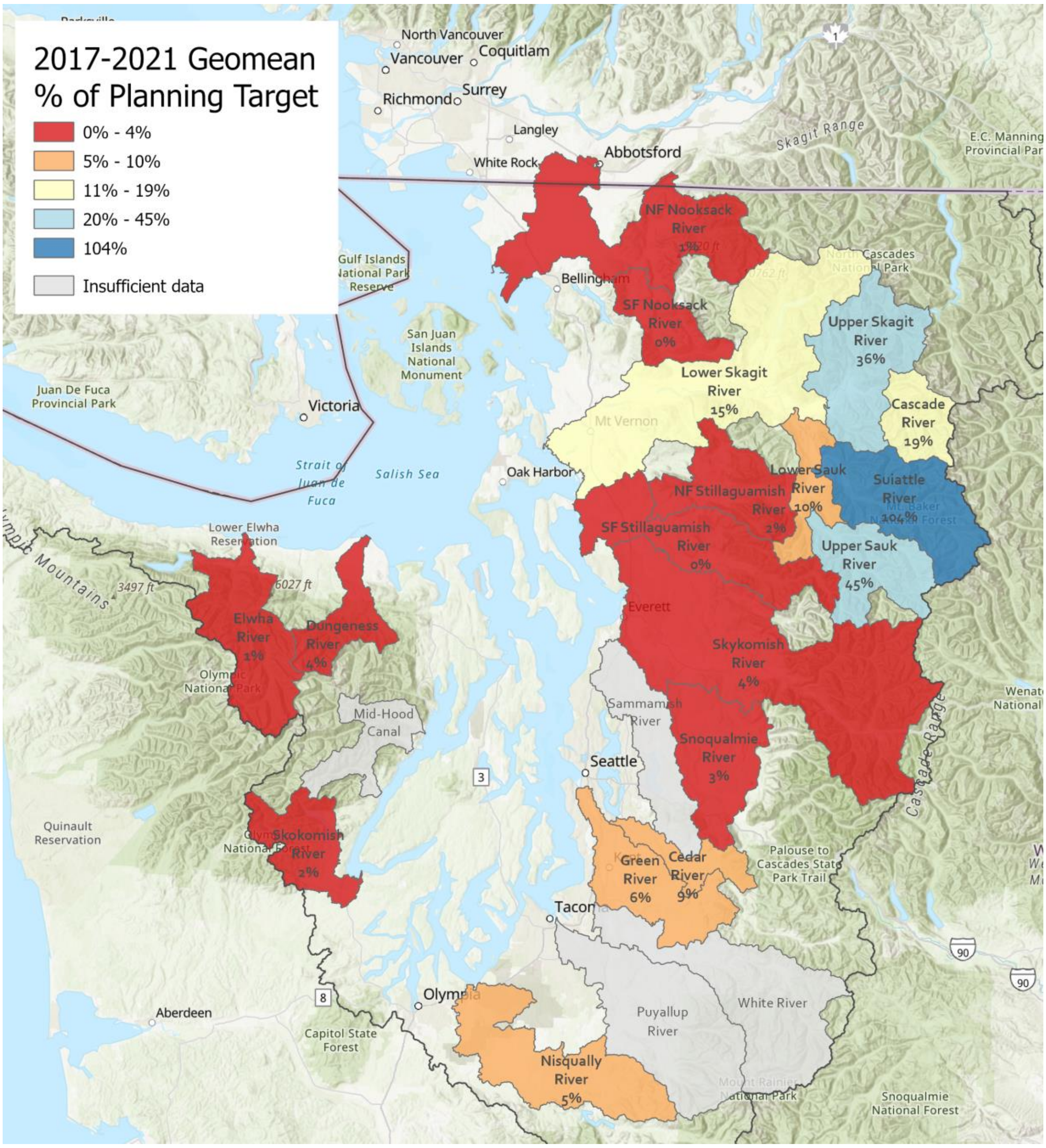

Figure 3. Puget Sound Chinook Population Abundance as Percent of Their Recovery Planning Target.

Lower Sauk summer Chinook are those that spawn in the Sauk mainstem and its tributaries (excluding the Suiattle River), mostly downstream of the Darrington Sauk Prairie bridge. Most of these fish spawn above the Suiattle River confluence from September through early October (SRSC and WDFW 2005). Their juvenile rearing habitat is mostly from Darrington downstream.

Upper Sauk spring Chinook are those that spawn in the Sauk mainstem and its tributaries upstream of the Darrington Sauk Prairie bridge. Most of these fish spawn between the Whitechuck River and the confluence of the North and South Fork Sauk Rivers from late July to early September (SRSC and WDFW 2005). Their juvenile rearing habitat is from the North and South Fork Sauk Rivers downstream.

Suiattle spring Chinook are those that spawn in the tributaries of the Suiattle River. Most of these fish spawn from late July to early September (SRSC and WDFW 2005). Their juvenile rearing habitat is from the Suiattle River downstream.

All three of these populations can exhibit both ocean and stream-type life history strategies, though the co-managers assume that summer Chinook are composed mostly of ocean-type while spring Chinook have more significant proportions of stream-type life history strategies (estimated at ~50% yearlings) (SRSC and WDFW 2005). Ocean-type juveniles can display four additional life history strategies, including fry migrant, nearshore fry migrant, delta rearing migrant, and parr migrant (Zimmerman et al. 2015).

Lower Sauk summer Chinook escapement estimates are shown in Figure 4 from 1974 to 2020, ranging from a high of 2,738 to a low of 112. Their annual escapement appears to be decreasing, with many recent years not meeting their low abundance threshold of 400 adults and thus limiting any harvest opportunities in those years. Juvenile Skagit Chinook migrant estimates are not partitioned out to population levels, meaning there are no population-level estimates used to discern freshwater productivity and survival for the population level.

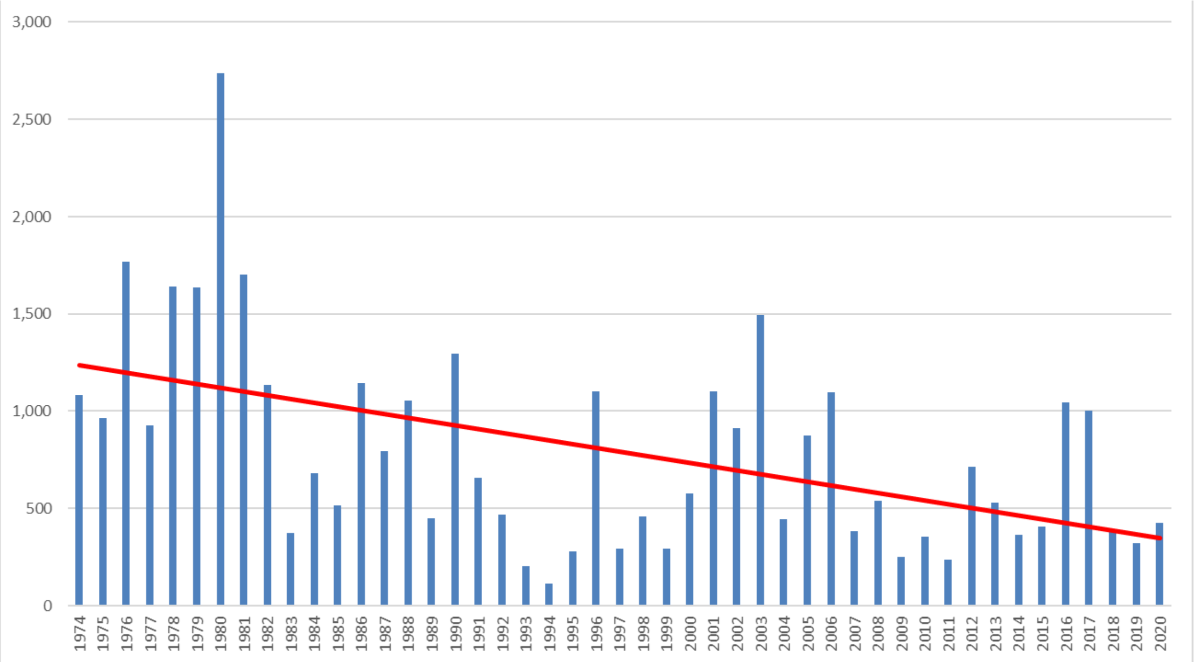

Figure 4. Adult escapement estimates for Lower Sauk summer Chinook (SASSI).

Upper Sauk spring Chinook escapement estimates are shown in Figure 5 from 1967 to 2020, ranging from a high of 1,826 to a low of 109. Note that the method to estimate escapement for Skagit spring Chinook populations changed in 1994 and may have yielded early overestimates via the extrapolation methodology. Unlike the other two populations in the Sauk River, Upper Sauk spring Chinook salmon escapement to the spawning grounds appears to have reliably increased over the recent period of record.

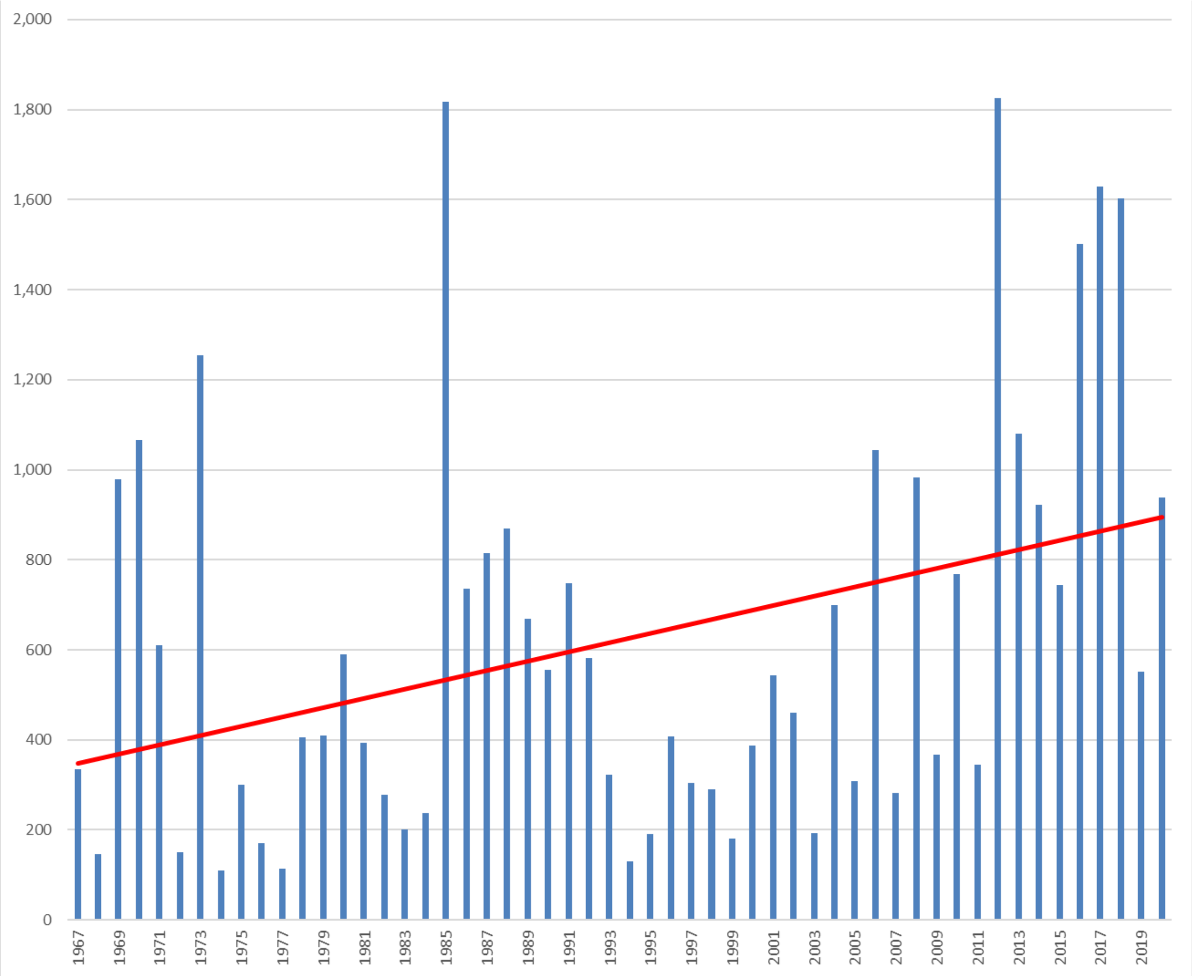

Figure 5. Adult escapement estimates for Upper Sauk spring Chinook (SASSI).

Suiattle spring Chinook escapement estimates are shown in Figure 6 from 1967 to 2020, ranging from a high of 1,805 to a low of 108. Note that the method to estimate escapement for Skagit spring Chinook populations changed in 1994 and may have yielded early overestimates via the extrapolation methodology. This population's adult escapement to spawning grounds appears to be either decreasing or stable over the period of record, since caution should be taken in comparing data before and after 1994.

