# Water Resource Inventory Area (WRIA) 1
# Salmonid Habitat Restoration Strategy

**(Version 2.5a)**

WRIA 1 Salmon Recovery Board
(Lead Entity)

Bellingham, Lummi Nation, Nooksack Tribe, Whatcom County Government,
Whatcom County Small Cities, Washington State Department of Fish and Wildlife

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# 1. INTRODUCTION

The WRIA 1 Salmonid Habitat Restoration Strategy identifies and prioritizes projects that protect and restore habitats and the ecosystem processes essential to the recovery of Endangered Species Act-listed chinook salmon and bull trout, along with other salmonids native to Water Resource Inventory Area (WRIA) 1.

The need for this Strategy is two-fold. First, the State of Washington Salmon Recovery Funding Board (SRFB) has required that each Lead Entity, as described under RCW 77.85, develop a strategy to guide local habitat project identification, prioritization, and sequencing. The strategy integrates local restoration needs and priorities with current SRFB guidance and requirements. The State of Washington has placed an emphasis on the salmonid stocks listed under the ESA as described in both the RCW 77.85 and in A Guide to Lead Entity Strategy Development (SRFB October 30, 2003). The local priorities described herein incorporate that guidance.

Second, this Strategy constitutes an important component of the WRIA 1 Salmonid Recovery Plan, which incorporates recommendations for all 4 "H's" (habitat, harvest, hatchery, and hydropower) and, in addition to voluntary measures, also covers regulatory and incentive-based actions.

This Strategy can, and should, also inform and guide habitat projects driven by funding or priorities other than those defined by the SRFB. By the use of strategic project sequencing, it will be possible to "keep our eyes on the prize" of recovering ESA-listed salmonid stocks while also providing for the ecosystem functions necessary to recover other salmonid species. Using this approach it is possible to continue to build on the existing base of voluntary projects that may target lower priority stocks yet are important to overall ecosystem health and diversity and that meet broader watershed recovery objectives. Maintaining momentum on visible projects using appropriate funding sources will be especially important in the lowland areas of western Whatcom County, where much of the population and the agricultural community are located, and where sustained community support and involvement are essential to achieving recovery of the salmonids native to WRIA 1.

The Strategy has been developed by a group of government agencies, tribes, and nonprofit organizations, with lead work by the Nooksack Tribe's Natural Resources Department. It will be adopted by the member governments of the WRIA 1 Salmon Recovery Board, including the City of Bellingham, Lummi Nation, Nooksack Tribe, the small cities of Whatcom County, Washington Department of Fish and Wildlife, and Whatcom County.

## 2. GOAL

The ultimate goal of salmon recovery efforts in WRIA 1 is healthy, self-sustaining runs of salmon at harvestable levels. The primary goals of this Strategy are to protect properly functioning habitats and restore and maintain to within the range of natural variability the landscape processes that form habitats to which wild salmonid stocks are adapted. Since funding is limited, prioritization is necessary to focus and direct restoration efforts in the near term towards recovery of the species most at risk--ESA-listed species. Over the long term, prioritization based on species of interest merely alters the sequence, rather than the types, of restoration projects (Beechie and Bolton 1999). Further, adopting a process-oriented approach based on a sound scientific understanding of the biological and physical processes limiting salmonid production ensures benefits to multiple species, even while benefits to priority species are maximized.

The Strategy's secondary goal is to encourage the establishment of coordinated watershed restoration programs through: (1) encouraging partnerships of restoration practitioners, resource managers, landowners and community stakeholders (e.g., Nooksack Recovery Team, Marine Resources Committee, Agriculture Preservation Committee); (2) increasing knowledge, information and tools for watershed restoration and management; and (3) providing opportunities for community-based employment, training, education and stewardship. Since restoration must be implemented and evaluated at the watershed scale and over long time frames, institutionalization of restoration into communities and agencies will be necessary (Williams et al. 1997). For example, there is a need for road culverts to be inventoried and evaluated for the ability of fish to travel freely up and downstream since this was not always considered in the past. Whatcom County's development of a comprehensive database of culverts related to both public and private roads provides the basis to build fish barrier correction into annual agency budgets as well as to help connect private landowners with resources to fix passage problems.

