APPENDIX E3 CHANNEL STABILIZATION CONCEPTUAL PROJECT DESIGN MEMORANDUM

Technical Memorandum

To: **Skagit Watershed Council**
Richard Brocksmith, Executive Director

From: **Natural Systems Design, Inc**.
Shawn Higgins, Tim Abbe, PhD, PEG, PHG, Jen O'Neal, Colin Riordan, and Danny Stratten

Date: October 23, 2023

Subject: Conceptual Design for Sauk River Channel Stabilization

Background

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 1). 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 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 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 during channel migrating flood events. Addressing channel instability in the Sauk River fits well into both goals of restoring floodplain and spawning habitat despite not being explicitly identified as an issue or restoration strategy in the recovery plan.

To address channel instability a conceptual restoration project was developed to illustrate a treatment approach. Reach SA050 was selected to design the conceptual restoration project. The reach has the most pronounced changes in channel width and fastest channel migration rate within reaches downstream of Clear

Creek. The average migration rate in SA050 is 41 ft/yr between 1944-2015 and average channel width has increased 54 percent from 528 ft in 1949 to 813 ft in 2015. A migration rate of 41 ft/yr relative to an average floodplain width of 3,280 ft in SA050 leads to a floodplain turnover rate of approximately 50 years, considerably less than the 100-200 years needed to grow trees to a size where they can function as stable key pieces for log jam formation and persistence (Fetherston 2005; Montgomery and Abbe 2006). Between river miles 17 and 19 in Reach SA050 the river has shown loss of riparian vegetation from erosion, and channel and widening straightening (Figure 2). A segment approximately 0.6 mile long near river mile 19 was chosen to develop the restoration concept due to the presence of a braided channel, low abundance of large log jams, and recent erosion of a mid-channel forested island.

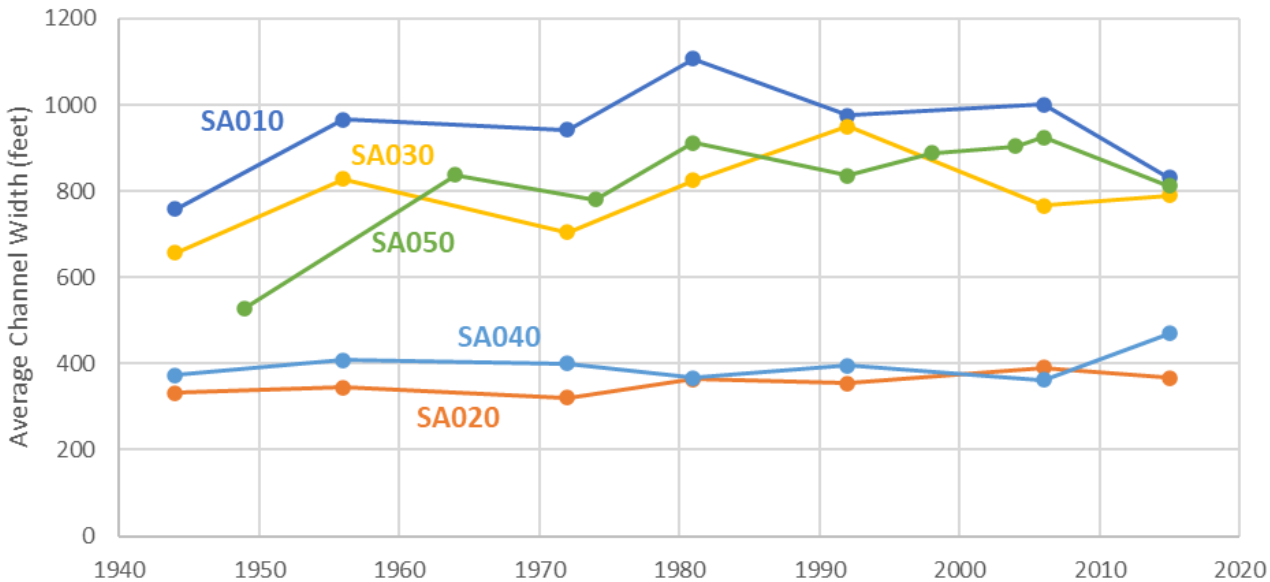

Figure 1. Time series of average channel width by reach. Data from Geomorphic Mapping and Channel Migration Evaluation for the Sauk River Habitat Plan (Appendix C).

