SOUTH FORK NOOKSACK RIVER WATERSHED CONSERVATION PLAN

Prepared by the Nooksack Indian Tribe Natural Resources Department
May, 2017

Executive Summary

This Watershed Conservation Plan is for the South Fork Nooksack River Watershed, located in eastern Whatcom County, Washington. The Plan is based upon several years of research and analysis of watershed conditions, and aims to provide information and recommendations for protecting and restoring our water resources.

The Nooksack Indian Tribe Natural Resources Department, along with numerous other stakeholders, embarked upon this process with the hopes that this Watershed Conservation Plan will be helpful for residents, landowners, and other parties who are concerned about the long-term health of the watershed. Above all, this document is intended to serve as a tool for engaging dialogue and thinking holistically about watershed management decisions.

> "Upstream and downstream, water stakeholders will have to be involved in management decisions. It is impossible to maintain the integrity of a balanced ecosystem without an overall strategy on water resources management. We all have a shared responsibility for protecting the shared environments surrounding rivers and their associated watersheds."
>
> *- United Nations Department of Economic and Social Affairs, International Decade For Action: Water is Life*

Water quality and water quantity are major concerns in our watershed. The South Fork Nooksack River does not meet federal and state Clean Water Acts (CWA) standards, and as such, the river is listed as on the CWA Section 303(d) as an impaired water body for high temperatures and excessive fine sediment. The Watershed Conservation Plan addresses these concerns by presenting pertinent detail on watershed characteristics, including the legacy impacts of past land use and continued climate change, and offering recommendations on actions that could reduce the severity of these impacts.

This Executive Summary provides an overview of the Watershed Conservation Plan, with excerpts from the sections on Watershed Characteristics, Land Use, Hydrology, Sediment, Stream Temperature, Riparian Conditions, Channel Processes, Salmon, Physical Habitat, Restoration Projects, and Climate Change. Following a synopsis of Community Engagement, **opportunities for voluntary action** are offered for discussion and consideration.

Watershed Characteristics

The South Fork Nooksack River (SFNR) is one of three forks that form the Nooksack River (geographic Hydrologic Unit Code (HUC) 17110004). Figure 1 shows the location of the SFNR watershed within Water Resources Inventory Area (WRIA) 1, which includes the Nooksack River, Sumas River and several independent drainages to the Strait of Georgia. The SFNR originates on the east side of the snow-dominated Twin Sisters Mountain Range, the west and south margins of Loomis Mountain and the west side of Dock Butte, and drains about 164 square miles of watershed area before joining the North Fork Nooksack River to form the mainstem Nooksack River at river mile 36.6. Elevation ranges from approximately 7,000 feet on the Twin Sisters Range to approximately 236 feet at the confluence with the North Fork Nooksack River. There are no longer active glaciers on the Sisters Range and other areas of the upper watershed; however, vestigial ice with a total area of 0.42 square miles remains. The river has an average annual flow of 1,104 cubic feet per second (cfs) measured at the USGS gage at Saxon Road Bridge (Site Number 12210000). Base flow during the summer is supported by a small amount of melting ice but predominantly groundwater inflow. Late fall, winter and spring flows are provided by rainfall and snowmelt.

Figure 1: The South Fork Nooksack Watershed within WRIA 1.

The upland portion of the watershed has very steep valley walls sculptured by geologically recent glaciation and is dominated by forested areas, including commercial forestry, small forest operations, and wilderness designated areas. The SFNR channel lies in a largely low-gradient valley with a variable degree of confinement, with glacial till, glacial lake and gravelly outwash deposits mantling the valley walls. In several reaches the channel flows through confined bedrock canyons, while in others it migrates across a wider alluvial plain. Where the confinement and gradient lessen, the SFNR exhibits a dramatic increase in the width of the 100-year floodplain from 0.1 miles to between 1.0 and 1.3 miles (FEMA 1990). The wide floodplain and low gradient make the SFNR Valley an area of fine sediment deposition, channel migration and wood accumulation. The lower valley (below river mile 13) is a wide, glacially carved, flat glacial outwash valley with steep walls. The valley floor has an extensive wetland system and houses a number of dairy farming operations, berry fields, hayfields, corn, and Christmas tree plantations. Development on the valley floor covers a small cumulative area and is comprised of rural residential and small areas of commercial development at the towns of Acme and Van Zandt.

Land Use

Logging has historically been the most significant and widespread land use and commercial activity in the South Fork watershed since European settlement in the 1880s. Timber was originally transported down the river until a railroad system was constructed. Rails were eventually replaced by forest roads throughout the watershed. By the 1930s, much of the forest and wetland areas on the lowlands had been cleared and drained for agricultural production, resulting in rapid channel migration and expansion of the unvegetated channel area around the river. Subsequent channel erosion led to installation of bank stabilization infrastructure (i.e. riprap) that eventually led to narrowing of the active channel width. Channel straightening has resulted in a loss of about 3,500', or about 5% of channel length, and reduction in effective shade and hyporheic exchange in the channel. Current land use in the SFNR watershed is dominated by forestry in the uplands, with agricultural use restricted to the valley floor. The U.S. Forest Service manages the headwaters of the watershed downstream to approximately river mile (RM) 33. Between RM 33 and RM 25, Seattle City Light purchased the river-adjacent property for conservation as mitigation for hydroelectric dams on the Skagit River.

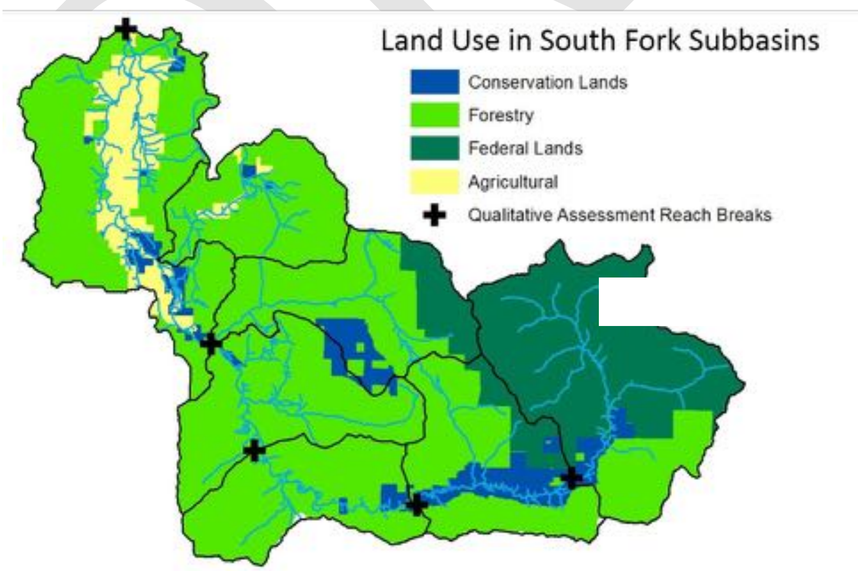


Figure 2: Generalized land use in the South Fork Watershed.

Present-day watershed function is the result of both current land uses and legacy impacts that have altered the forests on the hillslopes of the watershed and in the riparian zones of the tributary network. These forest changes affect the upland water cycle, sediment transport, and in-channel river processes. In particular, land use has reduced upland water storage, and the export of water from the watershed has been accelerated relative to natural conditions, leading to lower summer streamflows and warmer stream temperatures. Climate warming will exacerbate these conditions with less snowpack and earlier melt, resulting in further reductions in summer streamflow and increases in stream temperature. Upland watershed function affects the health of both terrestrial and aquatic ecosystems. In addition to a warming climate over the past 100 years, human-caused impacts such as forest harvest, road-building, fire, beaver trapping, and in-channel wood removal reduce the amount of water stored or accelerate the export of water from the watershed. Thus, opportunities exist to adapt management practices and restore watershed function in order to buffer projected climate change impacts. Restoration of these river systems will increase sediment and water storage and slow the export of water from the network. Together these restorative changes can have a considerable impact on peak flow, base flow, and groundwater resources.

Hydrology

The Nooksack basin lies within a convergence zone with Arctic weather from the north, and Pacific weather systems from the south and west (U.S. Forest Service 1995). In the summer months, the Pacific systems dominate with mild, clear weather and low levels of precipitation. In the winter, Arctic systems move into the area bringing storms, high levels of precipitation, and occasionally very low temperatures. The hydrograph of the South Fork River is bimodal and reflects rain, spring snowmelt, and occasional rain-on-snow events (Figure 3). This means that the period of lowest flow also corresponds with the warm summer months, often leading to water quality impairment in the river. The hydrograph reflects regional climate patterns, with nearly 50% of the annual precipitation occurring between November and January and snowmelt occurring in April through June.

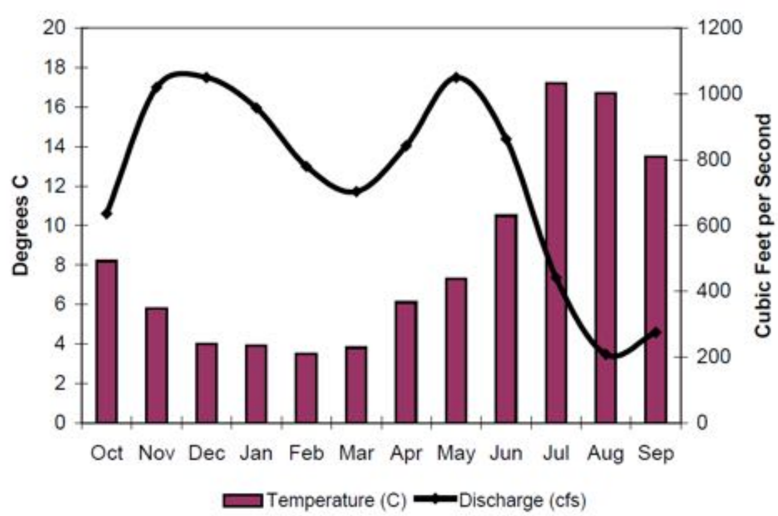


Figure 3: Mean monthly discharge and temperature at the SF Wickersham stream gage (River Mile 15).