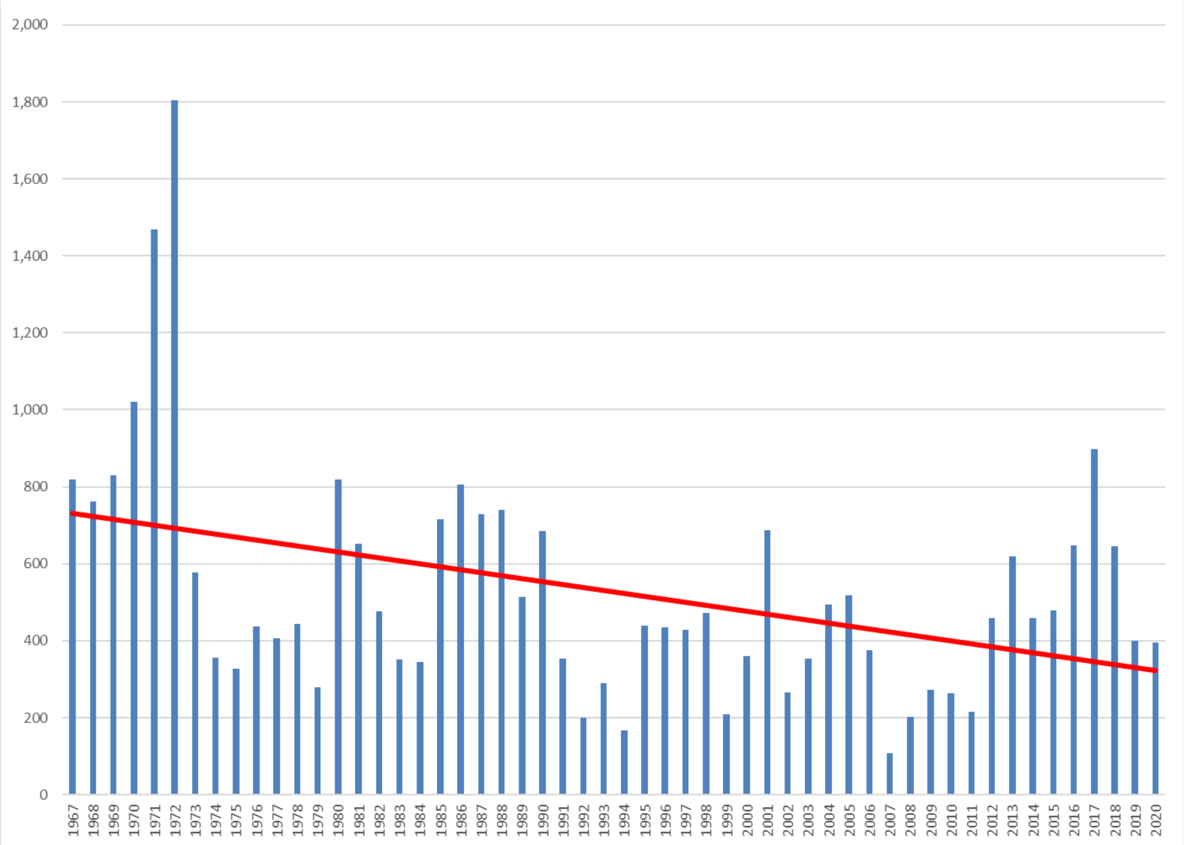

Figure 6. Adult escapement estimates for Suiattle spring Chinook (SASSI).

History of Hatchery Outplant Programs

In the 1980's and early 1990's, Washington Department of Fish and Wildlife created off-channel rearing ponds to outplant and imprint juvenile coho salmon, and possibly steelhead trout, in the floodplains of the Sauk River. These were government's earliest efforts to address the lack of rearing habitat that has limited the productivity of coho and other salmon species, before turning to habitat restoration in the late 1990's. Several locations were used to excavate rearing ponds, mostly outside of regular flood levels but within channel migration zones, including Boyd Road at rivermile 20-21, the North Sauk River Road at rivermile 25, and the Old Sauk Trail at rivermile 28. Additional excavation of ponds along lower Mouse and Dan Creeks on the South Prairie Road may have been completed as mitigation sites for transportation or flood conveyance projects rather than as pure enhancement projects. These sites have now been abandoned for approximately 30 years, with no plans currently in place to use them.

Habitat Limiting Factors

The Sauk River is used by all five species of Pacific salmon (Chinook, pink, coho, sockeye, and chum), including adults and outmigrating juveniles from the three independent populations of Chinook described above, summer and winter run steelhead, sea run cutthroat trout, and bull trout

(WDFW 2023). The mainstem and side channels support all life history stages for many of these populations.

The Skagit Chinook Recovery Plan (SRSC and WDFW 2005) identifies three major rearing habitat types that currently limit population sizes of Chinook salmon in the Skagit River basin: (1) tidal freshwater and estuary habitats in the delta, (2) shallow nearshore habitats including pocket estuaries, and (3) freshwater rearing areas in floodplains. A fourth aspect of habitat loss is the alteration of watershed processes that control tributary habitat conditions, including changes in sediment supply, flow regime, and riparian functions. There has been a net loss of 73% of tidal delta and 98% of non-tidal delta areas, 86% of pocket estuaries, and 37% of the large river floodplain (upstream of the non-tidal delta). Each of these areas has the potential to provide significant rearing area for juvenile Chinook of all life history types, and all life-history types are present to colonize restored habitats. Therefore, the Chinook Recovery Plan recommends restoration and protection actions that address each of the factors that limit recovery of Skagit Chinook. The purpose of many identified habitat restoration projects in the Skagit Chinook Recovery Plan, and this Sauk Plan, is to increase carrying capacity for juvenile Chinook to improve growth and therefore survival rates.

The Skagit Chinook Recovery Plan (SRSC and WDFW 2005) conducted an assessment of seeding levels of adults returning to spawning grounds. In that analysis, half of the six populations were likely adequately seeded (i.e. Lower Skagit falls, Upper Skagit summers, and Suiattle springers) while the remaining population assessments of seeding levels were indeterminate (i.e. Lower Sauk summers, Upper Sauk springs, and Upper Cascade springs). Adequate seeding of spawning habitat in the face of low or declining populations suggests the major habitat limiting factors are rearing habitat.

The Recovery Plan notes that while the Suiattle spring Chinook salmon population is likely adequately seeded, its spawning habitat is limited to lower reaches of tributaries of the Suiattle River, and those spawning areas have seen significant reductions from flood events in the 1990's and 2000's. This leaves open the hypothesis that Suiattle spring Chinook are limited by spawning habitat quality and quantity as well as rearing habitat. Regardless, this Sauk Plan does not further explore Suiattle spring Chinook spawning habitat areas, instead focusing on rearing habitat at and below the Suiattle River confluence within the Sauk River geomorphic floodplain.

The Skagit Chinook Recovery Plan (SRSC and WDFW 2005) suggests that the Lower Sauk summer Chinook salmon population is potentially impacted by additional factors than exhibited on the other five Skagit populations. It suggests that incubation survival rates for this population are generally poor and variable due to heavy, episodic siltation and bedload movement in the mainstem channel and mass-wasting and loss of pool-riffle sections in the tributaries, mostly downstream of the Suiattle. It further indicates that the mainstem area upstream of the Suiattle confluence is less degraded and it infers that decreasing trends apparent in spawner escapement estimates is not paralleled by a decline in spawning and rearing habitat quantity in that less impacted floodplain area above the Suiattle confluence. This set of observations suggests that protection and restoration strategies for the Lower Sauk summer Chinook salmon population should include spawning and incubation habitat improvement in addition to the rearing habitat improvements for all Chinook populations. This Plan conducts new habitat analyses which further strengthens and refines the conclusion that spawning and incubation habitat quantity, quality and connectivity are critical habitat limiting factors potentially reducing the productivity of the Lower Sauk summer Chinook salmon population, including between Darrington and the Suiattle River confluence. Biological studies of salmon use and productivity in these areas are needed to draw stronger conclusions for limiting factors.

More recent analysis of decades of summer low flows in minimally disturbed streams and rivers of Puget Sound found evidence that climate change is decreasing summer low flows (Shedd et al 2023). Two sites with long flow records in the Upper and Lower Sauk River were found to exhibit an increase of about 50% and 90% in the percent of days below the 25th percentile of low flow in the 1999-2021 average and 2017-2021 average, respectively, indicating actively worsening conditions. Further, the Lower Sauk had the highest count of years below baseline minimum flows of all Puget Sound Rivers analyzed. Decreased summer low flows likely contribute to increased water temperatures, decreased rearing habitat capacity, and decreased access to or availability of spawning areas, impacts which will likely get worse with climate projections.

4 FLOODPLAIN PROTECTION AND RESTORATION FACTORS

In this section we provide a brief summary of the important salmon recovery and community-based principles and technical context that form this Plan. This work builds on previous analyses and restoration strategies developed for the Skagit River watershed, including the Skagit Watershed Council's Habitat Protection and Restoration Strategy (SWC 1998), the Skagit Chinook Recovery Plan (SRSC and WDFW 2005), the Sauk River Comprehensive Flood/Erosion Control Management Plan (Snohomish County 2011), the Middle Skagit Plan (SWC 2011) and the Watershed Council's Strategic Approach (SWC 2022).

Salmon Habitat Recovery Principles

The Skagit Watershed Council's Habitat Protection and Restoration Strategy (SWC 1998) and Year 2022 Strategic Approach (SWC 2022) are founded upon an overarching goal of encouraging the voluntary restoration and protection of natural landscape processes that formed and sustained the habitats to which salmon populations are adapted. This *process-based* approach, also referred to as ecosystem restoration, aims to re-establish natural rates and magnitudes of physical, chemical, and biological processes that create and sustain river and floodplain ecosystems, thereby supporting recovery of Chinook salmon while avoiding placing single species habitat needs over those of other aquatic species.

Important process-based restoration actions in the freshwater portion of the Skagit and Sauk Rivers include restoring river-floodplain interactions and the formation of off-channel habitats, and plant growth and successional processes in riparian areas (SRSC and WDFW 2005). Additional goals include re-establishing more natural rates of erosion and sediment transport, storage and routing of water, input of nutrients and thermal energy, and nutrient cycling in the aquatic food web. Process-based restoration focuses on correcting human disruptions to these processes, so that the river-floodplain ecosystem recovers with minimal future maintenance and has the capacity to respond to future climate change through natural physical and biological adjustments (Sear 1994, SWC 2022).

Efforts that re-establish habitat forming processes promote recovery of habitat and biological diversity and include river dynamics as criteria for success. Because process restoration focuses on restoring critical drivers and functions, such actions will help avoid common pitfalls of engineered solutions such as creating habitats that are unsuited to the natural potential of a site or building habitats that are ultimately destroyed by untreated watershed or river processes (Beechie et al 2010).

Restoration actions should (1) address the underlying cause of degradation, (2) be tailored to local physical and biological potential, and (3) match the scale of restoration with the scale of underlying problem (Beechie et al. 2010). Each reach in a river network has a relatively narrow range of channel and riparian conditions that match its physiographic and climatic setting and restoration actions should be designed to correct disruptions to driving processes and redirect channel and habitat conditions into that range. Moreover, in order for restoration actions to succeed, the scale of the action must be at a scale that matches the scale of the underlying cause of degradation. That is, reach-scale problems such as riparian degradation or channel constraint by levees can be addressed at the reach scale, whereas sediment supply or hydrology issues must be addressed at larger watershed scales.

The Year 2022 Strategic Approach (SWC 2022) identities that the principle of protecting functioning processes and habitats from further degradation is essential for anchoring highly productive spawning and rearing areas for long-term recovery and is more cost-effective than attempting to restore degraded processes and habitats (Beechie et al. 2008). In addition, the Year 2022 Strategic Approach calls for focusing protection and restoration actions into the most biologically important areas, which was a key driver in the decision to conduct this assessment and planning effort. The manifestation of this principle is our main priority of focusing habitat protection and restoration efforts into estuarine, nearshore, and floodplain rearing habitats that will benefit the most number of species, populations and life history strategies in the most geomorphically active reaches with the highest fish rearing capacity.

Social and Economic Principles

The Sauk River Comprehensive Flood/Erosion Control Management Plan (Snohomish County 2010) conducted a stakeholder intensive planning effort with a representative sample of the community to develop a local mission statement for their Plan: to produce balance between the need for infrastructure and property protection and the need to protect and restore the natural resources of the Sauk Watershed in a manner that is acceptable to affected landowners, resource agencies, local tribes, interest groups, and local governments.

Similarly, for any long-term initiative such as floodplain protection and restoration to be successfully implemented by multiple parties, it must have effective opportunities for impacted stakeholders to engage on its most basic principles and alternatives for meeting community needs. Salmon recovery and habitat restoration in the face of ongoing flood and erosion hazard management is no different.

This Plan recognizes that protection and restoration of floodplain habitat forming processes are favorable for salmon but can be at odds with human needs to impart order and manage property and land uses along the river. As such an appropriate and sustainable approach needs to be struck between resilient infrastructure, flood/erosion protection, and fisheries habitat. This Plan uses both salmon habitat recovery principles and these socio-economic principles to develop criteria framework for rating benefits and impacts of conceptual habitat actions (Sections 7 and 8).

This Plan was first drafted in 2022 and finalized in 2023 with enough information to qualify relative fish habitat benefits and community impacts for each habitat concept developed. While this Sauk Plan was completed in 2023, the need to continue community review, input, and decision-making through following decades to improve its recommendations and how they are implemented is essential.

Climate Change

Changes in climate are impacting the hydrologic, geomorphic, and ecologic processes that affect habitat conditions for salmon and other aquatic organisms in the Sauk River Watershed. Warming temperatures raise freezing levels and result in a greater proportion of winter precipitation that falls as rain instead of snow. Watersheds characterized by a mix of rainfall- and snowmelt-driven flows are sensitive to changes in climate due to a shift in the seasonal timing of flow resulting in higher flows during winter and lower flows in summer (Elsner et al. 2010; Lee and Hamlet 2011; Hamlet et al. 2013).

Peak flows in the Sauk River have increased in frequency and magnitude over recent decades (Natural Systems Design 2014) and model simulations of future climate scenarios project that peak flows will further increase 27% to 38% by the end of the 21st century (Bandaragoda et al. 2019). Climate-related changes to streambed scour are anticipated to have negative consequences on egg-to-fry survival rates for salmon with greatest risk to fall spawners (Mantua et al. 2010; Goode et al. 2013). Additional geomorphic responses to accelerated peak flows include anticipated channel widening, increased sediment supply, increased channel migration rates and channel braiding, and reduction in anabranching channel segments (Natural Systems Design 2014; Natural Systems Design 2015).

Extreme low flows are also sensitive to changes in climate (Tohver et al., 2014, Lee and Hamlet 2011). The glaciated area of the Sauk River Watershed decreased by 23% over the historical period 1959-2009 resulting in a substantial reduction of meltwater contributions to summer flows (Riedel and Larrabee 2016). Model simulations of future climate scenarios project a greater than 50% decrease in low flows in the Sauk River by the end of the century (Bandaragoda et al. 2019). Maximum daily water temperatures during the summer low flow period are projected to increase by 2-3 °C (Bandaragoda et al. 2019). The combination of decreased streamflow and higher temperatures will have clear, negative consequences for salmon populations that have freshwater rearing periods in summer (Mantua et al. 2010) and reduce the quantity, quality, and accessibility of spawning habitats for late summer/early fall spawners like the Lower Sauk summer Chinook salmon.

Habitat protection and restoration actions offer an opportunity to mitigate the negative impacts of climate change (Battin et al. 2007; Beechie et al. 2012). Coordination with on-going research initiatives such as the Skagit Climate Science Consortium will help support strategic efforts to assess, plan and adapt to climate related impacts.

5 SAUK RIVER ASSESSMENT

The assessment phase of the project was designed to collect and summarize existing physical and habitat data available for the study area as the basis for identifying protection and restoration opportunities in the Sauk River mainstem, using the Middle Skagit Plan as a starting template. This is an approach to evaluating reaches that is based on the strategies for freshwater rearing habitats identified in the Chinook Plan:

- Acquire floodplain parcels for conservation and/or restoration in priority areas.
- Reconnect historic floodplain channels
- Remove or relocate floodplain modifications (e.g. berms, levees, road fill) to restore natural floodplain processes that form backwaters and floodplain habitat
- Remove or remediate hydromodifications (e.g. bank rip-rap) on the main channel to restore degraded edge habitat depth and complexity and cover.
- Replanting and maintaining native riparian vegetation.