## 3. PURPOSE

The Salmonid Habitat Restoration Strategy is intended to serve as the Lead Entity Strategy for WRIA 1. The primary purpose of the Strategy is to direct the process for project selection and ranking for Salmon Recovery Funding Board (SRFB) funding. The Strategy will also provide the following functions (SRFB 2003):

1. Guide project selection for other funding sources;
2. Guide mitigation resulting from environmental permitting;
3. Document the scientific and community stakeholder priorities for restoration and protection of salmon habitat;

4. Contribute to the habitat restoration and protection (non-regulatory) component of the Shared Strategy regional salmon recovery plan;
5. Contribute to the salmon habitat component of a sub-basin plan;
6. Contribute to the non-regulatory component of the habitat element of watershed plans under RCW 90.82 ("2514");
7. Communicate to project sponsors and community stakeholders the plan for salmon habitat protection and restoration and how to apply the Strategy in project identification and implementation;
8. Provide information for the Habitat Work Schedule, which is required by RCW 77.85.060;

In addition to the SRFB identified functions, the Strategy will also:

9. Inform on-going or future revisions to local, tribal, and state regulations; and
10. Direct state, federal, and local agencies to coordinate permits and mitigation requirements with restoration priorities.

# 4. SCOPE

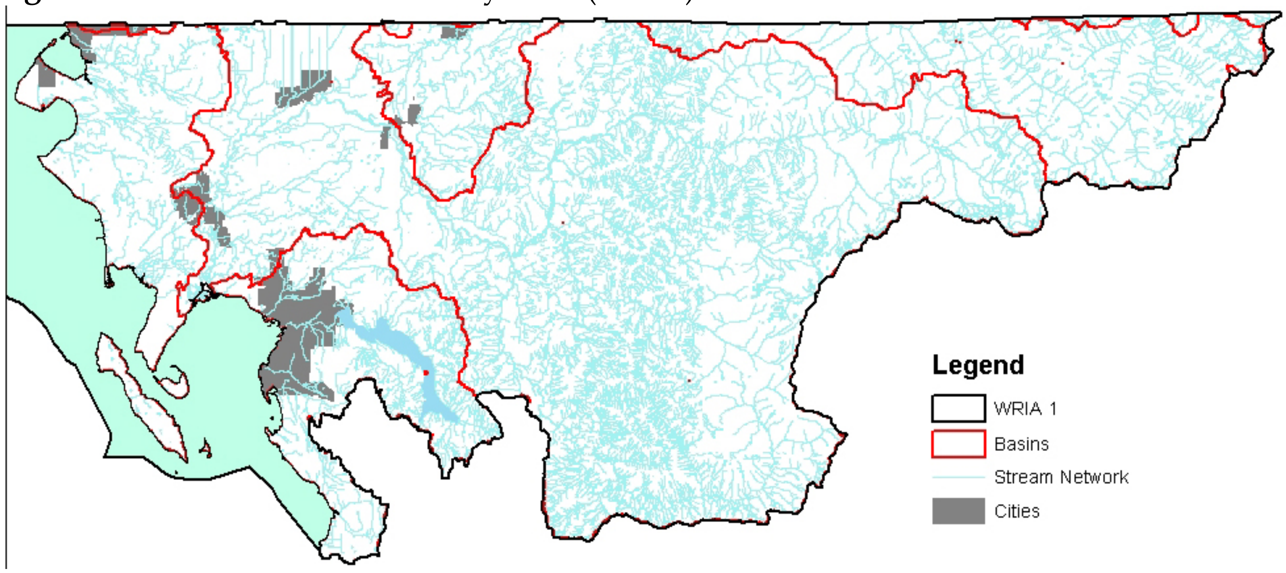
## 4.1 Geographic

The geographic scope of the Strategy includes all upland, freshwater, estuarine and nearshore habitats in WRIA 1, including watersheds of the Nooksack and Lummi Rivers, independent coastal drainages (Dakota Creek, California Creek, Terrell Creek, Squalicum Creek, Whatcom Creek, Padden Creek, Chuckanut Creek, and Oyster Creek watersheds) south to and including Oyster Creek, and Fraser River tributaries south of the Canadian border (Sumas and Chilliwack Rivers).

The Colony Creek and Whitehall Creek watersheds are designated by Washington State Department of Ecology as lying within WRIA 1. However, by agreement with Skagit County and to continue the long-standing working relationship between the state-designated regional fisheries enhancement groups (the Nooksack Salmon Enhancement Association and the Skagit Regional Fisheries Enhancement Group), salmonid habitat restoration work done in the watersheds south of Oyster Creek will be coordinated through the designated lead entity for WRIAs 3 and 4, the Skagit Watershed Council.

Some of the creeks in WRIA 1 originate in Canada, and may have water quality or quantity issues that do not fall under local, state, or federal jurisdiction. There are a number of efforts underway to coordinate with Canadian authorities on both surface and ground water resource issues, and this Strategy will incorporate the results of those efforts as appropriate.