The SFNR watershed is considered a transient watershed with snow-driven hydrology in the higher elevations and rain-driven hydrology in the lower elevations. Transient watersheds are the most sensitive to climate change impacts because small changes in temperature can substantially affect snow accumulation and snow covered area (Mote and Salathé 2010). Further, inter-annual variability in climate and weather can result in a large variability of snowpack, rain, temperature, and hydrology from year to year. In addition to climate variables, watershed characteristics that affect the timing and routing of peak flow include differences in elevation, slope, aspect, soils, and vegetation cover.

Monitoring of river flow in the South Fork Nooksack at Saxon Bridge has shown that the summer low flow period has lengthened and the annual minimum baseflow discharge has slightly decreased since 2009. Since 2009, the number of days between the onset of baseflow and the minimum baseflow has increased as well as the total number of days of the baseflow period. The WY 2015 hydrograph is similar to the projected shape of the South Fork Nooksack hydrograph under future climate change scenarios, where less snowfall will result in a reduction of the spring snowmelt peak and lower summer baseflow conditions. The variability in the timing and magnitude of peak flows and baseflows is likely due to differences in the inter-annual variability of the El Niño- Southern Oscillation (ENSO) or the occurrence of atmospheric rivers in the winter time (e.g. "Pineapple Express"). In addition, the amount of snowpack, rain-on-snow events, and intensity of rainfall can all affect the timing and magnitude of winter flows and onset and duration of baseflow.

The interaction between the surface water and subsurface water is particularly evident during the baseflow period. Seepage run studies (comparing flows between upper and lower stations of a river reach) during the baseflow period suggest spatial variability in the exchange of groundwater with surface water in the SFNR and its tributaries (Gendasczek, 2014). Generally, the upper SFNR valley consistently gains streamflow, whereas the lower SFNR below Skookum Creek is more likely to lose streamflow to groundwater storage. However, discrete cold-water anomalies with low diurnal temperature variability were recorded at two locations along the SFNR river miles 10 and 11.3, suggesting groundwater influx to the mainstem SFNR. These cold-water anomalies were associated with both bank and streambed seepage of groundwater as well as thermal stratification within pools associated with log jams. Continuously monitored groundwater-level altitudes in riparian wetlands and water surface stage of the SFNR suggest that some wetlands are dynamically linked to the river whereas other wetlands are perched on low-permeability floodplain sediments and receive their recharge from direct precipitation (Gendaszek, 2014).

Taken together, these data provide the foundation for a future groundwater-flow model of the SFNR basin that may be used to investigate the potential effects of future climate change, land use, and groundwater pumping on water resources in the study area. In addition to domestic, agricultural, and commercial uses of groundwater within the SFNR basin, groundwater has the potential to provide ecological benefits by maintaining late-summer streamflows and buffering stream temperatures. Cold-water refugia, created and maintained in part by groundwater inflow and groundwater exchange within the channel bed, can be key elements to restore the health and viability of threatened salmonids in the SFNR.

Sediment

Turbidity and suspended sediment transport in the Nooksack River watershed are dynamic, multifaceted, and complex – both temporally and spatially, as well as having a stochastic or random nature. Watershed hydrology, land use, weather and geology are the main drivers of baseline suspended sediment output; however, stochastic events (i.e. landslides, bank erosion, and rain on snow events) occasionally occur that can significantly increase that output. Because there is a minimal glacial component to hydrology in the SFNR, high sediment transport only occurs during peak flows in the rainy winter months. Spikes in turbidity generally mirror peaks in discharge due to the SFNR's predominantly rain-dominated watershed. Snowpack in the uplands or prolonged periods of drought stall or reduce sediment transport. In the SFNR, turbidity and SSL generally decrease downstream from Saxon Road to Potter Road (NNR, 2017). The decrease in turbidity and increase in discharge from upstream to downstream likely indicates that most of the sediment sources to the SFNR are above the Saxon Road site. In addition, the lower SSL at Potter Road would suggest that fine sediment is being stored in the lower SFNR reach. It is interesting to note that sediment transport in the SFNR is seasonally opposite of the MFNR or NFNR, which are driven by summer glacial ice melt.

Natural processes and human activities affect the volume, distribution and frequency of sediment delivery to stream channels. In general, erosion rates in forested mountain watersheds are highly variable and depend on differences in slopes, soils, geology, vegetation, and climate (Rice et al. 1972). While sediment transport processes are episodic over some time scale, channel response to sediment depends on the channel's ability to transport and store material relative to the amount of sediment supplied. When the sediment supply is greater than the ability to transport sediment, channel responses such as aggradation, channel widening, substrate fining, pool filling and channel braiding can occur. Conversely, a reduction in sediment load can lead to channel incision and bedload coarsening. Either of these changes can negatively affect the quality of instream habitat. The SFNR is on the Clean Water Act (CWA) 303 (d) list for fine sediment that exceed the Washington State CWA criteria.

Glacial deposits overlay the bedrock through much of the SFNR watershed. These deposits vary in composition from thinly bedded clay, silt and sand to boulder-laden glacial till. These deposits are also largely associated with the numerous stream-adjacent failures that line the South Fork Nooksack from its headwaters to below Lyman Pass (River Mile 18). These landslides have a substantial impact on water quality (Section 2.4.3). There have been 875 shallow-rapid landslides mapped in the watershed upstream of Saxon Bridge over the 55-year photo record (Watts 1996, Kirtland 1995, Cascade Environmental Services 1993, Peak Northwest 1986). Of the characterized landslides, 62% (483 of 779) were associated with land use activities and 80% (465 of 580) delivered sediment to a stream. The most common land use associated with shallow rapid failures was recent timber harvest. A more recent reconnaissance mapping of 101 landslides in the SFNR Watershed following the 2009 storm found that the percentage related to land use had been greatly reduced to 11% associated with roads and 28% with a harvest unit or young forest (Powell et al. 2010).

Elevated turbidity, which is a measure of water clarity and can be used as a proxy for fine sediment, can directly affect the growth, survival, reproduction and ecological integrity of aquatic life in multiple ways. Turbidity grab sampling efforts in 1998, 1999 and 2012 have shown that turbidity in the mountain tributaries to the SFNR Valley was heavily influenced by forest practices, particularly road fill failures in the Todd Creek watershed (Soicher 2000). Many sampling locations exceeded the 1-hour "Slight Impairment" threshold of 38 NTU at least half of the time sampled, which can cause behavioral effects to fish such as disorientation and altered feeding. Some of the locations also surpassed the 1-hour threshold for "Significant Effects" (160 NTU), which can cause more permanent changes to growth and habitat. A more recent study by the Nooksack Indian Tribe that uses continuous turbidity records in the SFNR indicates that turbidity at both Saxon Rd. and Potter Rd. exceeds the 24-hour "Slight Impairment" criteria nearly 50% of a water year on average. Both locations exceed the 10 month "Significant Effects" criteria (3 NTU) for most of a given water year (NNR, 2017).

Stream Temperature

The SFNR is listed on the Clean Water Act (CWA) 303(d) list for excessive temperatures, so a Total Maximum Daily Load (TMDL) is under development to assess heat allocations for the river and develop an implementation plan to address water temperature. The Environmental Protection Agency (EPA), Washington State Department of Ecology (DOE), and the Nooksack Indian Tribe are cooperating on the development of this effort. In addition to this regulatory objective, EPA Region 10 has partnered with EPA's Office of Research and Development (ORD), Office of Water (OW) and Nooksack Indian Tribe (NIT) together initiated a Pilot Research Project to consider how projected climate change impacts for the SFNR could be incorporated into the TMDL and influence restoration plans that are robust in the face of climate change. The release of two EPA publications that result from this project is imminent and includes: 1) Quantitative Assessment of Temperature Sensitivity of the SFNR under Future Climates using QUAL2Kw (Butcher et al. 2016) and 2) Qualitative Assessment: Evaluating the Impacts of Climate Change on Endangered Species Act Recovery Actions for the South Fork Nooksack River, WA (EPA et al. 2016).

High water temperatures during summer represent an important limiting factor for Nooksack early Chinook salmon and other salmonids in the Nooksack River watershed, especially in the SFNR. High water temperatures in the SFNR regularly exceed optimal temperature ranges and approach lethal limits for salmonids. In 2015, the 7-day average of the daily maximum in the SFNR was nearly 23°C, well in excess of the temperature ranges considered optimal for Chinook Salmon incubation (11-15°C) and juvenile rearing (14.2°C-16.8°C) (Coe and Cline 2009; NNR 2012, 2013, unpublished). High temperatures in the lower SFNR stress holding and spawning fish and increase susceptibility to disease, which can cause prespawning mortalities or otherwise reduce reproductive success. Although increases in average temperature over time may seem small, salmonids and other aquatic life are very sensitive to these small changes. As much as 0.5° C (0.9° F) can alter life stage timing and duration thereby affecting feeding behavior and growth. Water year 2015 for the SFNR was indicative of what is projected for the future with regards to low streamflow and high temperatures: higher temperatures and lower streamflow in the summer, and higher temperatures, less snowpack, and more flooding in the winter. Discrete temperature measurements at both Saxon Rd and Potter Rd. indicate a general trend of warming since 2009, where both locations frequently exceed beneficial use criteria during summer months (Figure 4). These trends could be indicative of decadal variability as the period of record is not long enough for longer-term analysis.