In addition to freshwater rearing habitat limitations, the Chinook Plan also documents declines and necessary improvements in spawning habitat quantity and quality. In addition to isolated spawning habitats due to physical barriers such as culverts and roads, the Chinook Plan calls for identifying and addressing causal mechanisms for impairment to watershed processes that lead to degradation or loss of spawning habitats. A Chinook Plan chapter (and much subsequent road remediation work in the Sauk Watershed) is devoted to upland land and road management to reduce sediment and hydrology alterations but is less descriptive and prescriptive for other causal mechanisms. For this reason, this habitat assessment builds on and expands the Chinook Plan reference to impacted stream and alluvial fan simplification caused by hydromodification, floodplain modification, and wood removal. This report adds approaches to analyzing freshwater spawning habitats identified in the Chinook Plan:

- Restore channel planform and bed stability in spawning areas
- Restore access to spawning areas

A number of existing data sets were compiled and analyzed for these purposes. These are briefly summarized below with more detailed information included in the Sauk River Reach Assessment, RM 0-24, included here as Appendix A. Much of the assessment data was incorporated into a reach-level assessment where the range of conditions present within the study area are summarized and contrasted to identify priority reaches to target for habitat protection and restoration. The spatial data developed in the reach assessment was next used to develop reach-level strategies and finally to identify priority protection and restoration concepts within the reaches consistent with the reach strategies and the adopted prioritization scheme. Many of the data sets and analyses will also be used to further develop the project concepts.

Sauk River Study Area and Reaches

The Plan study area was determined by the project's requirement to control costs and focus on existing data. To complete a comparable analysis to that done in the Middle Skagit Plan required hydraulic modeling, habitat and floodplain delineations, etc. The most limiting dataset was hydraulic modeling outputs which occurred from the Sauk confluence with the Skagit River (river mile (RM) 0) up through Backman Creek just above RM 24. No tributaries were included in that modeling or the reach analysis section of this Plan. Fortunately, other datasets extended further and those have been included and analyzed where appropriate.

The Plan study area was divided longitudinally into nine reaches (Figure 1) based on distinct geomorphic characteristics originally developed by Hayman et al. (1996) and later used in the Application of the Skagit Watershed Council's Strategy (Beamer et al. 2000) and the Skagit Chinook Recovery Plan (SRSC and WDFW 2005). A recent report explored the geomorphology of the Sauk and Suiattle Rivers, identifying in more detail a larger number of distinct geomporphic reaches (Skagit Quaternary 2023), though their results were not available for this Sauk Plan.

The outer boundaries of the original floodplain reaches were originally based on the regulatory 100-year floodplain as a starting point and adjusted for subsequent uses to reflect additional geomorphic factors. This "geomorphic floodplain" polygon has been consistently used in Skagit Watershed restoration planning and adaptive management & monitoring and was not edited before incorporating into this Plan. It was selected for use and sustained not because it is considered more accurate than other or more recent floodplain delineations, but to ensure comparability between this Plan and the 2005 Recovery Plan. It most generally represents the area where channel migration and habitat formation might be expected to occur over the next few decades in the absence of roads, development, and erosion protection structures. It does not represent the area likely to be flooded at a specific flow and does not define the floodplain or channel migration zone for any regulatory purpose.

An overview of channel and floodplain characteristics by reach is presented in Table 1 and Table 2.

Table 1. Reach channel characteristics.

REACH	CHANNEL LENGTH (MI)	CHANNEL WIDTH (FT)	CHANNEL GRADIENT (FT/FT)	SINUOSITY
SA010	5.3	610	0.0020	1.4
SA020A	2.2	360	0.0020	1.1
SA020B	1.8	345	0.0031	1.0
SA030	3.4	593	0.0026	1.3
SA040	1.4	408	0.0022	1.1
SA050	6.3	661	0.0035	1.1
SA060D	0.6	314	0.0041	1.1
SA060A	1.2	307	0.0043	1.2
SA060B	9.4	253	0.0076	1.1

Table 2. Reach floodplain characteristics.

REACH	FLOODPLAIN AREA (AC)	AVG FLOODPLAIN WIDTH (FT)	CONFINEMENT RATIO: CHANNEL WIDTH/ FLOODPLAIN WIDTH	RATIO: FLOODPLAIN AREA (AC) / CHANNEL LENGTH (MI)
SA010	2,615	5,680	9.3	493
SA020A	326	1,294	3.6	148
SA020B	128	603	1.7	71
SA030	874	2,799	4.7	257
SA040	159	969	2.4	114
SA050	2,279	3,280	5.0	361
SA060D	116	1,863	5.9	193
SA060A	104	870	2.8	87
SA060B	202	1,227	4.8	21

Reach SA010 begins at confluence with Skagit River and extends upstream approximately 5 miles until the valley and floodplain narrow. This reach is characterized by a dynamic channel and wide floodplain with side channels and a network of distributary channels. There is moderate development impairing the right bank floodplain including roads and homes, reducing the connection of distributary and side channel networks.

Reach SA020A is a naturally confined reach with a relatively narrow valley bottom and floodplain from river mile 5 to 7 where the Concrete-Sauk Valley Rd bridge crosses the Sauk River. The river is further confined by SR 530 and Concrete-Sauk Valley Rd on either side of the floodplain as well as rural development and flood protection structures on the right bank floodplain.

Reach SA020B begins at the Concrete-Sauk Valley Rd bridge and spans up to river mile 8.8. SA020B is also naturally confined and has an even more narrow floodplain with the lowest confinement ratio of the Lower Sauk reaches but differs from SA020A in that the valley is wider, though still confined by terraces. The floodplain of this reach also has low human development and is less constrained by SR 530.

Reach SA030 extends up valley to approximately river mile 12, just downstream from the SR 530 bridge and the Suiattle River confluence. The floodplain in SA030 is wider with a more dynamic channel, bearing the highest sinuosity in the reach assessment. The channel and floodplain contain braids, side channels, and forested islands. Near river mile 10 the Sauk flows around a large forested island that splits the mainstem into two large channels with the right bank channel flowing directly along the SR 530 road prism. The downstream portion of SR 530 in this reach was strategically set back onto the terrace and away from the shoreline, though a significant amount of abandoned bank armor remains.

Reach SA040 straddles the Suiattle River confluence and SR 530 bridge and continues up to river mile 13.4. The floodplain in SA040 is narrow with the second lowest confinement ratio and is constrained by hydromodifications associated with SR 530, natural terraces, and the influence of the Suiattle River alluvial fan. The channel, like the floodplain, is also narrow and straight.

Upstream of the Suiattle River, reach SA050 extends up to the downstream end of Darrington and river mile 21.1. SA050 contains the Sauk Prairie area and the Sauk-Suiattle Indian Reservation lands. The floodplain and channel are wide and complex and support a network of side channels, forested islands, and braids. Much of the left bank channel edge and floodplain is unimpacted by human modifications, but a significant portion of the right bank floodplain is impaired by roads and rural development in the Sauk Prairie area.

Reach SA060D is a short reach beginning in Darrington and extending from river mile 21.1 to 21.7. The reach encompasses the Hampton Lumber Mill site on the left bank floodplain in addition to the Sauk Prairie Road bridge. The channel and floodplain are naturally narrow as well as anthropogenically confined and thus the floodplain is the least connected of the Sauk River reaches. Below the Sauk Prairie Road bridge nearly the entire floodplain is isolated or impaired and the river is restricted to a single thread channel. Above the bridge the river is less confined and splits around a forested island. The channel gradient begins to steepen in SA060D, which continues through to the top of the reach assessment in reach SA060B. The Sauk Prairie Road bridge was recently upgraded and its width expanded to benefit habitat forming processes.

Reach SA060A is only 1.2 miles long, extending to river mile 22.9 and is most adjacent to the town of Darrington. The channel remains a similar width to SA060D and the floodplain widens but is constrained by a terrace on the left bank and the valley wall on the right bank. Despite running through Darrington, the floodplain of SA060A is well connected, mostly due to Darrington being situated on a terrace above the floodplain and the limited development within the floodplain.

Reach SA060B continues for 9 miles up to the confluence of the White Chuck River at river mile 32, however only the lower portion of the reach up to river mile 24 is included in the reach assessment. Reach SA060B has a narrow steep channel and naturally confined floodplain. There is some rural development within the reach, mostly along the terrace above the left bank floodplain and a portion of the right bank floodplain is isolated by the North Sauk River Road. The river is mostly a single thread channel with a few large gravel bars that split flow in wider floodplain areas.

Hydraulic Modeling

Hydraulic modeling was used to assess floodplain inundation. Hydraulic data were combined from two separate models. A 1-Dimensional hydraulic model was developed using the HEC-RAS by R2 Resource Consultants (DeVries 2008, 2009) as part of the Sauk River Comprehensive Flood/Erosion

Control Management Plan (Snohomish County 2010). The Snohomish County model extent covers from the reach upstream of Darrington at RM 24 to the confined channel segment downstream of the Concrete-Sauk Valley Road bridge near RM 5. The model excludes the confluence of the Suiattle River creating a gap between river miles 13.1 and 12.2, which lies within the SA040 Reach. A second model was created using a 2-Dimensional software package (RiverFlow2D) by Natural Systems Design (NSD 2018) as part of a restoration design project sponsored by Skagit County to address erosion along the Concrete Sauk Valley Road. The NSD model developed for Skagit County extends from RM 5 to the confluence with the Skagit River. Inundation area and inundation area/channel length are shown in Table 3.

Table 3. Reach floodplain inundation at 10-year modeled flows.

REACH	MAINSTEM LENGTH (MI)	FLOODPLAIN AREA (AC)	10-YR INUNDATION AREA (AC)	INUNDATION AREA/CHANNEL LENGTH (AC/MI)
SA010	5.3	2,615	2,053	386.4
SA020A	1.95	326	110	56.6
SA020B	1.8	128	86	47.4
SA030	3.4	874	448	131.1
SA040	0.9	159	40	44.6
SA050	6.5	2,279	1,351	206.3
SA060A	1.2	202	139	117.3
SA060B	1.4	104	90	62.6
SA060D	0.6	116	32	56.7
Average	2.7	756	483	120.6

Floodplain inundation areas are normalized using mainstem length for the reach to account for differences in reach length. Due to gaps in hydraulic model extents in reaches SA040 and SA020A, the mainstem lengths were adjusted to remove channel length not included in the hydraulic models.

Three reaches stand out in terms of geomorphic potential: SA010, SA030, and SA050. Reach SA010 has the highest floodplain inundation by a large margin. In absolute terms, it accounts for nearly half the entire inundation for all reaches combined and is almost double the next highest reach even relative to reach length. SA010 also has the widest floodplain and contains the alluvial fan and distributary network of the Sauk River, which contributes to the high inundation area. Despite 30% of the floodplain being impaired (Table 5), it still supports a dynamic mainstem channel and numerous high-quality side and distributary channels.

The next largest inundation areas in both relative and absolute terms are in reaches SA030 and SA050. Both reaches have similar floodplain width and confinement ratios (Table 3) Despite similar floodplain sizes, SA050 has considerably greater inundation area relative to channel length indicating more of the floodplain is inundated compared to SA030.

The remaining reaches have smaller and narrower floodplains and much lower inundation areas, aside from SA060A. Large portions of both the left and right bank floodplains are inundated in SA060A.

Streambank Modifications

This Plan compiled the most recent inventory of streambank hardening structures, or hydromodifications, conducted along the mainstem Skagit and Sauk Rivers (Upper Skagit Indian Tribe 2010). Bank structures such as riprap and levees degrade the low velocity edge habitat suitable for juvenile salmon, constrain the river, and impede the natural floodplain erosion and sediment deposition processes that create and maintain habitat for fish. Because of changes in the river and more precise field mapping techniques, this recent survey provided a much-needed update on these structures. For the 2010 inventory, geographically registered data gathered by boat and wading were imported into GIS format and linked to field photographs providing a data set useable for a variety of analyses. Detail on the data collected and methods are in the report (Upper Skagit Indian Tribe 2010). Data were summarized by the revised reaches in the reach assessment (Table 4).

Table 4. Length in feet and percentage of shoreline modifications by reach.

REACH	MAINSTEM CENTERLINE LENGTH (FT)	HYDROMODIFICATION LENGTH (FT)	% MODIFIED BANKS
SA010	28,048	1,088	4%
SA020A	11,290	3,609	32%
SA020B	9,600	1,409	15%
SA030	18,049	2,293	13%
SA040	8,237	3,232	39%
SA050	34,578	3,793	11%
SA060A	6,260	673	11%
SA060B	7,630	1,248	16%
SA060D	2,966	1,679	57%
Total	126,659	19,023	15%

While these data are a good indicator of relative impaired conditions by reach, field review in 2022 of many of these identified sites showed that there has been change since they were surveyed in 2010. For instance, some locations were completely eroded away, some locations were removed, some locations were extended, and at least one location may have been incorrectly called anthropogenic.

Floodplain Connectivity

The connectivity and function of floodplains has been inventoried and analyzed by the Skagit River System Cooperative and that data was provided for this summary. ***Isolated*** floodplain areas are completely surrounded by roads or hydromodifications, while ***shadowed*** floodplain areas are portions of the floodplain behind roads or hydromodifications that are only partially disconnected (SRSC 2011). Table 5 contains reach floodplain impairment data, presented by the relative percentage of the floodplain shadowed or isolated. Map books for floodplain impairment are provided in Appendix B.

Table 5. Reach floodplain impairment.

REACH	FLOODPLAIN AREA (AC)	% ISOLATED	% SHADOWED	% ROAD/DIKE /FILL	% TOTAL FLOODPLAIN IMPAIRMENT
SA010	2,615	15%	14%	1.6%	30.5%
SA020A	326	32%	10%	7.6%	49.9%
SA020B	128	1%	1%	2.3%	4.0%
SA030	874	0%	0%	0.0%	0.2%
SA040	159	0%	19%	1.7%	20.6%
SA050	2,279	0%	13%	0.3%	13.9%
SA060A	202	3%	10%	1.9%	14.5%
SA060B	104	9%	5%	1.7%	15.9%
SA060D	116	43%	16%	7.0%	66.0%
Total	6,803	8%	12%	1.4%	21.2%

The least hydrologically impaired floodplain is reach SA030, which has essentially no impairment. In SA030 there is little development and SR-530 is built along the edge of the floodplain so it does not isolate or shadow any significant portion of the floodplain. However, a section of SR-530 is built directly along the bank where the flow splits around a large forested island near river mile 10, limiting erosion and channel migration of the channel into the floodplain terrace. Reach SA020B also has low floodplain impairment but is also naturally confined by terraces.