**Figure 1**. Water Resource Inventory Area (WRIA) 1.




## 4.2 Actions

Four general types of voluntary ecosystem recovery actions (NRC 1992) are considered in this Strategy:

1. **Protection**. The underlying objective of protection efforts is to halt further habitat degradation by preserving portions of ecosystems with functioning natural processes. Voluntary protection measures include land acquisition and conservation easements.
2. **Restoration**. Restoration can be defined as the "re-establishment of pre-[anthropogenic] disturbance aquatic functions and related physical, chemical, and biological characteristics." Passive restoration involves removing anthropogenic constraints to natural ecosystem structure and function and allowing the system to recovery naturally, while active restoration involves major intervention that accelerates or circumvents natural processes (NST 2003).
3. **Rehabilitation**. Where restoration to pre-anthropogenic disturbance conditions is unfeasible, rehabilitation or enhancement tactics can be employed that improve habitat conditions or partially restore ecosystem processes.
4. **Substitution/creation**. Habitats can be substituted or created where they formerly did not exist, but such actions typically involve engineered solutions that require long-term maintenance.

Certainty of contribution to ecosystem recovery is greatest with protection, followed in order by restoration, rehabilitation, and substitution/creation (NST 2003). This Strategy emphasizes protection and restoration to properly functioning conditions, as defined by NOAA Fisheries (NMFS 1996) and described in the WRIA 1 Salmonid Recovery Plan (in preparation). However, it is recognized that rehabilitation and substitution/creation may be necessary in more heavily degraded and populated areas of WRIA 1.

In addition to these four types of recovery actions, high-quality assessment and monitoring projects should be considered for estuarine and nearshore marine areas, since less is known about structure and function of estuarine and nearshore marine ecosystems than about freshwater ecosystems.

# 5. STOCK PRIORITIES

The Strategy assigns the highest priority to actions that benefit the recovery and production of salmonid populations in the following descending order:

1. North Fork/Middle Fork and South Fork Nooksack early chinook salmon
2. WRIA 1 bull trout
3. Other Nooksack River salmonids, including wild-spawning coho, late-timed chinook, fall chum, pink, winter-run steelhead, summer-run steelhead, sea-run cutthroat, sockeye.

These priorities are based upon stock status (abundance and productivity) and Endangered Species Act (ESA) listing status. Naturally-spawned chinook in WRIA 1 constitute part of the Puget Sound Chinook Evolutionarily Significant Unit (ESU), listed as threatened under ESA (64 FR 14308, Mar. 24, 1999). The Puget Sound Chinook Technical Recovery Team (TRT) has identified two independent populations in WRIA 1: South Fork Nooksack (SF) early chinook and North Fork/Middle Fork Nooksack (NF/MF) early chinook. Both populations are considered essential for recovery of the ESU. Recent escapements of natural-origin spawners are critically low, averaging 228 (SF) and 161 (NF/MF) from 1995 through 2002 (WDFW, unpublished data). The South Fork Nooksack early chinook population is higher priority than the North Fork/Middle Fork population, because the latter is also supported by hatchery supplementation from the WDFW Kendall hatchery, which may buffer the short-term risk of extinction.

Bull trout in WRIA 1 constitute a component of the Coastal/Puget Sound Distinct Population Segment (DPS), also listed as threatened (64 FR 58910, Nov. 1, 1999). WRIA 1 bull trout comprise two of the eight core areas that have been defined within the Puget Sound Recovery Unit: Nooksack and Chilliwack.

Nooksack late-timed chinook are considered non-native origin with composite production (WDFW 2002). Nooksack Tribal elders have indicated there were historically native, late-timed chinook in the Nooksack River watershed, although limited genetic analyses conducted to date have found no compelling evidence for the current existence of an additional native chinook stock in the Nooksack River.

Puget Sound/Strait of Georgia coho salmon, including Nooksack coho, is a candidate for possible listing (64 FR 33466, Jun. 23, 1999). In a status review of Pacific salmonids throughout the Pacific Northwest (Nehlsen et al. 1991), Nooksack native coho were considered to be potentially extinct; the run is managed for and dominated by hatchery production (Weitkamp et al. 1995), although there is strong evidence of wild-spawning coho that are genetically distinct from hatchery coho in the upper North Fork Nooksack River (upstream from and including Glacier Creek; Small 2003). The Chilliwack drainage is not prioritized for habitat restoration or protection, due to relatively pristine habitat conditions and largely protected management status.