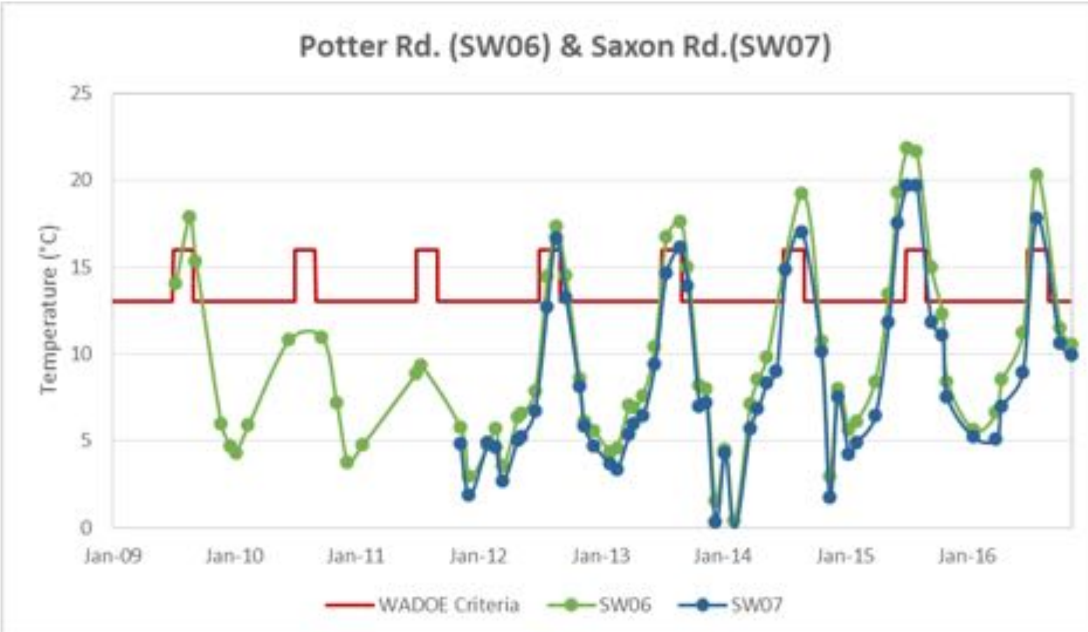


Figure 4: Instantaneous temperature at Saxon Road and Potter Road collected by NNR from 2009-2016.

Temperature is directly affected by the removal of riparian zone vegetation, which increases solar radiation reaching the stream surface. Additional land uses, such as forest practices, in the Nooksack River watershed have likely contributed to elevated stream temperatures. In a recent study performed by Pollock et al. (2009) in forest lands of western Washington, harvest in upland areas explained approximately 39 percent of the variation in stream temperatures, while harvest within the riparian areas explained 33 percent. This study suggests that commercial forestry, primarily roads, on upland areas of a watershed have similar or more impact on stream temperatures than forestry activities in riparian areas adjacent to the stream. Further, many tributaries that are non-fish bearing perennial, intermittent, and ephemeral alike, are not afforded protective buffers under the Washington State forest practice rules which likely further exacerbates temperature loading of the river. These processes need to be considered when identifying appropriate best management practices for temperature modulation in the Nooksack River watershed. Channel restrictions by flood control levees, hard armoring, transportation structures, and disconnection of the channel from its floodplain, coupled with draining of floodplain wetlands have also likely contributed to increasing temperatures, especially in the lower SFNR.

Riparian Conditions

Riparian conditions along the SFNR and its tributaries vary widely across the watershed. An inventory of riparian conditions on fish-bearing streams throughout the Nooksack watershed found that wood recruitment and shading potential were related to land use, as represented by zoning classification, in the following order from highest function to lowest: national park, national forest, commercial forest, rural forest, rural, urban and agriculture (Duck Creek

Associates 2000, Coe 2001). While substantial riparian restoration efforts have occurred across the floodplain subsequent to this inventory, the SFNR Valley is still the critical focus area for protecting and improving riparian conditions. The goal for the SFNR is to have mature, coniferous-dominated riparian zones of at least 200-300 feet wide to maximize shading and wood recruitment potential to the river. There have been extensive efforts made to establish riparian buffers and under-plant deciduous stands along the streams with coniferous seedlings to speed the forest along the successional pathway toward climax forest conditions.

Shade modeling of the South Fork River under current and site potential vegetation was accomplished as a part of the South Fork Nooksack temperature TMDL (Department of Ecology 2015 Draft). The site potential conditions for the riparian stands were assumed to be a 150' wide buffer of mature (>100-year old) conifer stands averaging 166' tall. A second sensitivity model run for historic conditions included modeling a wider (218') and taller (290') buffer (Butcher et al. 2016). This model run was thought to more accurately represent "natural conditions" or conditions that occurred prior to the pollution problem. The modeling of existing and site-potential shade showed a dramatic gap, likely due to the on-going and legacy impacts of land use on the riparian conditions.

The riparian zone of the river and its floodplain tributaries is impacted by a variety of existing infrastructure. For the mainstem SFNR, extensive riprap boulder bank armoring is the greatest impact to riparian function. Transportation infrastructure (roads, railroad) also limits the development of riparian stands within 300' of the river. In addition, agriculture and residential development eliminate large areas of forested land that would otherwise be available for recruitment to the river. The following directly impact riparian function in the SFNR watershed:

- 9.25 miles of bank armoring along SFNR
- 2.1 miles of road in the riparian zone of SFNR
- 31% of SFNR buffer and 16% of tributary buffers are actively farmed
- 11% of SFNR and 8% of tributary buffers impacted by residential development

Channel Processes

For much of the length of the channel, the width of the channel migration zone is only slightly larger than the current active channel width. This slow migration allows mature conifers to dominate the streamside forest. This improves the shading potential for the river, but limits the amount of large wood recruited to the channel. Channel migration rates naturally vary along the SFNR due to variation in channel confinement, bank resistance, valley slope, flow, sediment load and vegetation characteristics. In the upper reaches of the watershed, long sections of the river have shown essentially no migration through the historic period, while in the SFNR Valley there is topographic evidence of migration across the width of the broad floodplain. Changes in land use can influence this balance, causing the river to adapt to the changing conditions. Mapping by the General Land Office (GLO) in the 1890s showed a markedly different river through the SFNR Valley than can be seen even in the earliest aerial photographs (Figure 5). The channel was narrower, more sinuous and contained more side channel length (channels split from the main channel by forested islands) than can be seen today. These changes through time from a stable multithread channel to a rapidly migrating sinuous to braided channel have impacted habitat and private property throughout the SFNR Valley.

Figure 2: Comparison of the GLO survey map from the 1890's and the 2013 aerial photo and showing the loss of sinuosity and secondary channels.

The current reduction in sinuosity together with the loss of wood debris may have serious long-term impacts on channel incision and entrenchment. This entrenchment is thought to have an adverse impact on habitat quality by increasing shear stress through the reach resulting in reduced floodplain-channel interaction, increased red scour, increased sediment transport and the abandonment of many floodplain tributaries (GeoEngineers, 2002). Channel incision can isolate the channel from numerous secondary channels and its floodplain, and reduce the water stored in the uplands and in the riparian zone that contribute to critical in-stream flows for fish during lower flow (Wigmosta et al. 2015).

Legacy impacts on channel morphology and streamflow routing also affect the magnitude of baseflow. Where riparian forests and in-channel wood have been removed, stream channels have cut down into the sediment, leading to earlier depletion of water stored as shallow groundwater (Pollock et al. 2014). Where channels are incised, the increased gradient between the shallow groundwater elevation and the in-channel water surface elevation results in a lowering of the shallow groundwater elevation, less water available to riparian vegetation, and early dewatering of the stream (Pollock et al. 2014, Beechie et al. 2008, Emmons 2013).

Salmon

The lower SFNR provides habitat for all Pacific salmonid species, including spring and fall Chinook salmon, coho salmon, pink salmon, chum salmon, sockeye salmon, steelhead, bull trout, and cutthroat trout. South Fork (SF) Nooksack early chinook is an independent population of the threatened Puget Sound Chinook Evolutionarily Significant Unit that is essential for recovery. Chinook spawn upstream to the anadromous barrier at RM 31, although Sylvester's Falls at RM 25 constitutes a partial blockage, and in larger tributaries to the South Fork. The abundance of both early Chinook salmon populations (North Fork/Middle Fork early Chinook salmon, South Fork Nooksack early Chinook salmon) is critically low, on the order of dozens to a few hundred natural-origin spawners for each population. A report by the US Commission of Fish and Fisheries on Fisheries of the West Coast that includes 1895 Nooksack River catch data estimates that nearly 25,000 Chinook inhabited the Nooksack River at that time. The populations comprise two of 22 independent populations in the Puget Sound Chinook Salmon Evolutionarily Significant Units (ESU), which are listed as threatened under the Endangered Species Act (ESA). Nooksack early chinook (including both the SFNR and the North/Middle Fork populations) is the highest priority species, although restoration of Chinook habitat is expected to yield collateral benefits to other species.   Nooksack spring Chinook salmon hold great cultural and subsistence importance to the Nooksack Tribe and Lummi Nation.