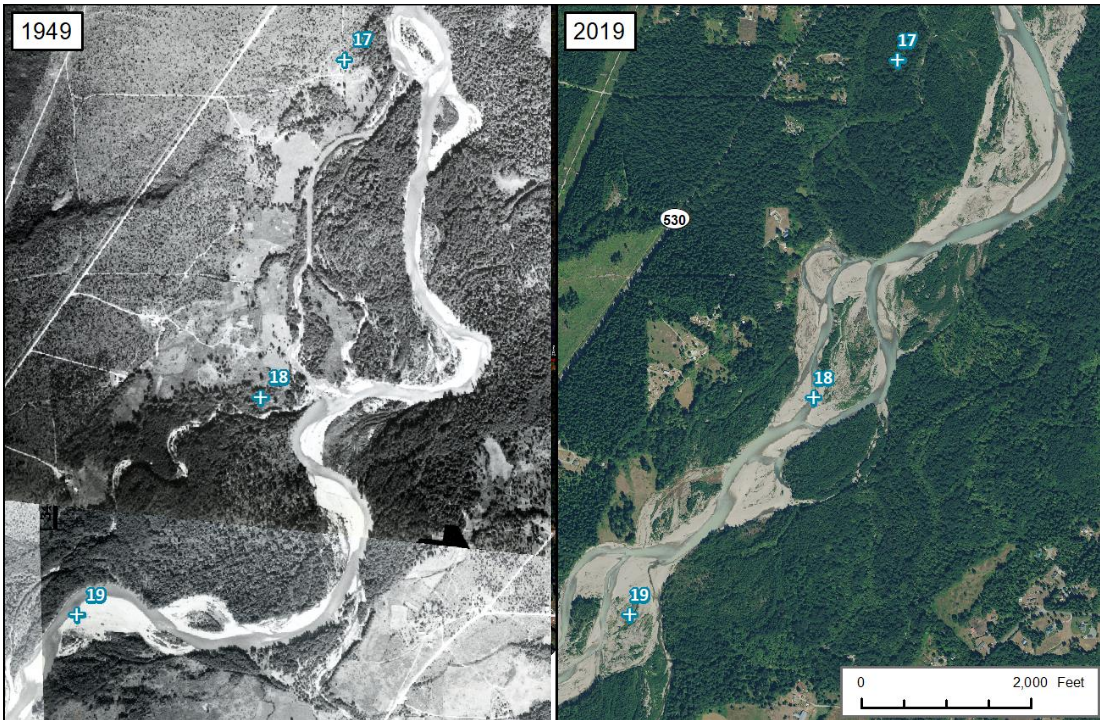

Figure 2. Historical aerial imagery of the Sauk River within Reach SA050, illustrating widening of active channel width, channel straightening, and loss of forested islands (Appendix C).

Objectives

Channel stabilization restoration addresses processes causing decreased channel stability resulting in loss of riparian vegetation, forested islands, stable side channels, and widening of unvegetated channels. Project actions slow erosion and channel migration, protect existing forested islands and side channels, and restore a density of stable logjams. Restoring stability will allow riparian vegetation colonization and forested islands to form, persist, and mature to reduce unvegetated channel width, allow formation of stable side channels, provide future sources of key wood pieces, and ultimately restore the river back to an anastomosing channel pattern.

Design Approach

To address the decrease in channel stability and restore processes needed to increase channel stability engineered log jams (ELJ) can be used to create stable hard points. In the absence of adequate stable natural log jams to create hard points, ELJs can be designed to sufficient size and stability to resist erosion and create artificial hard points. In addition to functioning as hard points, ELJs locally raise water surface elevations and create scour around upstream side of the structures, driving side channel engagement and creating pools with wood cover.

ELJs should be installed in a floodplain wide array. Floodplain wide installation is necessary because of the current highly dynamic state of the river where the main channel is actively migrating across the floodplain. By installing ELJs on a floodplain scale, the probability of having jams engaged is higher. The river will still migrate and try to form flow paths where obstructions (ELJs) are not present. ELJ arrays will split the river into smaller channels which in turn improves juvenile salmonid rearing habitat by reducing stream power, creating hydraulic diversity, flow refugia from the mainstem, fish cover, and allowing beaver colonization.

ELJs should be designed with a width of 100-120 ft and constructed using vertically driven log piles interwoven with a matrix of logs with rootwads. The Sauk River is an aggressive powerful river so large ELJs are needed to withstand the force of flood flows, and 120 ft wide structures are current maximum structure size for construction and stability feasibility. Within structure arrays ELJs should be spaced so gaps between structures are generally not larger than the active width of the main river channel to force channel splitting. An illustration of ELJ size, placement, and spacing is mapped in Figure 3. In addition to ELJ placement, the concept map shows additional functions provided by the structures including proposed flow paths that would form within the arrays, stabilizing developing floodplain, protecting existing islands and side channels, increasing connection of existing side channels, slowing channel widening into floodplain terraces, and stabilization of existing natural log jams with driven log piles. Existing bar top wood could be utilized as racking within ELJs and pieces large enough to function as key pieces could be stabilized with log piles to encourage log jam formation.

The floodplain wide ELJ array approach is expensive to implement given the number and size of structures needed to achieve restoration of channel stability, but methods can be utilized to reduce cost. Constructing ELJs on dry floodplain surfaces rather than in the active low flow channel helps reduce cost associated with diversion and dewatering. Implementation can also be broken up into phases, but within each phase treating the full floodplain with is critical to avoid channel migration issues from structures.