The most impaired reach is SA060D. The left bank floodplain is almost entirely disconnected by a dike along the Hampton Lumber Mill, and the Sauk Prairie Rd and bridge shadow a majority of the right bank floodplain.

In reach SA040, SR-530 and the SR-530 bridge shadow most of the floodplain below the bridge. Above the bridge, SR-530 is built along the left bank floodplain edge and a levee protects the road, so floodplain development and channel migration are functionally blocked. The Suiattle River confluence, on the right bank floodplain is a dynamic area but somewhat impacted by spur roads in the floodplain. SR-530 also shadows large portions of SA010 and SA020A.

The right bank floodplain of reach SA020A is bisected by SR-530, isolating the floodplain east of SR-530 and shadowing the western portion. Rural development and residential roads and dikes cause more isolation of the right bank floodplain. On the left bank floodplain, the lower portion of the reach is isolated by the Concrete Sauk Valley Rd. In Reach SA010, SR-530 also bisects the right bank floodplain, shadowing the floodplain to the west and isolating the floodplain to the east of SR-530. The impairment is also increased by Martin Rd and Rockport Cascade Rd, with the combined effect impacting a large portion of the eastern Sauk River alluvial fan and distributary network.

Reaches SA060A, SA060B, and SA050 have similarly low levels of floodplain impairment. In these reaches, most of the floodplain is connected, however roads and dikes cause some disconnection. For SA050, portions of the floodplain are shadowed by the Sauk Prairie Rd and spur roads along the right bank floodplain in the Sauk Prairie area, as well as armored levees near the top and bottom of the reach along the left bank. In SA060A portions of the left bank floodplain are shadowed by diking and fill. In SA060B, impairment is caused by the North Sauk River Rd along the right bank floodplain, and smaller areas are shadowed on the left bank.

Floodplain History, Relative Elevations, and Migration Rates

Natural Systems Design completed a technical memorandum to support characterization of floodplain topography and channel migration processes in the Sauk River. The report is provided in Appendix C. NSD developed a Relative Elevation Model (REM) of 2015/2016 floodplain elevations from LiDAR and analyzed historical channel changes using a GIS database of historical aerial imagery and channel features previously digitized by the Skagit River System Cooperative dating back to 1944. This produced rates of lateral channel migration and changes in active channel width and total channel area, summarized by reach in Table 6 and Table 7 and Figure 7 and Figure 8. A subsequent task completed by NSD developed an REM of 2022 floodplain elevations from LiDAR, which is available via SWC webmaps.

Table 6. Summary of average channel migration rate in reaches SA010 – SA040 for the period 1944-2015.

	SA010 (FT/YR)	SA020 (FT/YR)	SA030 (FT/YR)	SA040 (FT/YR)
1944-1956	31	4	24	3
1956-1972	25	2	15	3
1972-1981	46	8	30	8
1981-1992	30	4	28	10
1992-2006	31	4	16	4
2006-2015	26	4	23	13
1944-2015	**32**	**4**	**23**	**8**

Table 7. Summary of average channel migration rate in reaches SA050 and SA060 for the period 1949-2015.

	SA050 (FT/YR)	SA060 (FT/YR)
1949-1964	38	4
1964-1974	30	3
1974-1981	51	8
1981-1992	26	3
1992-1998	56	7
1998-2006	42	7
2006-2015	38	5
1949-2015	**41**	**5**

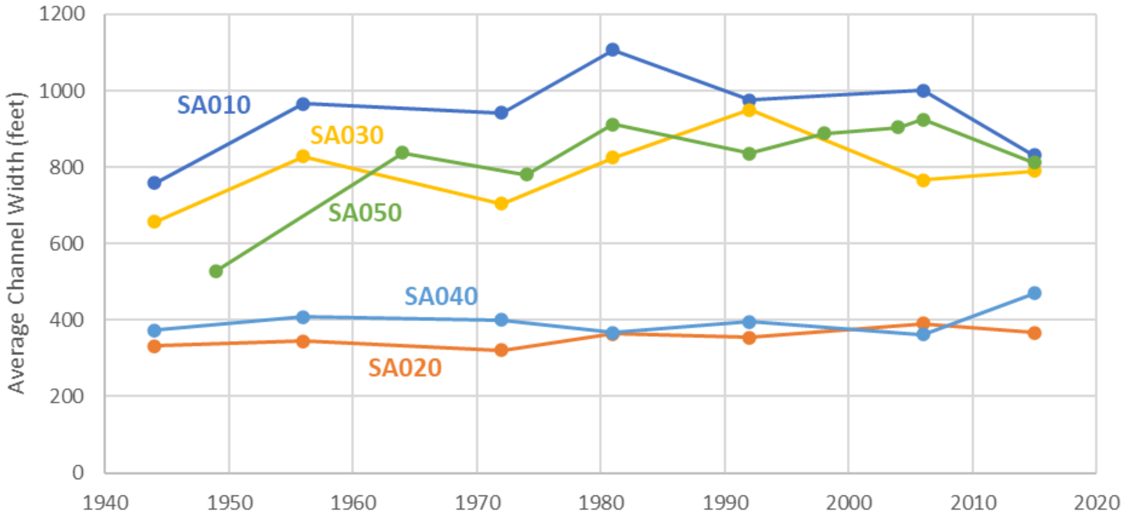

Figure 7. Time series of average channel width, by reach.

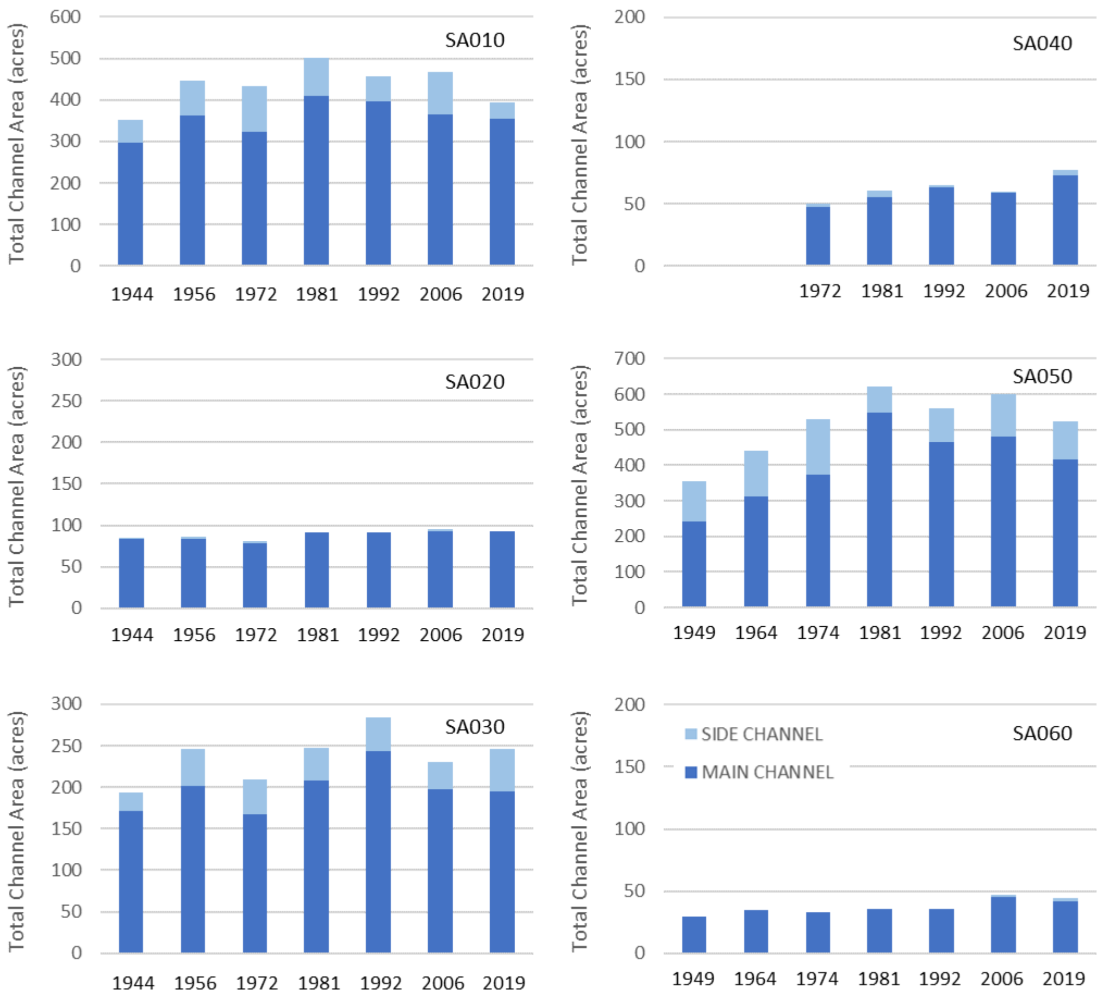

Figure 8. Time series plots showing relative amount of side channel and main channel areas, by reach.

Channel dynamics and channel migration history in the Sauk River were evaluated from the existing record of historical channels digitized by SRSC for use in describing the floodplain landforms in the 2015-2016 REM. Historic channel migration rates for the period 1944-2015 are summarized. The average rate of channel migration ranged between 4 and 41 feet/year and reveals a significant difference in channel migration between the confined (SA020, SA040, and SA060) and unconfined reaches (SA010, SA030, and SA050). Maximum rates of channel migration observed from the historical record are noted for the periods 1972-1981 and 1992-2006 and correspond to the two largest floods in the period of record (December 1980 and October 2003).

Measurements of active channel width reveal reach scale trends toward channel widening over the study period (Figure 7). The three unconfined channel reaches all expanded in width rapidly between the 1940s and subsequent imagery collected in the 1950s and 1960s. Channel width also increased rapidly in the period 1972-1981 (likely due to large flood in December 1980). Reach SA010 has since decreased in width from the maximum in 1981 to yield a net increase of 10% during the period 1944-2015. Reach SA030 continued to widen between 1981 and 1992 and then decreased slightly to yield a net 20% increase in channel width between 1944 and 2015. Reach SA050 was the most sensitive to changes in channel width showing a net 54% increase between 1949 and 2015 (Figure 7).

The database of historical channel features were further evaluated to quantify changes in the total amount of channel area and relative proportions of main channel and side channel areas. A general trend toward increasing amount of total channel area was noted in most reaches (Figure 8), with the magnitude of increase proportional to the changes in channel width noted above. The relative amounts of main channel and side channel areas with the reaches varied with time and by reach. Overall, the proportion of side channel habitat decreased 6% in reach SA010 and 11% in reach SA050 since the 1940s. The relative proportion of side channel area increased 8% in reach SA030 during the same period. Uncertainty associated with limitations identifying and mapping side channel habitat in historical imagery is likely comparable to the differences noted in the results.

Additional discussion and mapping continues in Appendix C, presenting a summary of observations, organized by reach, relating the channel migration history to the distribution of floodplain topography and landform as shown in the Sauk River REM.

Habitat Mapping

Habitat conditions were heads-up digitized with remotely sensed data for the year 2015 by SRSC and provided to the Watershed Council for this analysis. Delineated floodplain habitat types and quantity are shown in Table 8.

Table 8. Reach floodplain types (acres).

REACH	BACK WATE R	BRAID	CLEARE D FIELD	FORESTE D ISLAND	GRAVE L BAR	MAIN STEM	SIDE CHANNE L	VEGE-TATE D BAR
SA010	0.7	17.8	33.0	616.1	210.6	125.6	38.0	252.0
SA020A	0.0	6.5	0.0	12.4	24.1	62.8	0.0	11.2
SA020B	0.1	2.7	0.0	0.2	35.8	37.4	0.1	9.7
SA030	0.2	7.0	0.0	373.6	99.4	89.1	50.1	67.4
SA040	1.5	4.1	0.0	0.0	33.1	35.9	2.6	4.9
SA050	1.5	20.5	10.3	675.3	294.2	102.1	106.7	354.3
SA060D	0.0	5.0	0.0	2.6	7.3	9.2	0.0	4.6
SA060A	0.0	3.2	0.0	3.9	18.1	21.1	1.8	10.5
SA060B	0.1	1.0	0.0	8.2	13.8	29.5	0.0	3.7
Total	4.2	67.7	43.3	1,692.3	736.2	512.7	199.3	718.3

Off-channel area and area per channel length were calculated for all study reaches, with values provided in Table 9.

Table 9. Reach off channel habitat.

REACH	MAINSTEM LENGTH (FT)	OFF CHANNEL AREA (SQ FT)	OFF CHANNEL AREA/CHANNEL LENGTH (SQ FT/FT)
SA010	28,048	1,654,473	59
SA020A	11,290	0	0
SA020B	9,600	2,879	0.3
SA030	18,049	2,180,639	121
SA040	8,237	114,018	14
SA050	34,578	4,649,824	134
SA060A	6,260	79,243	13
SA060B	7,630	0	0
SA060D	2,966	0	0
Total/**Avg**	126,659	8,681,076	**69**

The top three reaches for off channel habitat area are the same reaches with the highest inundation area: SA010, SA030, and SA050 (Table 9). These three reaches account for 98% of all the off-channel habitat across the nine reaches. SA050 and SA030 have the highest amount of off channel habitat, both in absolute area and relative to reach length. Off channel habitat in SA010 is approximately half that of SA030 and SA050 relative to reach length. Notably reaches SA020A, SA060B, and SA060D contain no mapped off channel habitat, though small amounts of off channel habitat are known to exist in both SA060B and SA060D currently.

Existing Habitat Function for Juvenile Chinook Capacity

Habitat classifications for off-channel areas and edge habitat from SRSC 2015 datasets were used to estimate juvenile chinook capacities for each reach following methods from Hayman et al. (1996), the Chinook Salmon Plan (SRSC and WDFW 2005), and SRSC (2011). Areas of side channels from the floodplain typing dataset were used for off-channel habitat. Edge habitat was classified for banks, hydromodified banks, bars, hydromodified bars, and backwaters. Juvenile chinook capacity for each habitat type was calculated by using assumed density constants derived from Hayman et al. (1996) and SRSC and WDFW (2005), and are presented in Table 10. Tables for raw edge habitat areas and juvenile chinook capacity by habitat type and reach are available in Appendix A.