A significant proportion (38%) of returning SF Nooksack early chinook spawners sampled from 1999 to 2013 had out-migrated as yearlings, indicating the importance of freshwater holding and rearing habitat in the SFNR, floodplain tributaries and connected wetlands. Habitat degradation is considered the leading cause for the decline of salmonid populations in the Nooksack watershed. High temperatures and low habitat diversity are the most significant factors limiting SF Nooksack early chinook in the lower SFNR, followed by high fine sediment load, lack of key habitats, low flows, and human disturbance (WRIA 1 SRB 2005). Some of the major impacts include:

- Low proportion and frequency of pool habitat.
- Reduction in availability of complex edge and floodplain habitats.
- Lack of instream wood and other forms of cover.
- Frequent high water temperatures that exceed optimal ranges or reach lethal limits.
- High proportion of fine sediment in spawning substrates.
- Decreased summer flows and higher peak flows.
- Degraded water quality (i.e. dissolved oxygen, pH, turbidity, nutrients).

Salmonids are particularly vulnerable to climate change because of their ectothermic (cold-blooded) physiologies and anadromous (living in both freshwater and marine water) life histories that require migration through linear stream networks that are easily fragmented (Isaak et al. 2010). Climate change impacts on temperature, flow and sediment regimes could profoundly affect physiology, behavior, and growth of individuals; phenology, growth, dynamics and distribution of populations; structure of communities, and; functioning of whole ecosystems (multiple authors, cited in Rieman and Isaak 2010), with increasing complexity and thus difficulty predicting impact at higher levels (Rieman and Isaak 2010). Climate change impacts to salmonids as a result of increased temperature can cause lowered dissolved oxygen, changes in growth of juveniles, changes in timing of emergence and migration, creation of thermal barriers to migration, disturbance to community structure, and increased occurrence of pathogens (i.e. Columnaris) or filamentous algae. The impacts of climate change due to changes in timing and magnitude of discharge may result in reduced habitat availability, reduced access to floodplain or side-channel habitats, or changes in timing or length of life history stages. Projected increased sediment with climate change may result in reduced egg-fry survival, changes in feeding behavior, biophysical injuries, or avoidance of habitats completely.

It is important to consider the pace of climate change and the ability of salmonids to adapt to that change. Salmonids do have the capacity to rapidly colonize new habitats, so to the extent that climate change will affect the distribution and availability of critical habitats, salmonids may be able to exploit what emerges, assuming such habitat is suitable and accessible (multiple authors cited in Rieman and Isaak 2010). Salmonids may also adapt over time through natural selection—evidence indicates evolution can occur within 10 to 20 generations (40-80 years; multiple authors, cited in Rieman and Isaak 2010) – although there is uncertainty about climate change outpacing evolution rates. Climate change impacts will affect every life stage of Chinook salmon, increasing the difficulty of adaptation (Figure 6).

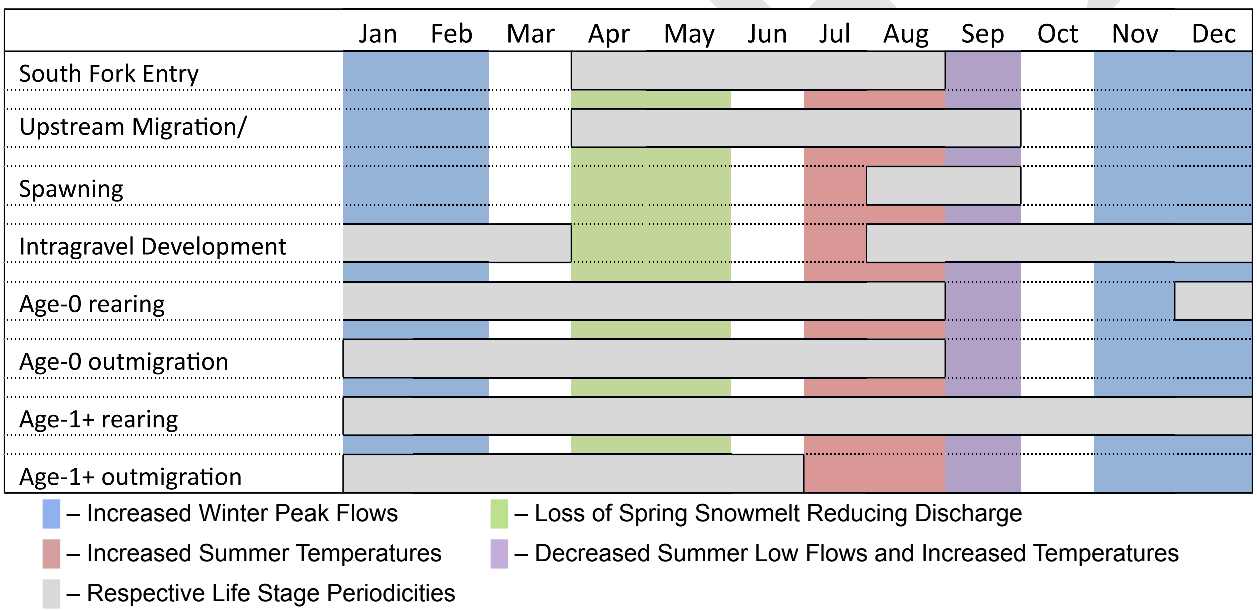
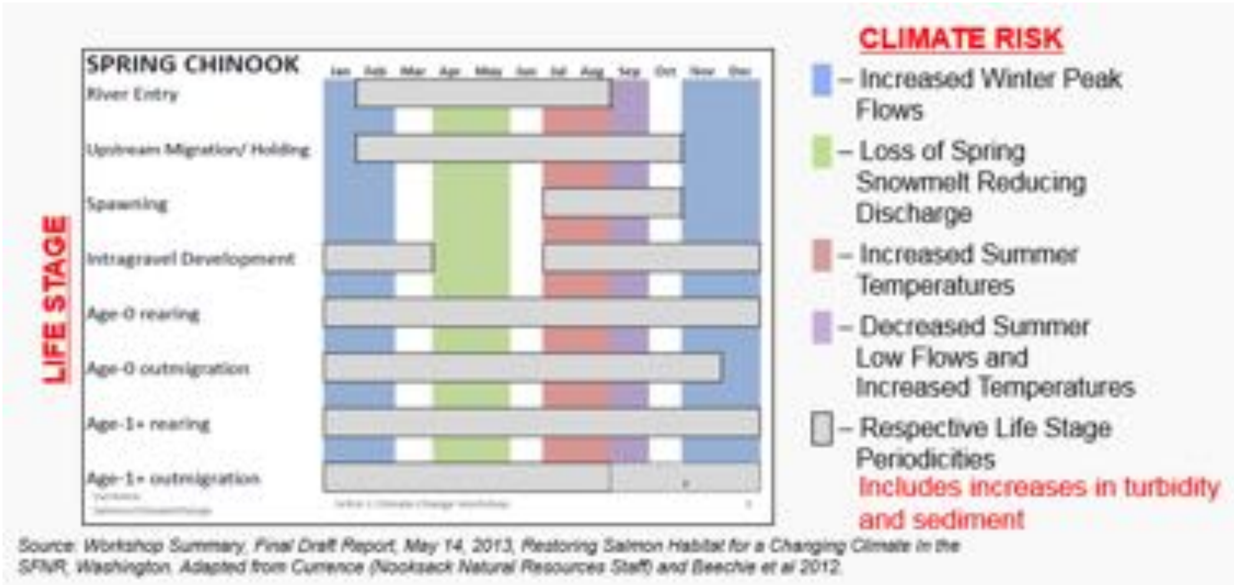


Figure 6: Spring Chinook Life Stage Periodicity in the South Fork and Vulnerability to Climate Change Impacts.



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Physical Habitat

The habitat needs of salmon, trout and char in streams vary with the location in the watershed, the season and the stage of their life cycle. All species of Nooksack River salmonids require cold, clean water and a complex, connected habitat structure to thrive. While the habitat requirements vary with species and life stage, they encompass two important attributes: food and shelter. Habitat capacity and productivity are related to the condition of the aquatic environment. The distribution and quantity of different habitat types, such as pools and riffles, determines the space available for different species and life stages to live in. The quality of the habitat can affect both the abundance of the populations and the survival of individuals to their next life stage: from fry to smolt for example. Habitat modeling of the South Fork Nooksack using the Ecosystem Diagnosis and Treatment model was used to help identify and characterize the factors that most limit the South Fork spring chinook population, and this modeling helped form the basis for the Salmonid Recovery Plan that covers the South Fork Nooksack watershed (Mobrand Biometrics 2004).

Holding:

Adult salmonids returning to their natal streams must reach spawning grounds at the proper time and with sufficient energy reserves to complete their life cycles. Flow, water temperature and water quality must be suitable during their migration season and the physical habitat must provide sufficient space and cover for the returning populations. In the SFNR, habitat modeling indicates that upstream migration and holding habitat quantity and diversity is limiting the spring chinook population (Mobrand Biometrics 2004). The lack of deep pools with complex cover (i.e. pools associated with log jams) limits holding by all species, but especially early chinook, summer steelhead and bull trout. Holding habitat in the reach has been degraded due to loss of habitat complexity, including bedform variation and woody debris cover, coupled with low flows and high water temperatures which together can stress the fish and render them vulnerable to disease, predation and poaching (Doughty 1987).