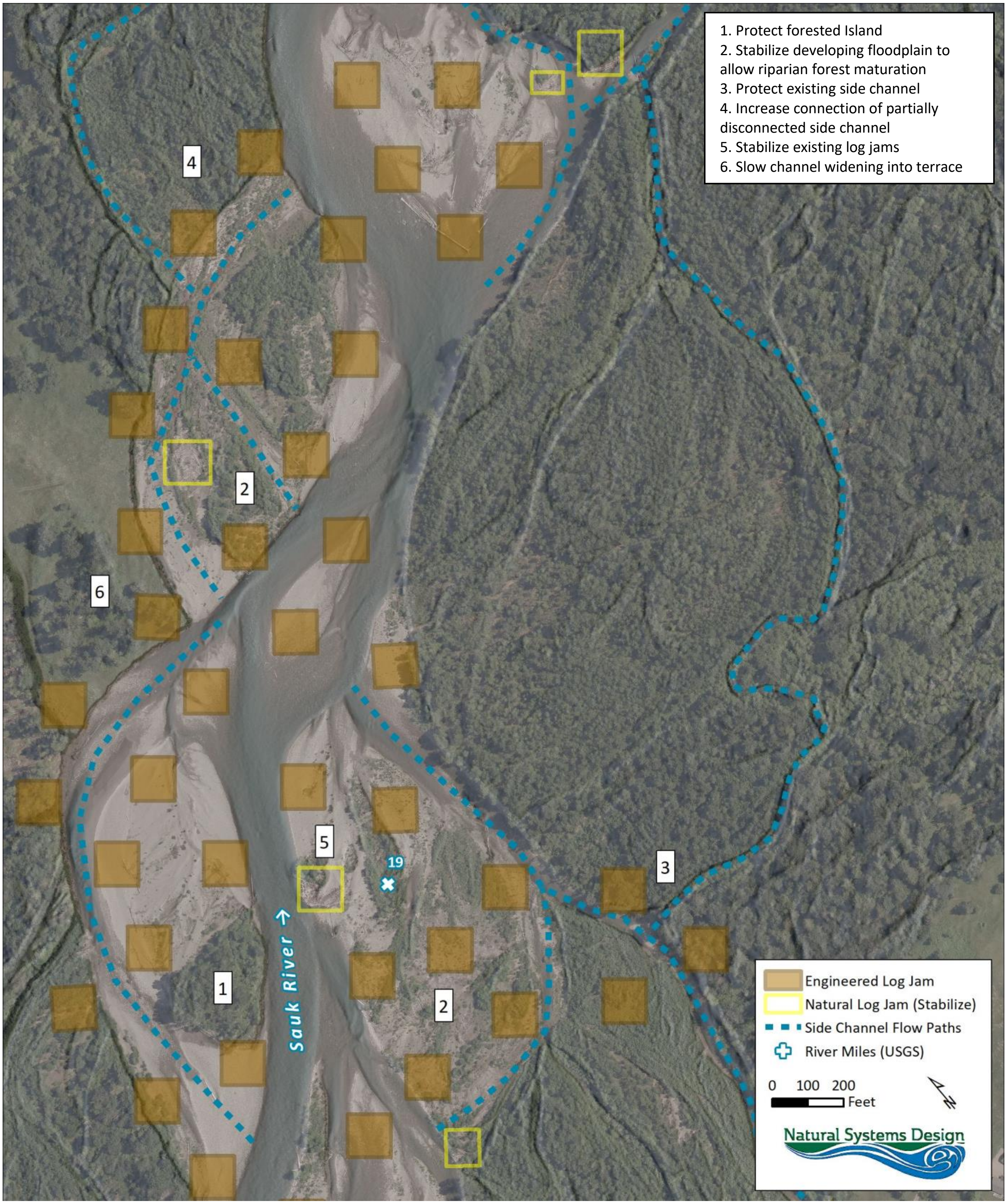

Figure 3. Channel stabilization concept map.

Next Steps

The Channel stabilization restoration concept is a planning level overview of an approach to address and reverse channel instability and the resulting habitat degradation in the Sauk River. Additional work is recommended before proceeding with formal design or implementation of this approach. Next steps for additional recommended analyses include:

- An analysis of the entire Sauk River downstream of Darrington to Identify all areas where channel instability and widening is occurring and assess which areas are most in need of treatment.
- Investigation of other processes potentially contributing to decreased channel stability. Examine the role of sediment delivery from upper watershed.
- Feasibility of ELJ construction with wild and scenic designation in the Sauk River.
- Developing and refining measurable restoration goals. What does successful restoration of channel stability look like and how do we assess it?

References

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

Fetherston, K.L., 2005. Pattern and process in mountain river valley forests. Ph.D. Thesis, University of Washington, Seattle, WA, USA.

Montgomery, D.R., Abbe, T.B., 2006. Influence of logjam-formed hard points on the formation of valley-bottom landforms in an old-growth forest valley, Queets River, Washington, USA. Quaternary Research 65, 147–155.

Skagit River Systems Cooperative (SRSC) and Washington Department of Fish and Wildlife (WDFW). 2005. Skagit Chinook Recovery Plan.