Table 10. Juvenile Chinook rearing capacity by reach

REACH	MAINSTEM LENGTH (FT)	TOTAL FISH	FISH/CHANNEL LENGTH (#/MI)
SA010	28,048	132,060	24,860
SA020A	11,290	39,421	18,436
SA020B	9,600	41,420	22,780
SA030	18,049	82,369	24,097
SA040	8,237	44,843	28,743
SA050	34,578	191,539	29,248
SA060A	6,260	26,857	22,652
SA060B	7,630	23,931	16,560
SA060D	2,966	16,006	28,492

The highest juvenile Chinook rearing capacities per mile are in reaches SA050 and SA040. Most reaches have similar juvenile Chinook rearing capacity relative to reach length, aside from SA020A and SA060B which were lower than the other reaches. All other reaches have rearing capacities in the mid to high 20,000’s of fish per mile of channel length. Similar capacity between reaches is somewhat surprising considering the larger amounts of off channel habitat in reaches SA010, SA030, and SA050, but mainstem edge habitats contain higher densities than off-channel areas (Hayman et al. 1996; SRSC and WDFW 2005).

Long-term Protected Lands

Assessment of existing land protection in the floodplain helps inform the progress of past actions and the potential for future restoration and additional land protection via conservation easements and land acquisitions. Overall, 58% of floodplain lands in the Lower Sauk Reach Assessment study area are already protected. Reaches SA030 and SA050 have the highest amount of floodplain already protected with over 80% of floodplain in conservation (Table 11). Both reaches have large floodplains and low floodplain development, so they are likely good candidates for identifying restoration actions within the already protected floodplain.

Table 11. Protected lands in the Lower Sauk River.

REACH	FLOODPLAIN AREA (AC)	PROTECTED ACRES	% PROTECTED FLOODPLAIN
SA010	2,615	1,081	41%
SA020A	326	38	12%
SA020B	128	64	50%
SA030	874	713	82%
SA040	159	79	50%
SA050	2,279	1,846	81%
SA060A	202	67	33%
SA060B	104	43	41%
SA060D	116	12	10%
Total	6,803	3941	58%

Reaches SA020B and SA040 have the next highest protection with 50% of floodplain land protected, followed by SA010 and SA060B with 41% protected floodplain, and SA060A with 33% protected floodplain. If this study had quantified protected lands above river mile 25, their percentage in SA060B would increase dramatically since Forest Service ownership becomes nearly continuous at that point.

Floodplain Forest Conditions

Vegetation conditions in floodplains and their riparian areas are important factors in the formation and maintenance of aquatic habitats. For instance, they provide shade to lower temperatures and woody debris for pool formation and fish cover. This assessment used SWC's 2013 riparian condition data (ESA 2017) to simply analyze forest versus non-forest conditions in the floodplain reaches. Non-forest cover is reported in Table 12 by acre and percent floodplain.

All reaches except SA060D have greater than 80% floodplain forest area. The Hampton Lumber Mill, its compost pit, and other floodplain development are the causes of floodplain forest loss in SA060D. The reach with the most intact forest is SA030 with a 97% intact forest.

Table 12. Reach floodplain forest condition.

REACH	FLOODPLAIN AREA (AC)	NON-FOREST (AC)	% NON-FOREST
SA010	2,615	441	17%
SA020A	326	49	15%
SA020B	128	23	18%
SA030	874	29	3%
SA040	159	16	10%
SA050	2,279	169	7%
SA060A	202	17	8%
SA060B	104	13	13%
SA060D	116	51	44%
Total	6,803	808	12%

Large Wood Dynamics Analysis

Large wood is an important element of geomorphic and biotic processes in rivers of the Pacific Northwest. Stable large wood and log jams function as hard points that resist erosion, form islands and allow maturation of riparian trees on floodplain surfaces, form scour pools, and promote hydraulic complexity and sediment sorting (Montgomery and Abbe 2006, Collins et al. 2012). Impaired large wood processes were hypothesized as a driver of the increase in active channel width documented within Reaches 010, 030, and 050 in the channel migration analysis conducted by Natural Systems Design (Appendix C). Within Reach 050 large wood dynamics were analyzed to assess the stability and persistence of log jams and examine trends in large wood abundance. A full memo describing the large wood dynamics analysis is available in Appendix D, and a brief summary is presented in this section.

Aerial imagery was used to digitize log jams larger than 200 m^2 present within Reach 050 in 1981 and tracked the fate of those jams through 2015. 200 m2 was used in this analysis to accommodate resolution of the 1981 aerial imagery and reduce measurement error. Roughly half the log jams present in 1981 were washed away a decade later and 29% persisted through 2015, indicating most log jams are not stable even considering the analysis only included jams larger than 200m^2. The quantity and area of log jams was also examined using datasets from 1981, 2005, and 2013. From 1981 to 2013 both log jam quantity and area markedly decreased (Figure 9). The lack of stability and persistence of log jams and the overall decrease in log jams over the last 30 years suggest large wood processes are impaired within Reach 050 and likely within Reach 010 and Reach 030 where channel widening has occurred. Channel widening through forested floodplain results in large wood recruitment to the channel, however the observed decrease in wood abundance from 1981 to 2013 suggests that wood is being lost faster than replacement in the Sauk. This is likely the result of multiple factors that include: (1) the historic removal of large floodplain trees that form stable large woody material when recruited to the channel, and (2) limited time for recovery of large trees within the Sauk River's channel migration zone.

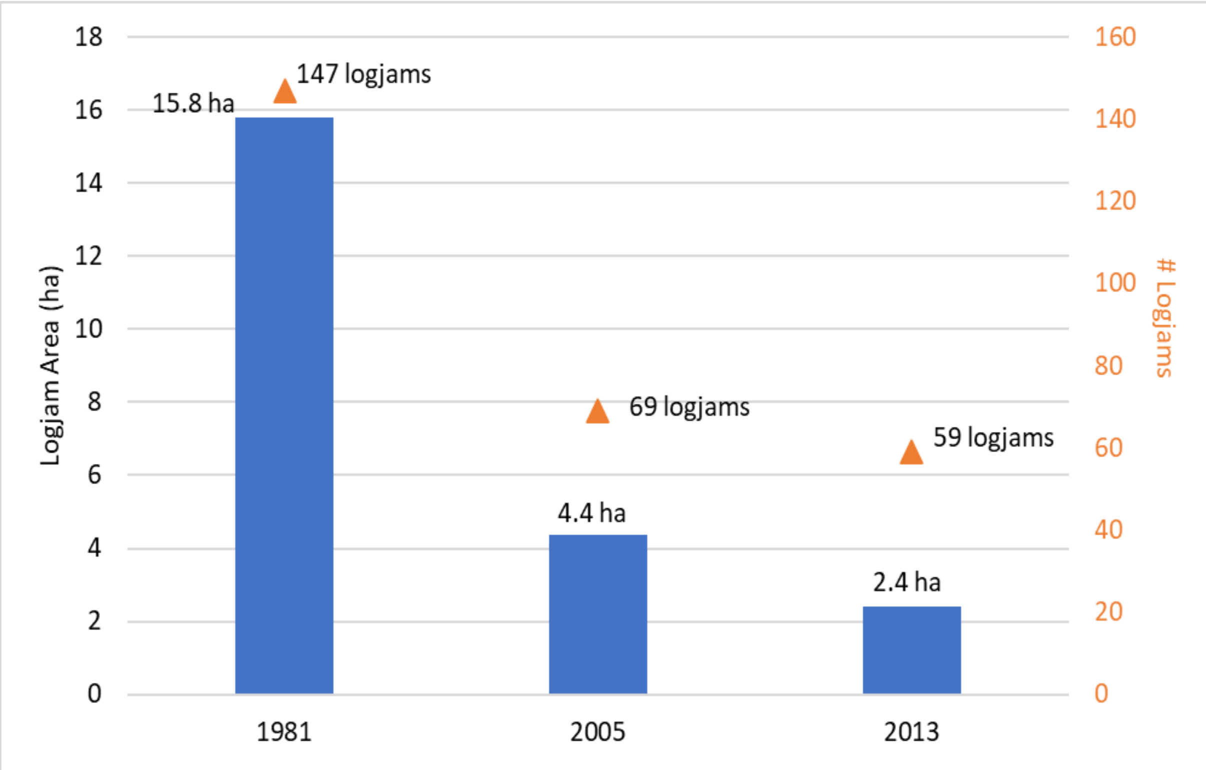

Figure 9. Logjam area and number of large logjams (>200 m^2) from 1981 to 2013. 2005 data from Snohomish County, 2013 data from Beechie et al.

Reach Assessment

This Plan uses the empirical data sets described in the previous sections to qualitatively rate floodplain reaches based on the conceptual model described in Figure 10. The conceptual model includes geomorphic potential, existing habitat function, and floodplain impairment as the primary factors for rating reaches. Geomorphic potential was considered the most important factor for identifying high priority reaches because dynamic channels and large floodplain areas are essential for creating and maintaining the floodplain and mainstem salmon habitats that are the focus of this Plan's goals. Existing habitat function and level of floodplain impairment were primarily used to distinguish between protection and restoration categories.

To rate reaches based on the conceptual model, one or two metrics were used for each factor and reaches were ordered based on the results. Reaches were compared on a relative scale, with the highest performing reaches rated as "High" for each factor and the lowest performing reaches rated as "Low." Each factor in the model is described below followed by tables with all metrics used to rate the reaches (
Table 13 – Table 15) and the summary reach evaluation matrix (Table 16) that compiles the rating calls for each factor to make a recommendation for restoration and protection priorities.

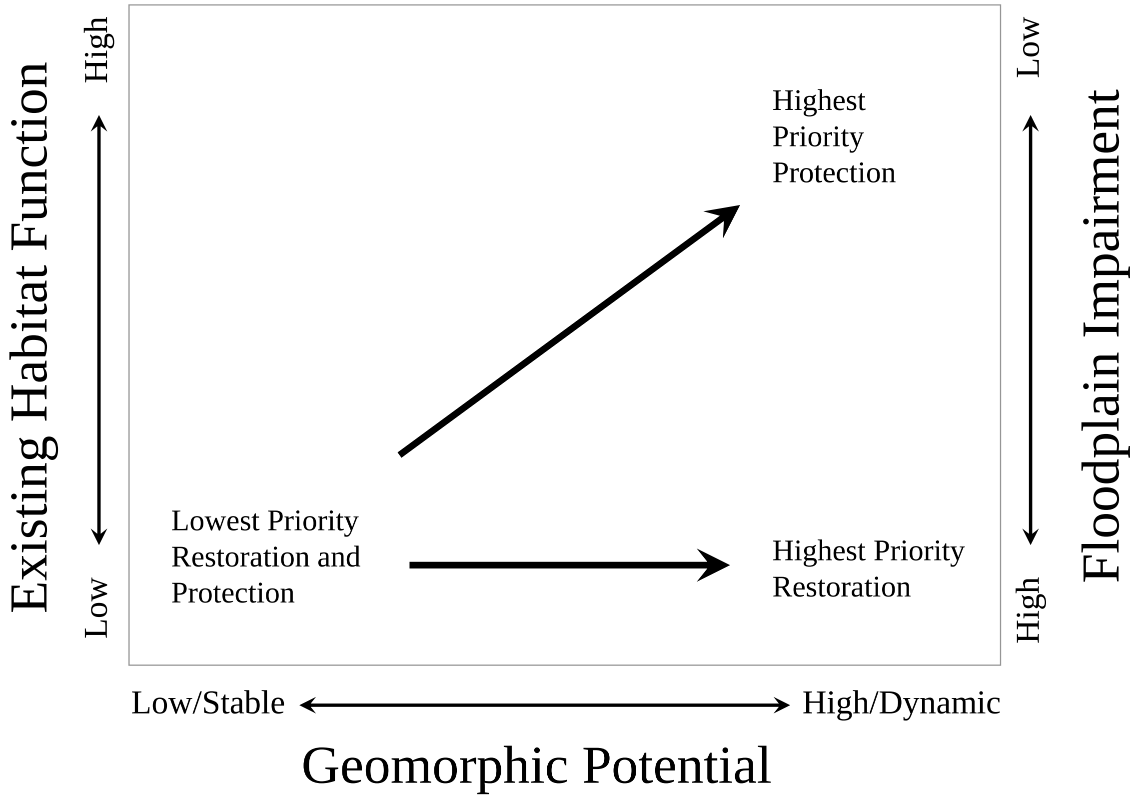

Figure 10. Conceptual model for rating reaches (SRSC 2011).

Geomorphic Potential Indicator Ratings

Geomorphic potential is evaluated by floodplain inundation and the amount of off channel habitat. Floodplain inundation was assessed using the 10-yr recurrence flow. Hydraulic modeling was performed using existing conditions, so hydromodifications and other infrastructure shadowing or isolating portions of the floodplain are reflected in the model results. Because existing conditions were used, the results do not represent the true geomorphic and floodplain inundation potential if floodplain infrastructure were removed to allow full connectivity. Qualitative ratings are provided in Table 13.

Table 13. Reach floodplain inundation and off channel habitat ratings.

REACH	INDUNDATION RATING	OFF CHANNEL HABITAT RATING
SA010	Very High	High
SA020A	Medium	Low
SA020B	Low	Low
SA030	High	Very High
SA040	Low	Medium
SA050	Very High	Very High
SA060A	Medium	Medium
SA060B	Medium	Low
SA060D	Low	Low

Existing Habitat Function Indicator Ratings

Existing habitat function is assessed by examining the juvenile Chinook rearing capacity for each reach. The juvenile Chinook rearing capacity is a measure of the amount of available habitat, so the more habitat available the greater rearing capacity. The quality of habitat also influences the rearing capacity with some habitats such as backwaters or natural banks providing greater rearing capacity than others such as hydromodified banks or open water. Rearing capacity is also normalized by mainstem length to account for differences in reach length. This Plan's existing habitat ratings are a function of both total Chinook rearing capacity per reach and capacity/mile since the ratings apply at the reach scale (Table 14).

Table 14. Existing habitat function by reach as indicated by rearing capacity rating.

REACH	EXISTING REARING CAPACITY RATING
SA010	Medium
SA020A	Low
SA020B	Low
SA030	Medium
SA040	High
SA050	High
SA060A	Low
SA060B	Low
SA060D	Medium

Caution should be used in comparing reaches based solely on these estimates of juvenile chinook capacity. Given the similarities in normalized juvenile Chinook rearing capacity, other factors such as geomorphic potential and floodplain impairment are likely more important for assessing which reaches should be targeted for protection versus restoration, a procedure which was used in the Sauk Plan's final reach ratings. Additional assessment of habitat capacity and quality could also be done to refine relative rankings for restoration and protection. Indicators of spawning areas or most limited populations' (e.g. Lower Sauk summer Chinook) primary spawning and rearing could also be considered.