Adult Chinook migrate and hold through the warm summer months when elevated water temperatures can impact their reproductive success. Pools can provide thermal refuge areas for adult chinook by intercepting groundwater or storing water cooled at night for a longer period of the day, since structural elements and substantial pool depth are two important factors that can promote seep development and thermal stratification in pools. Recent monitoring of thermal refuge areas in the South Fork has shown that many logjams are associated with water that is cooler than the adjacent average temperature of the river (Nooksack Natural Resources unpublished data). While thermal stratification of pools has dominated in backwater areas, generally the deep main channel pools have been well-mixed, emphasizing the importance of a diverse array of pool locations to meet different life history stage needs.

Spawning:

Substrate composition, local cover, water quality and flow are important habitat elements before and during spawning. The number of spawning fish that can be accommodated is a function of the area of suitable habitat, the size of redds constructed by the species, and the behavior of the fish. The main habitat impacts to spawning Chinook that have been identified in the Nooksack Watershed are increased fine sediment in spawning gravel and loss of eggs due to channel migration or bed scour (WRIA 1 Salmon Recovery Board 2005). Both of these likely affect the South Fork early Chinook population to some degree.

Research from Hyatt and Rabang (2003) suggests that redd loss is expected to be higher in mainstem channels than in side channels, floodplain tributaries and sloughs. In the North Fork Nooksack, the opportunity to create and maintain these more scour resistant habitat types has been the focus of recent habitat restoration activities. Since the majority of the South Fork early chinook population spawns in the low flow channel of the main river channel, the opportunities for improving side channels and tributary habitat is likely limited and reducing the impacts of flow depth on the channel is likely the best approach to improving incubation survival.

Juvenile Rearing:

Spring chinook have diverse freshwater rearing habitat requirements due to the three life history stages they display during the rearing phase. Chinook can migrate as fry, as fingerlings, or as yearlings. In the South Fork Nooksack, juvenile fish surveys have found rearing Chinook during the winter and early spring in the mainstem channel, as well as floodplain tributaries and sloughs, such as Landingstrip and Hutchinson creeks (Naef 2002). Recent fish inventories in the South Fork have found that most (76%) of the juvenile Chinook enumerated during a snorkel survey of the upper Acme-Saxon reach were associated with wood cover, including 51% with complex cover of multiple logs (Ecotrust, unpublished data). Most chinook were found in pools (49% of total), followed by flat-water glides (29%), braids (18%), and main channel riffles (4%) (Coe 2005). The Chinook habitat preference for pools and woody cover emphasizes the importance of stable wood accumulations for juvenile rearing habitat.

Restoration Projects

Substantial efforts to restore habitat in the South Fork watershed have been undertaken since the 1990s. Project partners identified 166 habitat improvement projects that were implemented between 1998 and 2003 in the South Fork Nooksack including sediment reduction, fish passage, habitat acquisition, instream restoration and habitat assessment (Nooksack Recovery Team 2009). Extensive voluntary riparian planting has been accomplished in the South Fork watershed by landowners either as part of an incentive program, such as the Conservation Reserve Enhancement Program (CREP), or through grant funding, such as the Centennial Clean Water fund. These projects include establishing riparian vegetation in places where no buffer exists, treating invasive species that can compete with native trees, and inter-planting conifers to speed forest succession toward a mature conifer forest. The majority of these projects were focused on improving watershed processes, rather than improving instream habitat for Chinook, which necessitates working in the challenging environment of the main channel of the South Fork Nooksack River.

Beginning in 2001, engineered logjam projects were implemented in the main channel to more directly improve the habitat for Chinook salmon. The first of these projects, and one of the first engineered logjam projects in the Pacific Northwest, was built by the Lummi Nation near Larson's Bridge (River Mile 19) on the South Fork. Initial monitoring of the project showed that it was successful at creating deep pools with wood cover and protecting an active landslide from erosion (Lummi Natural Resources 2002, Southerland and Reckendorf 2010, Maudlin and Coe 2012). After 5 years of assessment and design, the second engineered logjam project was located at the confluence of the South Fork Nooksack and Hutchinson Creek, an important cool water tributary of the South Fork. This project was completed in 2006 and included the installation of six engineered logjams with the removal and set-back of approximately 450 feet of armored levee. Monitoring results showed improved low-flow connectivity of Hutchinson Creek and the development of deep scour pools with wood at the logjams along the river (Lummi Natural Resources 2007, Maudlin and Coe 2012). Following construction of the Lower Hutchison project in 2006, 13 projects have been implemented in the South Fork Nooksack over the last 10 years (Table 1).

Table 1: Logjam project location, number of structures, sponsor and year completed.

Project Name	Location (River Mile)	Structures	Lead Sponsor	Year Completed
Van Zandt	1.1	15	Nooksack Tribe	2010
Todd	3.5	8	Nooksack Tribe	2008
Sygitowicz	4.0	7	Nooksack Tribe	2010
Kalsbeek	6.7	7	Nooksack Tribe	2007
Acme	9.0	5	Whatcom County	2010
Downstream Hutchinson	10	27	Nooksack Tribe	2015
Lower Hutchinson	10.5	6	Lummi Nation	2006
Nesset LWD	11.5	8	Lummi Nation	2008
Nesset Phase 1	12	20	Nooksack Tribe	2016
Skookum	14.3	3	Lummi Nation	2010

Edfro-Skookum Phase 1	14.3	5	Lummi Nation	2016
Fobes	18.5	14	Lummi Nation	2010
Larson's Bridge	20.0	6	Lummi Nation	2001
Larson's Reach	20.0	32	Lummi Nation	2015
River Mile 30	30.0	4	Lummi Nation	2007

Climate Change

Modeling of future climate indicates a shift in both air temperature and precipitation patterns for the South Fork Nooksack (Butcher et al 2016). Annual average air temperature has already increased in this region by 1.1°C over the last 100 years, according to the longest meteorological record at Clearbrook (Figure 7). While the annual precipitation will stay about the same, summer precipitation is expected to decrease and winter precipitation will likely increase, with the percent falling as snow decreasing, and the amount falling as rain increasing. The reduced snowpack and summer rainfall is expected to lead to a reduction in summer flow in the river, while the increase in winter precipitation falling as rain is expected to increase mean peak flow. Modeling of a moderately severe climate projection shows increases in mean annual temperature are expected to be most pronounced during the summer low flow period, pushing the maximum summer water temperature from 18.4°C to 25.1°C by 2080 (Butcher et al. 2016). Climate change projections are thoroughly discussed in Sections 2.3.1 and 2.4.2 of the SFNR Watershed Conservation Plan and outlined below:

- Increased winter precipitation and decreased summer precipitation
- Increased summer air temperature by 2080's of 2.81 °C to 6.31 °C (or about 5 to 11 °F)
- Increased winter air temperature by 2080's of 2.44 to 4.28 °C (or about 4 to 8 °F)
- Increased August stream temperature by 2080's of up to 6 °C (11 °C)
- Reduced snowpack and earlier snow melt
- Changes in timing and magnitude of flow (earlier snowmelt peak, greater peak flood events, longer baseflow periods)
- Increased sediment transport rates of 200-400%

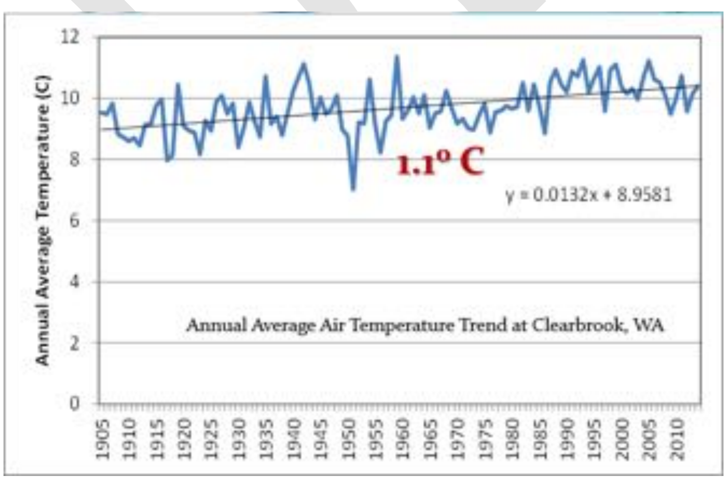

Figure 7: Change in annual average air temperature at Clearbrook, WA from 1905 to 2015.

Climate warming is projected to affect both the timing and magnitude of streamflow in the SFNR (Dickerson-Lange and Mitchell 2014, Elsner et al. 2010, Murphy 2016 cited from Dickerson-Lange 2017). In particular, warming temperatures will raise the rain-snow transition elevation which will result in diminished seasonal snowpack (both area and depth), earlier snowmelt, and a shift in the timing of the spring streamflow peak (i.e., the freshet) to earlier in the year. Associated with these key hydrologic changes are numerous impacts to humans and ecosystems, which include increased flood magnitude, reduced summer water availability, and increased summer stream temperatures (Beechie et al. 2012). Large increases in the 7-day average of the daily maximum (7DADMax) water temperature are predicted by 2080 if stream shading is left at current levels, with temperatures increasing to above 23 °C throughout much of the length of the river, which exceed the 7DADMax lethal limit for salmonids of 22 °C. The climate change project modeled stream temperature under a variety of climate change and recovery strategies and found that restoration of the historic channel and riparian conditions could largely off-set the effects of climate change on stream temperature.

As indicated previously, projected climate change will likely alter the SFNR hydrograph. As shown in Figure 8, the shape of the hydrograph will transform from the current bimodal shape to more of a unimodal shape. The base of the hydrograph will likely narrow, low summer flows will occur earlier and end later, there will be a nominal snowmelt signature to the hydrograph, and peakflows will be higher and occur longer during the fall through early spring period. This potential change to the hydrograph could have great implications to water availability. For instance, minimum instream flow as mandated by WAC 173-501 for the summer period is 300 cfs. The recurrence interval for that flow is approximately one or more times in two years. With climate change, the recurrence interval for that flow could be one or more times in 20 years depending on the climate change scenario. This shift in recurrence interval with assumed climate change suggests that junior water right holders would likely have less frequent access to water.

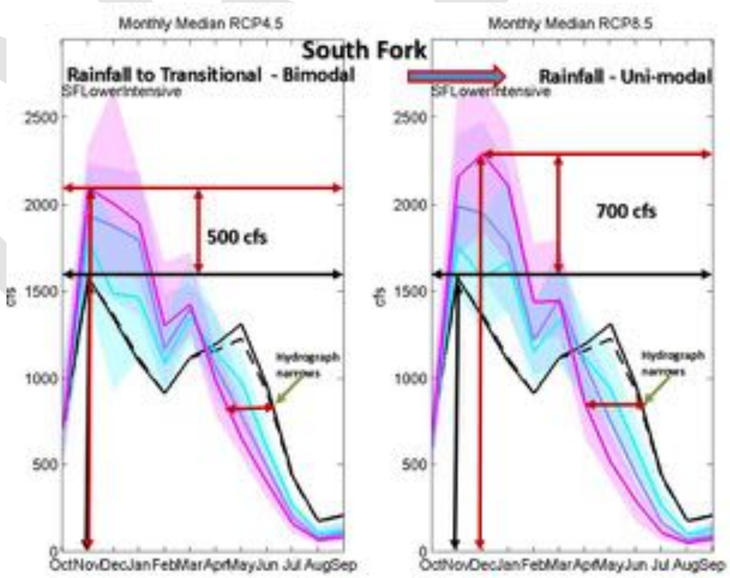

Figure 8: Change in Magnitude of Peak Flows and Timing of Flows Due to Climate Change (Taken from Grah 2016).

Sediment loads are likely to increase under climate change due to loss of soil-protecting snowpack, increased saturation of soils on steep slopes, increased frequency and magnitude of over-steepened slopes associated with valley glacier recession, increased entrainment and transport of sediment within the channels, and increasing intensity of precipitation events yielding more extreme peak flows (Grah et al. 2017). The channel shape and plan-form of the South Fork and its tributaries are expected to respond to increases in winter peak flow and more frequent high-flow events. Changes in channel width, depth, slope, grain size, bedforms, sinuosity and bed scour depth are all possible responses to increased frequency, magnitude and duration of flow. In the lower-gradient alluvial valleys of the South Fork and its tributaries, these changes will likely lead to an increase in bed and bank erosion. Increased sediment generation from forest roads is also possible due to increased road surface erosion and the increased likelihood of undersized culverts and cross-drains failing.

These projected changes highlight the important function of upland hydrologic processes to store water and sediment in-situ and to slowly release water to the stream network. These projections give credence to the need to plan and implement adaptation strategies now in advance of a future with continued climate change.

South Fork Nooksack Community Engagement

Incorporating community values was identified as a critical component of SFNR watershed conservation plan development early in the process. A comprehensive public outreach and stakeholder engagement program was implemented beginning in 2015. The hope was that any planning efforts in the watershed would be well-informed about the interests of the people who care about this place.

The approach to community engagement was based on an innovative method called “Strategic Systems Mapping.” The method is based on two concepts: 1) Creating a common understanding of the facts and 2) Building relationships. Information was made widely available through an interactive website (https://www.sfnooksack.com/).

The first part of the process was to gather together Interest Groups with people who had common issues, so that they could talk among themselves about their hopes and concerns. The Planning Team identified seven different interest groups: Agency and Tribal, Fish, Agriculture, Transportation and Utilities, Large Forest Landowners, Small Forest Landowners, and Recreation -Small Businesses. Following the Interest Group meetings, a community meeting was held and a community survey was conducted.

In early 2017, a Watershed Group was formed, for the following purposes:

A. To bring forward what had been learned from the Interest Groups, Community Meeting, and Survey, and identify areas of common ground.
B. To create a framework for dialogue about watershed conditions, goals, and strategies.
C. To provide feedback on the Nooksack Indian Tribe’s Watershed Conservation Plan.

D. To determine, after a facilitated series of four meetings, whether the Watershed Group would want to continue, and perhaps eventually develop a more comprehensive Community Watershed Plan to address other issues of concern to residents and landowners.

Forty-four residents and landowner representatives signed up to participate in the Watershed Group. An additional 353 people asked to be kept informed of the process and received regular updates. All of the meeting notes, input worksheets, agendas, and presentations were uploaded onto the website, and meetings were recorded and aired by the local low-power FM radio station, 102.5 KAVZ.

In addition to learning about the issues facing our watershed, the Watershed Group also worked to identify long-term goals and principles that could serve as a foundation for the Group moving forward, and to inform any agencies or other entities engaged in planning in the South Fork Nooksack River Watershed. The group used a consensus-seeking process to identify Long-Term Community Goals and Planning Principles, as follows:

Long-Term Community Goals

Although we have a wide range of perspectives and interests in the South Fork Nooksack River Valley, we are looking for win-win solutions to protect our water resources for:

- Our Families: Keep the rural way of life and protect it for our children.
- Our Farms: Maintain and protect productive agricultural lands and promote long-term agricultural economic viability.
- Our Forests: Maintain and protect the forestland base and promote a sustainable forest industry with a skilled and steady local workforce.

(* Additional goals related to “Our Fish” and “Our Recreation” are still under discussion).

Watershed Planning Principles

In order for us to achieve our long-range goals, we need:

- Communication, transparency, and trust between landowners, residents, agencies, and other stakeholders in the Watershed.
- Voluntary agreements between landowners and community partners, with incentives for landowner’s efforts to improve watershed conditions.
- Shared understanding and open dialogue around data, science, resource management, and the changing climate conditions that affect our watershed.
- Public education around how farmers, foresters, fishers, and other businesses are continually improving their practices to protect and improve water quality.

(*One additional principle related to respect for local landowners is still under discussion)

By April 2017, the SFNR Watershed Group had met four times and had scheduled a fifth meeting to provide feedback on the Nooksack Indian Tribe's Watershed Conservation Plan. While the future of the group is still being determined, there is broad support for continued meetings, education, and dialogue. Interests of Watershed Group members included:

- To pursue funding opportunities and resources to support landowner voluntary efforts
- To learn about and discuss watershed issues
- To give feedback on various agency plans and projects
- To develop a comprehensive Community Watershed Plan
- To provide public education opportunities on watershed issues

Recommended Actions for Watershed Restoration and Conservation

The Watershed Conservation Plan identified recommendations to facilitate the development, planning, and implementation of voluntary actions in the SFNR that are consistent with community goals and values and also would serve to:

- Support recovery of South Fork Nooksack early chinook and other salmonids;
- Help achieve compliance with Washington State Water Quality Standards for temperature, dissolved oxygen, and turbidity;
- Help meet instream flows; and
- Build ecosystem resilience to climate change.

Towards these ends, nine actions are recommended for discussion and consideration:

4.2.1. Floodplain Reconnection
4.2.2. Stream Flow Regimes
4.2.3. Erosion and Sediment Delivery
4.2.4. Riparian Restoration
4.2.5. Instream Rehabilitation
4.2.6. Acquisition and Easements
4.2.7. Fish Passage Barrier Removal
4.2.8. Community Engagement and Outreach
4.2.9. Planning

4.2.1 Floodplain Reconnection

Floodplain reconnection can restore river-floodplain dynamics that create diverse habitats and/or restore fish access to floodplain habitats. Reconnecting floodplains (including restoring vertical connectivity) can help ameliorate increased peak flows by increasing flood storage and reducing flood peaks, and ameliorate the effects of increased temperature and decreased base flow by increasing the length of hyporheic flow paths and restoring floodplain aquifer storage (Beechie et al. 2013). Temperature modeling indicates that enhanced hyporheic exchange in the South Fork mainstem lowers critical condition stream temperatures, although effects of restoring meander-scale hyporheic exchange were not modeled. The action can also potentially ameliorate increased sediment by allowing fines to settle in floodplain areas, thereby reducing sediment load in the main channel. These benefits may increase resilience of salmon populations to climate change impacts (Beechie et al. 2013). Actions include reconnecting floodplain channels, removing or setting back levees and bank hardening, or promoting aggradation through log jams. Floodplain and off-channel habitat reconnection is considered to have immediate and long-lasting benefits and a high probability of success.

Objective

The objective of floodplain reconnection is to restore the connectivity of the South Fork to its historic channel migration zone and floodplain to allow for natural habitat-forming processes (bank erosion, formation and maintenance of floodplain channels) and flood routing.

Challenges and Opportunities

Opportunity for floodplain reconnection depends on existing land ownership, use and development. The lower South Fork valley is prime agricultural land. Agricultural landowners often recognize the beneficial aspects of flooding to soil productivity, although post-flood cleanup of debris can be costly and time-consuming. Bank erosion is a greater concern, because, while an important habitat-forming process, it also may take away valuable agricultural land important to maintain economic viability. Floodplain reconnection must also avoid affecting existing development (buildings, other infrastructure).

There is approximately 9 miles of bank hardening in the lower South Fork, although much of it lies at the outer edge of the historic migration zone and protects working farms. The highest priority for restoring channel migration is the historic migration zone; approximately 310 acres of the historic migration zone has been isolated from the current channel by bank hardening. Reconnecting such areas will obviously require landowners willing to allow channel migration and sufficient funding to compensate them.