Floodplain Impairment Indicator Ratings

The primary metric used to determine floodplain impairment was the percentage of floodplain area shadowed, isolated, or filled. A secondary metric used for evaluating floodplain impairment was the percent of floodplain cleared of native forests due to human modification with the assumption that areas cleared for development, agriculture or other purposes are likely to continue to have poor floodplain function unless they are restored. Ratings for both are shown in Table 15.

Table 15. Reach floodplain impairment ratings.

REACH	FLOODPLAIN IMPAIRMENT RATING	RIPARIAN FOREST IMPAIRMENT RATING
SA010	High	Medium
SA020A	High	Medium
SA020B	Low	Medium
SA030	Low	Low
SA040	Medium	Medium
SA050	Medium	Low
SA060A	Medium	Low
SA060B	Medium	Medium
SA060D	High	High

Summary of Reach Assessment Results

To summarize the findings from the reach evaluation, the reaches are ranked in a qualitative way similarly to the Middle Skagit Plan. The reaches are assigned a High, Medium, or Low ranking for each of the evaluation categories. Reaches with high existing habitat function, geomorphic potential, and low floodplain impairment are highest priority for protection. Reaches with low existing habitat function but high geomorphic potential and high floodplain impairment are highest priority for restoration. As noted above, reach-level habitat function received lower weight than other factors.

Unlike the Middle Skagit Plan, indicator values in the Sauk reaches were not equally distributed across their numerical ranges and thus did not easily align in equal numbers of High, Medium, and Low. Instead, indicator ratings were graphed amongst themselves first and then graphed against each other as in Figure 10 for both protection and restoration conceptual models. Aggregations of reaches were identified across the rating spectrum and these aggregations formed high, medium and low bins for the final protection and restoration ratings (Table 16). Ratings in Table 16 vary modestly from initial rating calls made by NSD in Appendix A.

Table 16. Reach evaluation matrix summarizing assessment results.

REACH	GEOMORPH POTENTIAL	FLOODPLAIN IMPAIRMENT	HABITAT FUNCTION	PROTECT	RESTORE
SA010	High	High	Medium	High	High
SA020A	Med/Low	High	Low	Low	Low
SA020B	Low	Low	Low	Low	Low
SA030	High	Low	Medium	High	Medium
SA040	Med/Low	Medium	High	Medium	Medium
SA050	High	Medium	High	High	High
SA060A	Medium	Medium	Low	Medium	Medium
SA060B	Med/Low	Medium	Low	Medium	Medium
SA060D	Low	High	Medium	Low	Low

Reach Priorities

Throughout this evaluation three reaches stand above the others: SA010, SA030, and SA050. These reaches have considerably larger floodplains, the most dynamic channels, and highest current and potential geomorphic function. The key difference between the reaches is the level of floodplain impairment. To further characterize floodplain impairment, both the absolute area of impairment and percent of total floodplain impaired were considered since there is a wide size range among reaches.

SA010 has a high amount of floodplain impairment in both area and relative percent of the floodplain. SA050 contains a relatively low percentage of impaired floodplain however the area of impairment is second only to SA010 (Table 5). SA030 has an intact floodplain with low impairment, so protection is indicated as a higher priority than floodplain restoration.

Conversely, reaches SA020A, SA020B, and SA060D rated well below other reaches for both protection and restoration. This was driven by their low areas of flood inundation and their lack of mapped off-channel areas. These reaches did exhibit a range of floodplain impairments ratings, but their low geomorphic potential and relatively low existing habitat capacity did not allow their restoration calls to be rated higher than low.

Low-rated reaches were not considered much further in this portion of the assessment for obvious reasons, but it’s important to note that site specific actions and stewardship of these reaches could still be important. Additionally, SA060D is a particularly diverse reach that deserves attention because it has both the bottom end of a particularly functional and geomorphically-rich reach above the Sauk Prairie Road bridge as well as a highly impacted and isolated floodplain built over by the Hamilton Lumber Mill and its compost pit. This Plan’s rating system wasn’t robust enough to demonstrate the complexity and opportunities of this reach.

Falling between the clearly rated high and low reaches were three reaches rated as medium for protection and restoration, including SA040, SA060A, and SA060B. SA040 is the critical confluence and alluvial fan reach with the Suiattle River. While the two rivers together form a dynamic, biological hotspot, this Plan’s lack of flood inundation data and rating system failed to account for its unique qualities. While SA060A and SA060B aren’t the highest rated for protection and restoration, they both add significant value and opportunities for future work. SA060A is a relatively wide floodplain in the context of the Sauk River above Darrington; has two functional off-channel areas currently on both sides of the river; and has significant restoration opportunities that could normalize this historically impacted area. SA060B stands alone in this assessment as a result of the data limitation describing only the lower 1.4 miles of an otherwise long and relatively unimpaired floodplain. While the publicly-owned upper area of this reach has relatively limited protection and restoration needs, subsequent sections of this Plan will describe highly beneficial and feasible restoration concepts at its downstream end.

While grouped similarly, the habitat protection and restoration needs vary considerably and by degrees among the reaches, as elaborated upon further in this Plan.

6 PROTECTION AND RESTORATION STRATEGIES AND TREATMENTS

Restoration and protection strategies and treatments were adopted from the Middle Skagit Plan and new treatments were considered where needed to address habitat limiting factors identified in this Plan. Specific, conceptual habitat actions appropriate to the strategies and treatments were generated and analyzed for benefits and impacts to the salmon habitat and community-based principles using criteria as screening factors. Strategies were based on the conceptual model for ranking the reaches (Figure 11) using the reach assessment results and the data sets described above. The relative size of the arrows in Figure 11 indicates that more habitat is gained from restoration in geomorphically dynamic reaches.

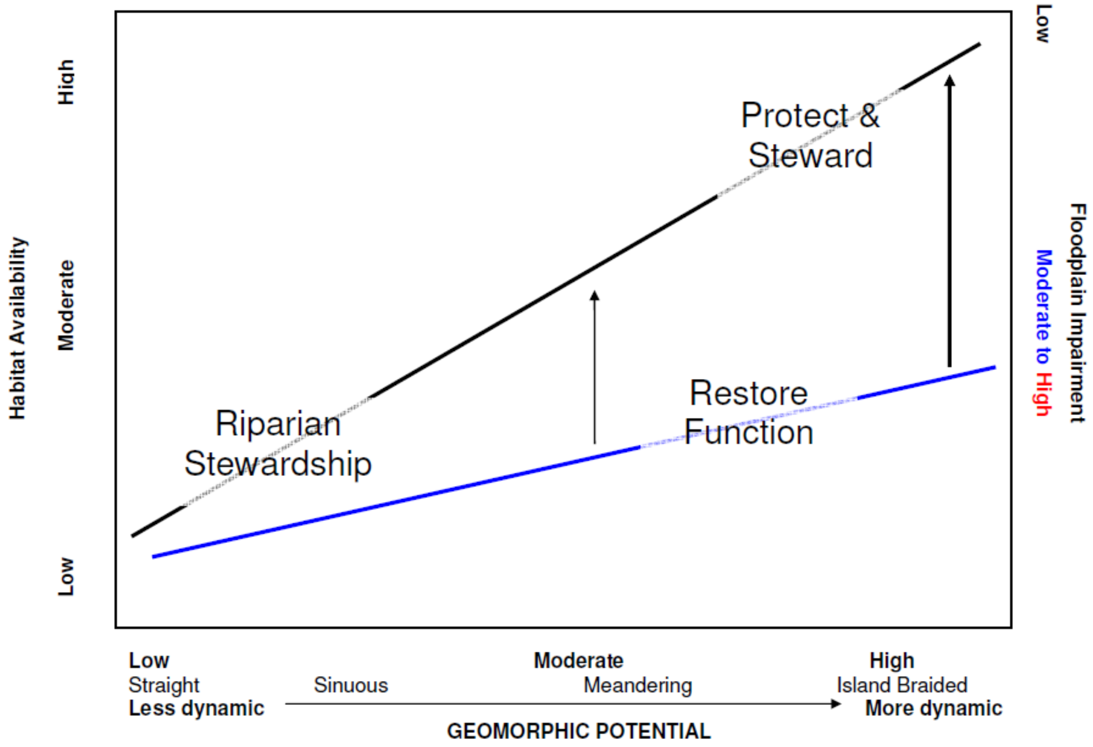

Figure 11. Conceptual model for generalized reach strategies.

Strategy Summary

The habitat protection and restoration strategies fall into five main categories: protection, restoring floodplain processes, improving existing habitat, landowner stewardship, and planning & research. More specific actions fall within each of those categories. The general strategies and treatments are summarized in

Table 17.

Table 17. Sauk Habitat Plan strategies and treatments.

STRATEGIES	TREATMENTS
Protection	Acquisitions to protect high quality habitats
	Regulatory enforcement to protect habitats
Restoring Floodplain Process	Acquisitions to enable priority restoration actions
	Remove modifications to reconnect isolated habitats
	Remove modifications to restore habitat forming processes
	Reforest floodplains
	Maintain plantings and control invasive species
Improve Habitat	Remediate bank armor to improve edge habitat
	Improve in-channel habitat
	Increase side channel connectivity
	Channel stability via engineered log jams
	Reduce impacts from recreational activities
Landowner Stewardship	Reforest floodplains
	Maintain native vegetation
	Reduce pesticide use and other contaminants
	Livestock exclusion
More Information	Technical assessments
	Project planning
	Infrastructure planning for strategic retreat
	Ecological research

Generalized Hierarchical Strategy

The Middle Skagit Plan and this Plan adopted a hierarchical strategy for prioritizing protection and restoration actions (Figure 12) based on a scheme from Roni et al. (2002) and revised in Roni et al. (2008). This framework has been adapted here for considering how restoration strategies and actions should be considered in a stepwise process to establish their relative priorities and other factors for successful implementation. Strategy numbers are cross-walked with criteria in Table 18 and identified for each project concept in Appendix E.

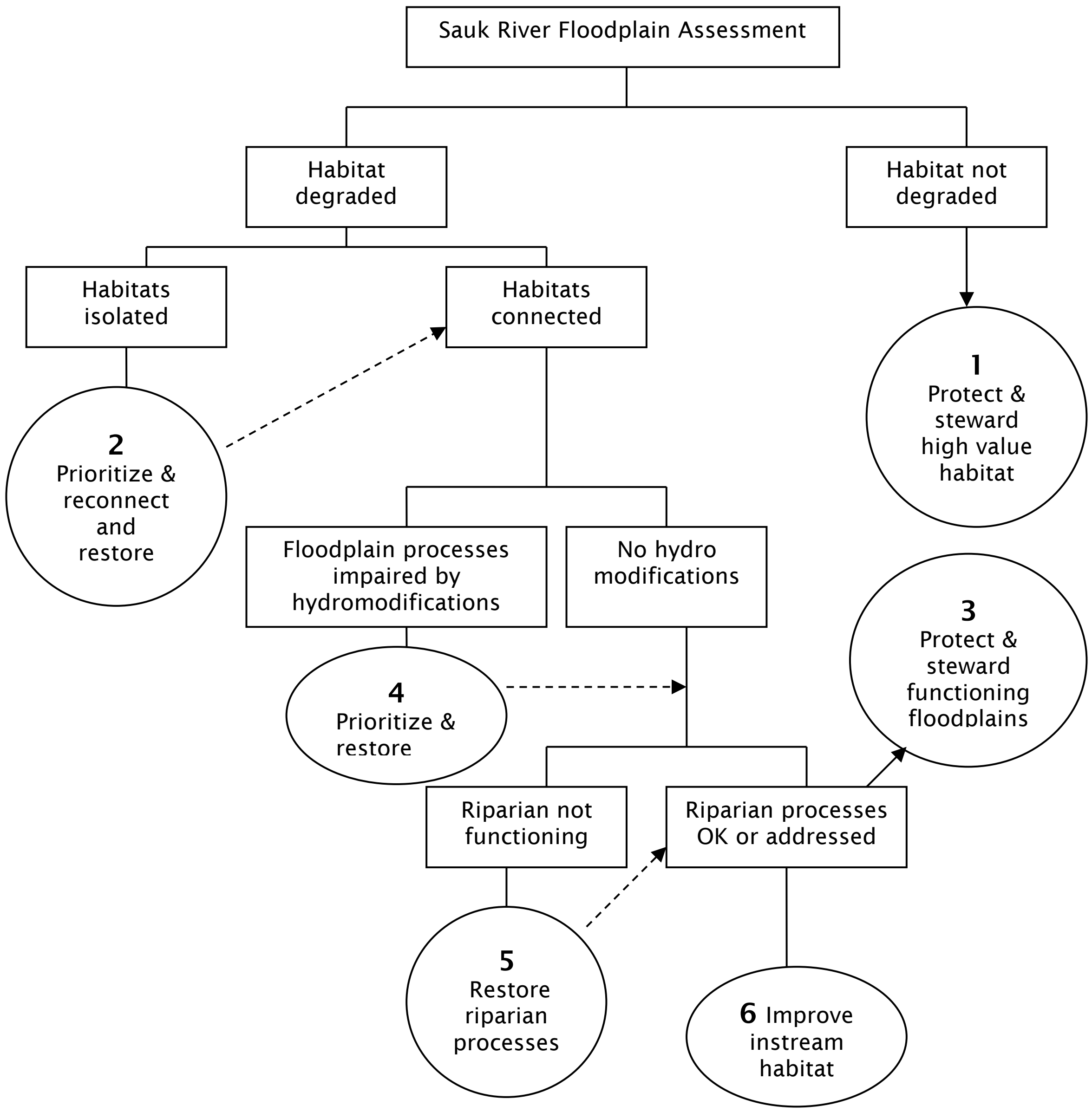

Figure 12. Hierarchical strategy for prioritizing and sequencing restoration activities in the Sauk River (adapted from Roni et al. 2002 & 2008). The numbered actions in ovals indicate priority sequence with associated criteria defined in text.