Flood control levees are not common in the South Fork, although infrastructure such as the railroad embankment, City of Bellingham pipeline crossing, several County roads and Highway 9, all act as levees at certain flow levels. Relocating such critical infrastructure outside the floodplain is expensive, but may be possible over the long-term as the infrastructure is maintained or replaced. For example, when the structurally deficient Potter Rd. bridge over the South Fork was replaced (2015-2016), the new bridge was designed with considerably wider spans to better convey floods.

Placing engineered log jams in the river channel can help reconnect floodplains by promoting aggradation in areas where landowners are willing to allow increases in flood elevation. Design of engineered log jam projects includes extensive analysis to ensure that project will be effective at meeting habitat objectives while avoiding negative impacts to adjacent landowners.

Geomorphic assessment helps proponents and stakeholders understand how the channel will respond to restoration, while hydraulic modeling informs how the project will affect flooding. As a condition of obtaining the floodplain development permit from the County, restoration proponents are required to show that project will not cause any increase in flooding (1% flood) at insurable structures. If a project is expected to increase flooding, approval from the landowner is required. Reconnecting floodplains is currently most feasible on lands in conservation ownership (e.g. Whatcom Land Trust). Community support for floodplain reconnection is more likely where it can be shown that it will benefit the community by reducing flood risk. As such, floodplain reconnection projects should integrate both salmon habitat and flood risk reduction into the design process. The Floodplains by Design grant program, administered by the Department of Ecology, provides funding for such integrated projects.

Actions

- Provide public education about the benefits of floodplain reconnection in maintaining soil productivity, reducing flood risk downstream, and improving water availability.
- Work with landowners, Whatcom County River and Flood, Acme/Van Zandt Flood Subzone, and the broader SFNR community to design and implement integrated floodplain. reconnection projects that reduce flood risk while meeting salmon habitat objectives.
- Continue to develop and implement restoration project designs that reconnect floodplains (setback/remove infrastructure, reconnect floodplain channels and promote aggradation) to the extent feasible given landowner willingness.
- Work with infrastructure owners to develop plans to set back infrastructure (railroads, roads, pipelines, bridges/bridge footings) in the floodplain to the extent possible as infrastructure is repaired or replaced, especially infrastructure that currently function as levees and/or requires bank hardening but also that which may be threatened under climate change scenarios.

4.2.2 Stream Flow Regimes

Description

Protecting and restoring stream flow regimes entails reducing water withdrawals, road or stormwater drainage input, avoiding increases in impervious surfaces, reconnecting floodplains and restoring floodplain wetlands. Recently, strategies suggested to buffer the hydrologic impacts of climate change include maximizing snowpack retention through spatially variable forest thinning or retention and maximizing soil water storage through forest thinning and uneven-age forest management suggest, or restoring upland hydrology by increasing soil moisture.

Actions to reduce upland surface water drainage include reducing length of road network, disconnecting road network from stream network, and reducing impervious areas. Impervious surfaces causes greater peak flood flows while decreasing infiltration potential and water storage in soils. This in turn causes lower summer baseflows without the input of cooler groundwater that can potentially ameliorate high summer stream temperatures.

Potential wetland restoration actions include removing drainage tile, filling drainage ditches, re-establishing direct connection of tributaries to the river, reforesting historically forested wetlands, revegetating scrub and herbaceous wetlands, and/or reintroducing beaver. Beaver ponds can have profound impacts on a watershed's potential for water retention. Active dams retain water in the dry season, metering it out downstream through gaps in the semi-permeable dam wall. Beaver dams can substantially reduce stream temperatures, trap sediment, and provide habitat for salmon.

Silvicultural practices can be used to optimize snow storage duration and maximize soil moisture. Practices include retaining and protecting forests in wind-exposed areas, gap cutting or thinning, and extending harvest rotations to allow maturation of selected stands. Developing management plans and implementing these recommendations would require explicit consideration of topographic (elevation, slope, and aspect), meteorologic (snowpack characteristics, wind speeds, cloud cover), and landcover (forest) characteristics.

Objective

The objective of this action is to reduce impacts (wetland modification, road networks) to the hydrologic regime, increase instream flows during summer low-flow and reduce peak flows, and build ecosystem resilience to climate change.

Challenges and Solutions

Restoring instream flow must be balanced with the need for water for irrigation, livestock watering, and domestic/municipal use. There may be some potential for landowners to reduce irrigation and utilize water banking. Opportunities for wetland restoration and beaver reintroduction in the SFNR valley will most likely be more viable in forested areas and less viable where there is high agricultural value. Foresters, farmers, and ranchers are often willing to support watershed conservation and restoration efforts, as long as those efforts do not negatively impact their economic viability.

Actions

- Incentivize and increase water conservation in the lower South Fork valley to the extent possible.
- Building on wetland assessment, work with willing landowners to protect and restore high priority wetlands along the lower South Fork, with the goal of maximizing temperature maintenance, baseflow maintenance, and sediment retention.
- Build on water rights assessment by reaching out to water right holders to explore opportunities for water banking to restore instream flow.
- Develop a groundwater-flow model coupled with a watershed model for the South Fork basin to quantify contribution of wetlands to South Fork hydrology and evaluate potential wetland restoration scenarios.
- Building on beaver assessment ground-truth beaver habitat model and work with landowners to identify locations where beaver can be reintroduced and work with federal, state, and County governments to enable beaver reintroduction where landowners are willing.
- Build on conceptual plan to restore upland hydrology by working with landowners to explore the feasibility of and model the hydrologic impacts of silvicultural practices that optimize snow storage duration and maximize soil moisture.

4.2.3 Erosion and Sediment Delivery

Description

With increased extreme precipitation events and subsequent increased peak flows projected for the region with climate change, erosion and sediment flux will also likely increase. Large amounts of sediment in a river system can have multiple adverse effects on aquatic habitat that can include widening and/or incision of the channel and aggradation of large pools, thereby increasing stream temperatures. Actions that could reduce sediment delivery to the South Fork include road resurfacing and landslide hazard reduction. Such actions have long-term benefits, but take 5-20 years to achieve those benefits. The projects are considered highly likely to achieve their goals.

Objective

The objective of this category of actions is to minimize sources of sediment and to incorporate understanding of current and future sediment regime into conservation and restoration project and program planning.

Challenges and Solutions

The greatest challenge is the lack of information on relative sediment sources and uncertainty about future climate impacts. The Nooksack Tribe is working with US Geological Survey and Western Washington University researchers to monitor baseline sediment conditions and estimate how future climate will affect sediment regime.

Actions

- Develop a relative sediment budget to identify priorities for source control (road surface, bank erosion, mass wasting) and to provide a basis for modeling future climate scenarios.
- Continue to refine sediment transport estimates and monitor sediment dynamics over the long term.
- When designing restoration in a project reach of the South Fork, continue to evaluate feasibility of reducing sediment inputs from any stream adjacent landslides in the reach.
- Work with USFS to evaluate, prioritize, and address road network deficiencies.
- Assess potential for orphaned roads to deliver sediment and prioritize and implement orphaned road abandonment projects.
- Map deep-seated landslides throughout the SFNR and monitor them over time.
- Model risk of shallow rapid landslides in the SFNR.

4.2.4 Riparian Restoration

Description

Restoring the riparian zone of the South Fork and subbasins would substantially ameliorate high stream temperatures due to climate change and has been a major focus of restoration activities in the watershed. Examples of this action include removing invasive plant species that inhibit the growth of native species, planting or interplanting native plant species, and controlling livestock grazing or other riparian zone disturbance. Not only does riparian vegetation provide direct shade, but forested riparian areas also deliver large wood to the channel that creates deep pools for thermal refugia. Riparian restoration is currently considered a moderate salmon recovery priority (WRIA 1 SRB 2016), because WRIA 1 SRFB/PSAR funding decisions prioritize projects that provide immediate benefit to chinook abundance and productivity, and there are alternative funding sources for riparian restoration (e.g. Department of Ecology Centennial Clean Water Fund, EPA section 319 funding, NRCS Conservation Reserve Enhancement Program). Riparian restoration is considered to have long–term benefits, but it can take decades to realize the benefits. Actions such as conifer interplanting have a high variability of success and low to moderate certainty of success.

Objective

The objective of this action is to restore mature riparian along and within 300 feet of the South Fork Nooksack River channel migration zone, as well as sufficient riparian buffers along tributaries to restore hydrologic and temperature regimes. The site potential buffer widths used in the TMDL "system potential vegetation" scenario was 150'.

Challenges and Solutions

Economic considerations limit landowners' ability and/or willingness to protect and restore riparian buffers on productive agricultural or forestlands beyond regulatory requirements. The Conservation Reserve Enhancement Program for agricultural land and the Forestry Riparian Easement Program for small forest landowners can compensate landowners for the loss of land. While there is no publicly available information on enrollment in the Conservation Reserve Enhancement Program (CREP) or the Environmental Quality Incentives Program (EQIP), it is evident from the aerial photo analysis that a great number of agricultural landowners are participating in conservation programs in the South Fork Watershed. Based on the available information approximately 10% of the 340 landowners in the assessment area appeared to be participating in a riparian conservation program. Much of this work was in the Black Slough floodplain area, where land is likely less suitable for agriculture than areas along the lower SFNR, where about 31% of the riparian area is actively farmed.