1. Protecting high value habitats is our highest priority. High value habitat is defined as those habitats supporting higher densities of juvenile Chinook (SRSC and WDFW 2005). Criteria for protecting high value habitats:
   a. Property complies with 2023 SWC Protection Strategy Update.
2. The next highest priority is reconnecting isolated channel habitats that benefit juvenile Chinook. Because reconnecting existing isolated habitat provides an immediate known benefit with little uncertainty, these actions are the first restoration priority.
3. Our next priority is protecting functioning floodplain areas, defined as: floodplains not highly impeded by roads, bank protection or other structures; and with natural or native vegetation intact.
4. Where floodplain and channel habitats are impaired by hydromodifications, habitat-forming processes are also impaired. However, more uncertainty is associated with removing hydromodifications to restore floodplain processes than reconnecting isolated channel habitats, hence a lower priority for restoration.
5. The success of projects to improve instream habitat structure and stability is dependent on first addressing the processes or factors limiting the existing habitat where possible, which is why riparian restoration should occur prior to or simultaneously with any projects to install instream structures. For consistency with the Middle Skagit Plan (SWC 2011), priority areas for riparian restoration or underplanting in order of importance are listed below. However, current policies for replanting projects with their primary purpose of revegetation for salmon recovery should meet one, 200-year site potential tree height with limited exceptions.
   a. Unforested or alder-dominated areas within 150 feet of existing mainstem, tributary, or off-channel habitat
   b. Unforested or alder-dominated floodplains within area inundated at 10-year flow (frequently flooded areas)
   c. All other unforested areas within the geomorphic floodplain and within 132 feet of that floodplain
6. After first addressing the processes and factors limiting habitat, projects to improve site-scale, instream habitat, connectivity and floodplain structure (such as woody debris and engineered log jams) or bank conditions can be successful.
7. Where information limits understanding of habitat-forming processes or high priority project implementation, further investigations are warranted. An example of this is the question of how to address reach-scale changes in channel stability because of the loss of large, relict woody structures and stable forested island edges.
8. Implement multiple treatments and strategies together that will lead to higher quality habitat than would be achieved with one strategy alone.
9. Artificial creation of off-channel rearing habitat has not been deemed a sustainable strategy in most places attempted in Washington State. However in degraded areas within built environments with no near-term potential for process-based restoration, it may provide temporary relief in some juvenile salmon density-dependent habitat situations. Evaluation of this strategy is on-going and should be approached with care and research.

7 RESTORATION PRIORITIES

This section contains methods and projects for conceptual Sauk River reach restoration and the criteria for analyzing and screening them into categorical recommendations.

Project Evaluation Criteria

The following criteria provide for assessment and screening of conceptual projects based on reach priority, restoration strategy and action type, habitat area gained or improved, community impacts, and relative cost (Table 18).

The screening process deviated from the Middle Skagit Plan by moving from a scoring and ranking procedure to a rating and screening approach that is more qualitative than quantitative. The change in approach allows for an analysis that considers concepts in a range of criteria and management categories.

Table 18. Criteria for rating restoration actions in the Sauk River. Numbers refer to strategy priorities in Figure 12 and described in Generalized Hierarchical Strategy.

CRITERIA	QUALITATIVE RATING		
	LOW	MEDIUM	HIGH
Reach Restoration Priority	Reaches 20A, 20B, 60D	Reaches 30, 40, 60A, 60B	Reaches 10, 50
Strategy and Action Type	Riparian restoration – Smaller (#5) Bank remediation (#6) LWD or instream treatment at local scale (#6) Create rearing habitat (#9)	Reconnects isolated other habitat (#4) Restores floodplain processes (#4) Riparian restoration – Larger (#5)	Reconnects isolated channel habitat (#2) Multiple treatments & strategies combined that lead to higher quality habitat than would be achieved with one strategy alone (#8)
Habitat Gain or Improvement: Increase in Channel and Floodplain Area	Small, local scale; <1,000ft channel; <25ac floodplain	Moderate scale	Large, reach scale; >4,000ft channel; >50ac floodplain
Community Impacts	Mostly public lands No changes in public use	Small number of private landowners involved, some public lands Modest changes in public use	Large number of private landowners involved Large changes in public use
Relative Cost	Lower $; no roads; no land purchase; no flood/erosion protection	Medium $; minor roads; engineered designs but lower flood/erosion protection	Higher $; major roads; >5 parcel purchases; flood/erosion protection

Reach restoration priorities were established in the reach assessment above (Section 5) and documented in the table above. Reach protection priorities were not used to screen restoration priorities.

Strategy and action types were adapted from the Middle Skagit Plan. Adaptations to the ratings framework were made to better fit the Sauk River environment and to reflect evolution in our strategic approaches to restoration over the last 12 years since the Middle Skagit Plan was written. An example includes recognition that larger riparian plantings restoring long-term floodplain functions are essential to habitat creation and maintenance.

Estimates for habitat gain were made for each conceptual project described below using data developed in Section 5 and best professional judgement given the lack of hydraulic modeling for proposed conditions. Polygons were digitized to estimate the area of potential effect. These estimates of channel and floodplain area were charted for all concepts to see the range of anticipated benefits and to determine natural breaks that would best fit low, medium and high ratings. There is both error and subjectivity in this criterion analysis which should be considered in applying this as a screening factor. However, this criterion is essential for screening for the highest benefit actions.

Also essential to this Plan are the potential impacts to social and economic principles described in Section 4. The area of potential effect maps estimated for each concept were used to quantify the number of parcels affected by each concept, the type of ownership of those parcels, the extent of impact of current use of those parcels, and the extent of impact to current use of the area and perceptions by the public in general. Examples of this latter type of use evaluated include loss of public access to waterways or public campgrounds or reduction in transportation choices.

Relative cost is also an important social and economic principle. Given the lack of detailed analysis of each concept it was not possible to estimate absolute costs. However, many scores of voluntary projects across the range of habitat strategy and action types over the last 25 years in Puget Sound provided the ability to assign concepts into rating bins, while noting the potential for error due to scoping limitations. Major factors to support this screening are noted in Table 18, including number of parcels necessary for purchase; type and extent of public infrastructure such as highways versus driveways; and whether significant engineering and flood/erosion protection components were likely necessary for successful project implementation.

Conceptual Project Development

Geomorphic reach assessment data, maps, and reports were comprehensively reviewed to conceptualize initial locations and ideas for potential restoration strategies and actions in the lower 24 miles of the Sauk River mainstem. Conceptual projects are considered here as a collection of one or more conceptual habitat actions that can be described, mapped, and analyzed quantitatively and qualitatively to ascertain the range of benefits and impacts that could be anticipated if implemented. These conceptual-level projects are not proposed or recommended projects, but instead are intended to capture a full range of potential actions and outcomes that can then be screened into categories based on the criteria presented. Subsequent sections of this plan describe habitat action recommendations screened from these conceptual projects for further consideration.

The most relevant data collected in the reach assessment and used to identify the first round of conceptual projects are shown in a series of maps (Appendix B) prepared to communicate floodplain conditions visually. Early in this project information on current, past, proposed, or stalled restoration or protection efforts in the study area were collected. The summary information collected was captured on data sheets and maps and incorporated into this Plan's learning and project development.

Map features were often reviewed in the field to verify native conditions. This provided a catalogue of photos for various sites and field-marked maps. It was not unusual to find incorrect or missing information in the remote-sensed map data from 2015 or earlier. While there are many examples of discrepancies (including recently eroded bank hydromodifications or smaller berms or road fill not in the floodplain impairment database), they were addressed by ensuring conceptual project conditions were ground-truthed where public access was allowed and by creating a new polyline shapefile of floodplain fill incorporated into the Plan and outputs going forward.

Following the methods in the Middle Skagit Plan, multiple maps were prepared (Appendix B), including a map to identify high value existing habitat (Map 1). The following data was used: 2015 habitat mapping, 2022 protected lands, 2015 hydromodifications, geomorphic floodplain, floodplain connectivity and 2022 aerial imagery. High priority areas for protection are the edge, backwater, off-channel, tributary junction, and riparian habitats mapped within the "unprotected" areas and displaying the highest quality and quantity of habitat relative to one another. Section 8 and Appendix F of this Plan further describes the SWC Protection Strategy Update (2023) conducted as a component of this Plan that quantified and compared salmon habitat quantity and quality and connectivity across all priority floodplains and their riparian parcels.

To identify priority areas for reconnecting isolated habitat (Map 2) we used the following data: 2015 habitat mapping, 2015 hydromodifications, and 2022 LiDAR hillshade to identify potential isolated floodplain channels and tributaries. Conceptual restoration sites were identified where mapped hydromodifications or roads intersect with identified rearing habitats. Concepts identified on Map 2 are incorporated into conceptual project development and Appendix E1. Culvert inventories were not incorporated into this analysis, likely resulting in missed identification of additional opportunities. Other isolated habitats are likely to have been missed. A systematic field survey of this area for channels and obstructions could net additional habitat reconnection sites. Recommended priority project sites were screened from the conceptual projects using criteria from Table 18, documented in Appendix E1, and described further in Section 8. In summary, opportunities to reconnect isolated rearing habitats exist in the Sauk River but are of a different nature and number than the Middle Skagit. There are a relatively smaller number of currently isolated rearing habitats such as shoreline hydromodifications cutting off floodplain channels or blocking culverts at tributary junctions. Of much higher significance in the Sauk River due to its dynamic channel instability and low summer flows is diminished (but not isolated), low flow side channel connectivity from the active mainstem. This opportunity for restoration is discussed below in subsequent sections of this Plan.

Data used to identify priority areas for protecting functioning floodplains in Map 3 include: protected lands, floodplain vegetation, and floodplain connectivity. High priority areas for protection of functioning floodplains are those forested areas not shown overlain by either protected lands or as isolated or shadowed hydromodifications. This mapping effort provided for a visual analysis of parcels of unprotected forest lands in the Sauk floodplain, though specific parcels must meet empirical thresholds established in the SWC Protection Strategy Update (2023) if salmon recovery funding is to be utilized for protection of high quality habitat as opposed to restoration.

The following data were used to identify conceptual and priority project sites and actions for restoration of impaired floodplains, and together with those conceptual and priority project sites compose Map 4: current habitat mapping, hydromodifications, floodplain connectivity, geomorphic floodplain, 10-year flow inundation, REM, and 2022 floodplain fill. Conceptual sites and actions crossing the range of this Plan's habitat strategies were generated to address habitat stressors associated with floodplain impairments and shoreline hydromodifications. These concepts focused on addressing identified, reach-scale stressors. Effort was made to identify concepts exploring a range of different habitat opportunities, recognizing that not all concepts were equally beneficial or impactful or feasible. However, this concept development effort stopped short of conceptualizing a few actions that had community impacts too high to justify the perceived habitat benefits at this time. For example, the construction of Hamilton Lumber Mill obliterated many acres of floodplain channels and confined the remaining mainstem, but its importance to the local economy and Darrington override conceptualizing habitat restoration at this time. An additional example is smaller-scale shoreline hydromodifications that may protect important transportation infrastructure but not have much of an impact on floodplain rearing habitat. In addition, this concept development effort did not conduct a thorough assessment of SR530 nor establish a complete list of strategic relocation or bank remediation sites for this state highway. Site scale stressors and related restoration concepts were also excluded from this assessment but should be considered for future implementation as opportunities arise and community impacts can be minimized. Recommended priority project sites were screened from the conceptual projects using criteria from Table 18, documented in Appendix E, and described further in Section 8. Restoration concepts were categorized into high priority, other priority, and infrastructure planning approaches. Each of these was categorized into short or long-term recommendations. Note that future changing conditions unknown at the time of this report could cause changes in future priorities and timelines.

The floodplain vegetation data described in Section 5 above were used to identify the priority areas for riparian restoration described in Section 6. Mapped datasets in Map 5 include floodplain vegetation at various distances from aquatic habitat. For consistency purposes with the Middle Skagit Plan, high priorities for riparian restoration are unforested areas within 150 feet of existing mainstem or off-channel habitat; unforested floodplains inundated within the modeled 10-year flow; and unforested areas within the geomorphic floodplain, in that order. Table 19 provides a summary by reach of those high priority areas. Not all unforested areas are impaired but instead may be naturally revegetating gravel bars as they go through the successional process following natural disturbance, mainly flooding, erosion, and deposition. It should be noted that current salmon habitat funding for projects with their primary purpose as revegetation should extend to one, 200-year site potential tree height (SPTH), with specific exceptions as noted in the most recent SWC Lead Entity Program Guide.

Table 19. Total unforested areas in acres by reach.

REACH	UNFORESTED WITHIN 150 FT OF 2015 CHANNELS (AC)	UNFORESTED WITHIN 10 YEAR FLOOD (AC)	UNFORESTED FLOODPLAIN (AC)
SA010	69.4	264.1	441.2
SA020A	14.8	5.8	49.4
SA020B	12.8	2.5	23.2
SA030	12.1	6.7	28.7
SA040	8.3	1.0	15.8
SA050	37.7	41.7	169
SA060A	6.2	3.2	16.5
SA060B	6.0	4.2	13.2
SA060D	7.8	1.8	50.7
Total	175.0	331.2	807.8

The list of conceptual and priority projects in this report is not inclusive of all potential or known restoration locations or activities for three reasons: resolution, scale, and public access. There are limits to the data collected and photography used, in particular identifying floodplain channels under forest canopy and bank hardening covered in silt and vegetation. For the purpose of this effort, we were targeting projects with larger benefit vital to watershed and regional Chinook recovery. Site reviews were not conducted on private lands where permission was not obtained in advance of field reviews.

8 PRIORITY HABITAT ACTIONS

The priority habitat actions presented here were first and foremost based on salmon habitat recovery and social and economic principles described above and in the context of the Sauk River's unique geomorphic and ecological conditions. These recommendations are meant to both guide the Watershed Council's future work and communicate the priority floodplain habitat opportunities for Chinook salmon within the lower 24 miles of the Sauk River. To accomplish this, it will be important to continue learning; coordinating and sharing information among stakeholders; taking actions; and publicly documenting progress and lessons learned.

Protection of High Quality Habitat

As noted in Section 6 and Figure 12, it is imperative that existing salmon habitats are protected and stewarded into the future to ensure our quality of life and long-term viability of salmon and steelhead in the Skagit and Sauk Watersheds. All watershed habitats will benefit from the strategies described in this plan (

Table 17), including voluntary stewardship of public and private lands, enforcement of existing regulations, and voluntary acquisition of private lands by public entities where the highest quality rearing habitats remain and are under threat of degradation.

This Plan lays the foundation for voluntary acquisition of the best remaining salmon and steelhead habitats in the Sauk River as identified in the geomorphic reach assessment. Table 16 rates the nine reaches of the Sauk River mainstem as either high, medium or low priority for protection. The highest priorities for protection are the most active geomorphic reaches with the highest habitat function and the lowest floodplain impairments: reaches SA010, SA030 and SA050. This is generally where voluntary acquisition is, and should continue to be, focused.