Actions

- Purchase riparian easements and/or continue to implement and expand CREP program through the lower South Fork, with willing landowners.
- Work with forest landowners to voluntarily provide wider buffers on tributary streams.
- Control non-native invasive vegetation that outcompete native vegetation to accelerate trajectory to recovery in riparian areas along the South Fork and tributaries (especially Hutchinson Creek).
- Conduct riparian stand assessments and develop a riparian restoration plan for the South Fork watershed that identifies and prioritizes appropriate treatments by location.

4.2.5 Instream Rehabilitation

Description

Instream rehabilitation primarily involves the strategic placement of engineered log jams or other woody structures to encourage the formation of deep pools and coldwater refuges and increase habitat diversity and the availability of complex woody cover for hiding and resting. Instream restoration projects may ameliorate temperature increases by creating cold-water refuges through thermal stratification (Gendaszek 2014) or pool formation in areas of cool water input (Nooksack Indian Tribe, unpublished data), increasing hyporheic exchange (Parzych 2015), and narrowing active channel width, thereby increasing effective shade. Instream restoration can also ameliorate sediment inputs from large deep-seated landslides, as observed for the South Fork Larson's Bridge project that was implemented by Lummi Natural Resources in 2001.

Objective

The objective of instream rehabilitation is to form deep pools and temperature refuges, increase habitat diversity (number of habitat units) and complex woody cover, and reduce the length of bank hardened with riprap.

Challenges and Solutions.

There is broad awareness about the importance of log jams to salmon and habitat formation, especially among long-time residents of the valley who have witnessed the loss of log jams and associated deep pools over time. There is also concern over negative impacts, such as changes in channel alignment or flooding or increased risk to recreational users. In addition to recognizing the importance of wood, long-time residents of the valley understand that the river is dynamic and changes over time. Project proponents must also undertake a rigorous design and permitting process that includes explicit evaluation of channel and flooding response to restoration, and any public safety risk must be avoided or mitigated.

Opportunity for restoration among agricultural landowners could be increased by pursuing integrated habitat restoration and bank protection projects, especially at the outer edge of the historic migration zone to minimize constraints to channel migration. USDA National Resources Conservation Service's Regional Conservation Partnership Program can fund such projects, although salmon recovery funding may be necessary to help defray the high design costs that are typical of engineered log jam projects.

Actions

- Continue instream restoration in high priority reaches of the South Fork that create coldwater refuges, increase effective shading, increase channel roughness to promote hyporheic exchange, reconnect floodplain channels, reduce redd scour, create flood refuge habitat, decrease shear stresses, and create hydraulic refuges.

- Share information and solicit input about proposed restoration projects in community forums.
- Work with landowners to develop, seek funding for, design and implement integrated habitat restoration/bank protection projects that provide mutual benefits to landowners and salmon habitat and replace riprap bank hardening with complex woody cover.
- Evaluate and communicate restoration project effectiveness to the SFNR community.
- Research mechanisms to maximize temperature refuge formation and maintenance (i.e. hyporheic, groundwater and surface flow dynamics that contribute cool water; pool morphology or structural elements like wood that prevent immediate mixing of cool and warm water) and incorporate findings into restoration project designs.
- Improve habitat quality in cool-water tributaries, especially floodplain tributaries that provide important flood refuge and overwinter rearing habitat, by placing logs and log jams.

4.2.6 Acquisition and Easements

Description

This action includes acquisition of fee-simple title, conservation easements, and purchase of development rights from willing landowners.

Objective

The objectives of this action are to: (1) prevent watershed degradation through conversion of forest and agricultural land to development; and (2) to increase opportunity for riparian and floodplain restoration.

Challenges and Opportunities

The SFNR community values agriculture and forestry (see community long term goals), and support is strong for maintaining those land uses and avoiding conversion to development. In some cases, funding for easements or acquisition of less productive/income generative resource lands can help sustain active farm and forest operations while achieving restoration objectives.

Actions

- Implement purchase of development rights where landowners are willing, including
  - Quantify available development rights in the SFNR and prioritize acquisition.
  - Outreach to landowners of priority parcels to evaluate willingness
  - Develop strategy to secure sufficient funding to purchase development rights from willing landowners.
- Increase the opportunity for floodplain reconnection and riparian restoration by acquiring conservation easements or fee simple title to property in the floodplain from willing landowners, or otherwise working with landowners to support stewardship efforts. Look for opportunities to exchange river-adjacent land for property further from the river.

4.2.7 Fish Passage Barrier Removal

Description

Restoring longitudinal connectivity is intended to reestablish salmon migration to diverse habitats that have been lost through construction of artificial barriers. Reconnection often also restores downstream transport of sediment, wood or other organic matter, and flow. We have expanded the action beyond artificial fish passage barriers to also include evaluating improving passage at natural fish passage barriers that prevent migration into the upper portions of the South Fork watershed, where summer stream temperatures are considerably cooler than the lower elevation portion of the watershed. Actions also address barriers in tributaries and floodplain channels that limit access to crucial rearing habitat and overall lower stream temperatures. Reconnecting habitat is considered to have immediate and long-lasting benefits and a high probability of success.

Objectives

The objectives of this category of actions are to restore fish passage at all artificial barriers and to evaluate improving passage at natural barriers (South Fork at RM 25 and RM 31, Skookum Creek at RM 0.5 and 2.4) to cooler upstream habitats.

Challenges and Solutions

While fish passage restoration projects may inconvenience landowners in the short-term during construction, the long-term impacts are typically neutral or, where associated with road improvements or upgrade of bridge load capacity, positive. Insufficient funding and lack of technical resources are the greatest barrier to fish passage restoration on private lands, but funding sources and project partners are available. Potential funding sources for fish passage barrier removal include Washington Department of Natural Resources' Family Forest Fish Passage Program (private forestlands), U.S. Department of Agriculture Natural Resources Conservation Service's Regional Conservation Partnership Program (agricultural lands), and Washington Department of Fish and Wildlife's Fish Passage Barrier Removal Board. Local conservation partners who engage in fish passage barrier removal projects include Whatcom Conservation District and Nooksack Salmon Enhancement Association.

Actions

- Compile available data on fish passage barriers in the SFNR watershed and prioritize replacement according to length of habitat reconnected, salmonid species benefitted, and temperature of connecting waters. Make information publicly available.
- Outreach to landowners of priority barriers and connect landowners with funding sources and project sponsors.
- Increase use of cooler upstream habitats through release of hatchery-origin South Fork chinook smolts to such habitats.
- Evaluate feasibility of improving passage at natural barriers (South Fork at RM 25 and RM 31, Skookum Creek at RM 0.5 and 2.4) – and implement feasible projects.

4.2.8 Community Engagement and Outreach

Description

This action includes education and outreach and participating in community forums, such as the South Fork Watershed Group and Acme-Van Zandt Flood Subzone.

Objective

The objectives of this action are to build trust, raise awareness, and improve transparency to build community support for conservation and restoration efforts in the SFNR.

Challenges and Solutions

There is considerable interest among South Fork Watershed Group members in continuing to meet as a group. Group facilitation is helpful to identify areas of agreement and build consensus. The Nooksack Tribe provided funding for the initial series of meetings, but new sources of funding will likely be needed to sustain the effort as the Watershed Group moves forward as a self-organizing body, to provide for administration and communications.

Actions

- Encourage conservation partners to participate in community forums, such as South Fork Watershed Group and Acme/Van Zandt Flood Subzone, to solicit input on conservation and restoration projects and programs.
- Develop targeted education and outreach materials to communicate importance of and build support for restoration and conservation projects and programs in the SFNR.
- Support education and outreach in community forums on topics of interest that relate to conservation and restoration projects and programs. South Fork Watershed Group members expressed interest in further conversations around the following topics:
    - Agriculture
    - Water Rights
    - Tubers/Water recreation
    - Strategy for public education & outreach
    - Forestry
    - Wildlife
    - Tribal Treaty Rights
    - Pioneer history & management techniques
    - Habitat Restoration
    - Flood Management
    - Water Quality (temperature, sediment)
    - In-stream restoration/log jams
    - Railroad/Highway impacts
    - Elk Habitat
    - Emergency Preparedness
    - Beaver re-introduction & re-location

4.2.9 Planning

Description

This action relates to planning of restoration and conservation programs and projects and supporting community efforts towards comprehensive watershed planning.

Objective

The objective of this action is to support long-term, holistic planning in the watershed and encourage community investment and participation in activities that advance watershed health for current and future generations.

Challenges and Solutions

Critics of conservation planning assert that it often lacks transparency and sufficient opportunity for public input. Continuing efforts to provide information and opportunities for meaningful community engagement in planning and project development is critical to success.

Actions

- Support the efforts of the Watershed Group to develop a comprehensive Community Watershed Plan, to advance long-term community watershed goals.
- Work with the SFNR community and the Acme/Van Zandt Subzone to re-evaluate the potential for integrated floodplain management planning, integrating flood risk reduction, agricultural protection, and salmon recovery needs.
- As a comprehensive water settlement approach develops to resolve conflicts at the broader Nooksack River watershed scale, work with the SFNR community to evaluate willingness to participate. Lummi Nation has proposed an approach that would integrate water quantity, water quality, and habitat restoration.
- Incorporate climate change information into updates to *WRIA 1 Salmonid Recovery Plan* and development and prioritization of projects for SRFB/PSAR funding.

Conclusion

Watershed Planning is a continuous process, which leads to valuable interactions among the planners, scientists, residents, landowners, organizations and government entities. It creates opportunities for innovation and collaboration to achieve common goals, and requires patience to understand and learn from differences. This plan would not have been possible without the dedication of many community members and allies who care about the SFNR watershed and are actively seeking to understand its history and intelligently shape its future.