As a part of this Plan, the Watershed Council extended its 2017 Protection Strategy Update into the Snohomish County portions of the Sauk Watershed (approximately rivermile 17-24). That work includes a landscape assessment at a parcel scale quantifying rearing habitats by type, floodplain habitats by level of impairment, riparian habitat quality, tributary junctions, reach-scale conservation levels and adjacent conservation levels to establish threshold values for which parcels could be considered appropriate for voluntary acquisition using salmon recovery funding. These methods and outcomes were documented and adopted concurrently to this Plan by the Watershed Council and documented in the SWC Protection Strategy Update (2023) and included herein as Appendix F. During this update the Watershed Council also evolved how it considers habitat stressors and their restoration approach (e.g. hydromodifications, levees, and degraded forest cover) on parcels with high intrinsic potential habitat and eligible for Skagit's reach-level conservation grant funding, referred to as the process for acquiring restorable lands. These policies also pertain to this Sauk River Plan and ensure high quality habitats are both protected and restored where necessary.

Floodplain Restoration Actions

Three different approaches were employed in this Plan to comprehensively conceptualize, analyze, and prioritize opportunities for improving habitat functions for salmonids while avoiding and minimizing community impacts: stressor-based restoration priorities, strategic enhancement concepts, and channel stability restoration concepts.

Stressor-based restoration priorities

As described in Section 7, a substantial understanding of environmental conditions was generated in the reach assessment and was used to comprehensively conceptualize habitat restoration sites and strategies to increase habitat value for salmonids and aquatic function. Thirty-five individual concepts were described and mapped (Appendix B) and rated (Appendix E1) for the five criteria in Table 18. Assumptions were made by the authors about the scale of restoration likely, lumping and splitting concept restoration strategies, and the resulting benefits and impacts, while recognizing subsequent feasibility and design studies would refine these concepts and their outcomes. Habitat benefit and community impact indicator values and the resulting ratings are shown by concept in Appendix E1. Habitat is measured in both channel and floodplain area using an estimated area of potential effect digitized into polygons. These same mapped areas of potential effect were used, in addition to other information, to estimate community impacts and relative costs indicator values and resulting ratings.

Following review of project concepts and the evaluation framework by planning participants described above, it was decided to keep a comprehensive list of project concepts in a working list that would describe the opportunities to meet the Sauk Plan's goals, even if not currently rated high priority or feasible. From there, the concepts in the highest priority reaches and implementing the highest priority strategies were screened for and identified. Conversely, the projects with the least habitat restoration potential within lower priority reaches and using lower priority strategies were temporarily set aside until a time when they may make more sense to prioritize for implementation.

From this shorter list of the right thing in the right place, concepts with the largest floodplain and channel benefits were screened for and identified as "high priority" for the Sauk Habitat Plan. A few additional locations and sites were included if they met two of these three criteria.

Community impact and relative cost ratings are important for being able to begin to identify how future proposed projects will be perceived by the community and identify actions and dialogue that would be necessary before proceeding into proposed feasibility studies.

This screening process yields about 13 general locations and 15 concepts that are likely the biggest habitat restoration opportunities in the lower Sauk River floodplain. These projects are identified in the map series as high priority and the general locations identified with open circles (Appendix B, map 2) for future investigations.

A few conceptual projects were identified as important infrastructure planning opportunities for the governments who own them. Five concepts fit into this category as a result of their high costs and community impacts and/or their relatively low immediate habitat benefits. Three of these are bank armor removal or modification projects along SR 530 (owned by WSDOT) and Clear Creek Road (owned by Snohomish County (#10, 12, 34). The remaining two concepts point to the Seattle City Light Transmission towers (#14, 17) and the increasing risk that bank erosion could threaten the towers and access roads that serve them. The recommended action for all five of these projects is to proactively plan for strategic setback (WSDOT and SCL) or vacation (Snohomish County) of the road in the timeframes most appropriate for their owners rather than reacting under an emergency to further armor and harden the shoreline.

Estimates of the areas of potential effect of all conceptual projects in Appendix E1 are 92,540 linear feet or 17.5 miles of channel formation or improvement and 857 acres of restored floodplain processes, confirming that significant restoration of these essential salmonid rearing habitats is possible in the Lower Sauk floodplain. The 15 high priority concepts initially screened here account for about 75% of that restoration potential.

Estimates of the length of time likely needed to start project feasibility and design were made for each of the priority project recommendations. "Short term" describes several situations such as a project that has already begun preliminary planning or has a high feasibility of beginning soon in some form. This may just involve the early but important work of consulting landowners or answering more detailed benefit and feasibility and policy questions. “Long term” describes larger infrastructure projects belonging to government agencies that take time to either put projects into their capital plans or for that existing infrastructure to cycle through its remaining life span. Long term can also describe the recognition that it could take many decades to assemble properties to effect reach scale restoration or that there are no active projects in that area currently to build momentum from.

Strategic enhancement concepts

An additional suite of conceptual project opportunities that strategically enhance the connectivity to and habitat quality in existing channel features were identified to supplement the stressor-based restoration priorities discussed above. Strategic enhancement opportunities are overlaid with other concepts shown in Map 2 (Appendix B) and summarized in Appendix E2. The enhancement concepts identified in this section typically involve strategic placement of stable wood jams to increase connectivity between the main channel and existing side channels or high flow channels in the floodplain. The strategic enhancement projects differ from valley scale channel stabilization concepts described below and in Appendix E3 in that strategic enhancement concepts are narrower in function and localized in scale to a single side channel or portion of the floodplain.

The primary objective of projects identified as strategic enhancement opportunities is to increase aquatic habitat quantity, diversity and stability by improving the connectivity between the main channel side channel or off-channel areas with complex edge habitat and cover. In some examples, there are existing channel features that have existing connectivity of flow between main channel and side channel areas but lack sufficient sources of wood recruitment to form and maintain wood jams. Recent studies such as the Skagit River Yearling Phase 3 study indicate higher densities of juvenile Chinook salmon occurring around wood accumulations at side channel outlets (NSD 2022).

Fourteen opportunities were identified to enhance existing floodplain features by increasing the frequency and duration of connectivity with the main channel flow, though these should be considered representative and an undercount of these types of potential sites. This approach typically applies to secondary channel features in the floodplain that are currently connected during periods of high flow but disconnected from the main channel during the normal range of flows. The techniques recommended to enhance connectivity typically involve installation of stable engineered logjams in strategic locations to back up and deflect flow out of the main channel and toward the floodplain channel features (Abbe and Brooks, 2011; Abbe et al, 2016, 2018; Collins et al, 2012; McHenry, 2007; Pess, 2012).

Project sites identified as strategic enhancement opportunities are complementary to proposed actions previously identified as stressor-based restoration opportunities at select locations. These sites are identified in Map 2 as separate opportunities; however, they could be combined as one project for implementation.

Floodplain areas with potential construction access for materials and equipment was a consideration for site identification; however, no design plans for site access have been established as part of this plan. Additional design evaluations are needed to consider feasibility and longevity of identified concept opportunities given channel migration trends and sediment transport processes.

Channel stability restoration concepts

The Sauk River downstream of Darrington is transitioning from an anastomosing channel and floodplain with forested islands and stable side channels to a less stable, braided, dynamic system. Geomorphic analysis of channel dynamics in the Sauk River from 1940’s to 2015 show an increase in channel width indicating decreased channel stability within the wider unconstrained reaches: SA010, SA030, and SA050 (Appendix C) (Figure 7). Loss of channel stability causes degradation of aquatic and riparian habitat. River channels become braided, unstable mainstems with shifting, ephemeral side channels, poor edge habitat quality, and less frequent and shallower pools. Riparian forest recruitment is impaired as shifting channels erode vegetation and inhibit growth, maturation, and succession of trees within riparian areas. Young riparian forests in turn limit local wood recruitment to small wood, leading to unstable large wood pieces and accumulations. Stable log jams have been shown to function as hard points in rivers of the Pacific Northwest, creating spots that resist erosion and allow maturation of floodplain surfaces, leading to formation of islands and mature riparian stands (Collins et al 2012). Unstable channels with mobile beds also cause mortality of incubating eggs and alevin, reducing egg to fry survival.

In addition to channel widening, the Sauk River shows signs of reduced large wood and log jam function associated with decreased channel stability. Within Reach SA050 an analysis of large wood dynamics showed a decrease in log jam frequency and area over a 32 year period from 1981 to 2013 (Appendix D). For log jams greater than 200 m^2 there was a 60% reduction in log jam frequency from 12.3 log jams/km in 1981 to 4.9 log jams/km in 2013, and an 85% reduction in log jam area from 15.8 ha to 2.4 ha in the same period.

Restoring floodplain processes is a strategy identified in the 2005 Skagit Chinook Recovery Plan (SRSC and WDFW 2005). The plan describes the importance of floodplain habitat for flood refuge and increased juvenile rearing productivity. Within the Recovery Plan floodplain restoration strategies are mainly focused on the removal of floodplain impairments and hydromodifications, however channel instability also causes degradation of floodplain habitat as described above. Additionally, restoring impaired spawning habitat via process-based restoration is identified as an important action for Chinook recovery. Unstable, over-widened channels and loss of sheltered side channels with lower stream power cause degradation of spawning habitat due to bed and resulting redd scour and burial during channel migrating flood events. Addressing channel instability in the Sauk River may address goals of floodplain and spawning habitat despite not being explicitly identified as an issue or restoration strategy in the recovery plan. Thus, addressing this data and analysis gap in Skagit Chinook salmon recovery planning is recommended as a next step to further exploring this identified habitat constraint. If supported following this analysis by the Skagit salmon co-managers, additional concepts such as that developed and presented in Appendix D3 for installing arrays of engineered log jams to create stable hard points in the floodplain and its channel should be explored.

Acquisition for Restoration Purposes

There is already a detailed, voluntary Skagit Watershed Council Protection Strategy (2023) (Appendix F) implemented via the members of the Watershed Council to protect the highest quality remaining habitats in the Sauk and Skagit floodplains through reach-level grants. This and previous plans (SWC 1998) also endorse a voluntary acquisition strategy to purchase private lands necessary to implement high priority restoration recommendations that have been reviewed and supported by the Watershed Council's Technical Work Group (TWG) as feasible and timely. The area of potential effect maps developed for conceptual projects in Section 7 form the basis for greenlighting specific parcel acquisitions in supported restoration locations using reach level grants if the restoration concepts are approved by the fisheries co-managers and TWG, essential parcels become available for purchase that would be necessary to enable the restoration concept in a timely manner, and the proposal is consistent with the SWC Habitat Strategy (1998) and policy for acquiring restorable lands in the SWC Protection Strategy (2023) by sponsors ensuring commitment to restoration.

Riparian Restoration Actions

This Plan identified unforested areas within various distances from aquatic habitat (Map 5 in Appendix B). Land cover data was reviewed to find the most substantial areas in need of reforesting, not including recently disturbed natural areas like gravel bars or areas already being actively reforested or where small residential properties and dwellings would be too highly impacted. Fourteen such sites were identified within 200 feet of aquatic habitat, representing approximately 177 acres of impaired floodplain (Table 20). These sites were identified as points in Map 5 and will be presented to Watershed Council member organizations specializing in voluntary reforestation on public and private lands to determine next steps if any towards landowner contact for implementation.

Table 20. Recommended restoration actions by reach and size.

NUMBER	LOCATION	REACH	AREA (AC)	OWNERSHIP
101	McLeod Slough	SA010	17.1	Public
102	McLeod Island	SA010	14.6	Public
103	Martin Slough	SA010	29.9	Private
104	Lower Sauk Slough	SA010	10.7	Private
105	SCL Tower 1	SA030	7.8	Public
106	SCL Tower 2	SA030	18.6	Public
107	Lower Bryson	SA050	4.6	Private
108	Upper Bryson	SA050	6.7	Private
109	Prairie Creek	SA050	15.6	Private
110	Everett Creek	SA050	9.5	Private
111	Terrace	SA050	5.2	Private
112	Homestead	SA050	9.0	Private
113	Boyd Road	SA050	23.2	Private
114	Mill Compost Site	SA060D	4.7	Private
Total			177.2	

Future Assessment and Project Planning Needs

- Additional private and public landowner contacts for priority project areas to answer outstanding questions regarding project interest and feasibility.
- Additional governmental agency contacts to address priority habitat actions using a long-term infrastructure planning strategy.
- Functional river corridors need to include protected areas to provide for channel migration, flooding, and riparian functions. In addition, these corridors can provide public safety functions such as better delineating areas to safely manage public infrastructure and private property into the future. This Sauk assessment provides the necessary information to delineate protective corridors, though local governments and communities would first need to establish a dialogue about the need and implications before further corridor planning work is completed.
- Delineation of a regulatory CMZ.
- Better understand historic fish out-planting to manmade rearing ponds. Do these ponds maintain value for future hatchery operations, or should they be allowed to adjust back into natural habitats subject to natural habitat-forming processes?
- Replicate the side channel inlet flow connectivity and frequency study done in Skagit relicensing to confirm and/or strengthen diagnoses and climate change projected impacts.
- Conceptual habitat actions were identified through review of aerial photos and other remotely sensed products and limited site reviews as a tool to screen for beneficial habitat projects with limited community impacts. Concepts recommended for further consideration will need additional due diligence and study to establish landowner permission, refined strategies, hydraulic effects, preferred alternatives, estimated fish benefits and cost estimates.
- Initiate a woody debris/engineered log jam enhancement committee led by fishery co-managers to study the necessity for and extent of restoration recommendations for how an expanded wood strategy could be supported towards more robust floodplain management. Incorporate into the Skagit Chinook Recovery Plan scientific rationale and into the SWC Strategic Approach for future management purposes, if warranted. Implement the

committee’s recommendations for next steps such as scour/stability analyses, phased approaches, cost containment approaches, etc.

- Egg to fry survival and other fish biology studies, including genetic differentiation at smolt traps, to continue to strengthen the hypothesis that the lower Sauk summer Chinook salmon population is likely limited by degraded in-gravel rearing conditions as well as fry rearing conditions.
- Continue monitoring trends in channel width, wood stability and side channel connectivity to assess geomorphic response to watershed and floodplain conditions.

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APPENDIX A REACH GEOMORPHIC ASSESSMENT

APPENDIX B MAP SET

APPENDIX C CHANNEL MIGRATION ANALYSIS

APPENDIX D WOOD STABILITY ANALYSIS

APPENDIX E CONCEPTUAL PROJECT EVALUATION

APPENDIX F 2023 SWC PROTECTION STRATEGY UPDATE