Important to ecological restoration, but not prioritized at this time, are WRIA 1 native chum, pink, and sockeye salmon, winter and summer-run steelhead, sea-run cutthroat trout, Lake Whatcom kokanee, non-ESA listed native char, and resident native salmonids. WRIA 1 stock priorities will be revisited periodically as new information becomes available.

Stock priorities are intended to emphasize listed and candidate species in habitat restoration and protection projects. However, strategy implementation will also yield benefit to other species. For instance, restoration of natural habitat conditions in priority species' habitats will directly benefit non-prioritized species, to the extent that the distributions of priority and non-priority species overlap. Further, restoration of habitat-forming processes throughout the watershed will ultimately benefit all salmonid species.

# 6. GUIDING PRINCIPLES

The following principles are important elements of strategic watershed restoration and form the foundation of the WRIA 1 Salmonid Habitat Restoration Strategy. Given that the primary purpose of the Strategy is to direct the process for project selection and ranking for Salmon Recovery Funding Board (SRFB) funding, it is also important that the Strategy remains consistent with SRFB guidance, which continues to evolve. Ensuring such consistency will improve the likelihood that the WRIA 1 project list will be adequately funded from year to year. Thus, although priorities outlined in this document have been developed locally, the Strategy has also been informed by SRFB policies, principles, and criteria. This information should be updated for each new SRFB funding round. Please refer to the SRFB website at **http://www.iac.wa.gov/srfb/docs.htm** for the most current SRFB information.

## 6.1 Process-Based Restoration

This Strategy emphasizes projects that address the root causes, rather than symptoms, of watershed degradation by focusing on disruptions to habitat-forming processes (i.e., the natural rates of delivery of water, sediment, heat, organic materials, nutrients, and other dissolved materials; NMFS 1996). By restoring the natural rates and magnitudes of habitat-forming processes, habitat conditions will naturally tend to express the array of habitat conditions to which local stocks are adapted (Beechie and Bolton 1999) in both freshwater and nearshore marine areas. Historical reconstruction is key to identifying disruptions to habitat forming processes. Implicit in the process-oriented approach is the move away from managing for static habitat conditions, instead restoring natural ranges of temporal and spatial variability in habitat conditions. For instance, natural channel migration may cause degradation of a side channel in one location while allowing for creation of similar habitats in other locations. Examples of projects that address disruptions to habitat-forming processes include: riparian restoration, sediment source reduction through road drainage improvement or abandonment, removal of riprap and levees to provide for channel migration, restoration of woody debris and detritus inputs to estuaries, and removal of shoreline armoring to restore feeder bluff functions. Where population abundances are critically low (e.g., Nooksack early chinook populations), process-based restoration will need to be balanced with interim measures that have more immediate benefit. Examples include large woody debris placement necessary to form and maintain complex in-channel adult c holding and juvenile chinook habitat, and beach nourishment to provide the sediment particle sizes preferred by forage fish for spawning. Additional discussion is provided under Section 6.4, Interim Measures.

## 6.2 Evaluating Magnitude of Benefit

The magnitude of benefit of projects should be evaluated in terms of expected benefit to the salmonid populations of interest, namely the impact on their abundance, productivity, diversity, and spatial structure. Although tools for linking watershed processes and habitat conditions to salmonid population performance are limited at this time, the following methods and principles will guide identification and prioritization of projects.

### Chinook Populations

Ecosystem Diagnosis and Treatment (EDT)[1] has been applied in WRIA 1 to both establish quantitative recovery goals for South Fork Nooksack and North/Middle Fork Nooksack early chinook (see *WRIA 1 Salmonid Recovery Plan*, in preparation) and to determine geographic priorities and reach-specific limiting factors and life stages for the two populations. Geographic and limiting factor priorities (see Tables C-1 through C-4), which are linked to the recovery goals, should be used to guide the identification and

[1] The EDT method models the effects of habitat conditions scenarios on the abundance, productivity, and diversity of a given chinook population. Input data include: (1) characteristics (spatial and temporal distribution of life history stages) of the salmonid population of interest and (2) ratings (based on data or expert opinion) of conditions for each of 48 habitat attributes within each habitat reach used by the population. The EDT model applies a set of biological rules, based on scientific literature and/or expert opinion, for how specific habitat attribute ratings affect life stage survival and capacity within each reach and effects are integrated over all life stages and reaches of the population. EDT represents an expert system (ISAB 2003), a formalized method of organizing and applying information and opinion that is preferable to expert opinion in that it makes the underlying assumptions explicit and clear.

prioritization of projects designed to benefit these populations. EDT can also provide insight into limiting factors for other salmonid populations, to the extent that the habitat requirements and spatial and temporal distribution of those populations overlap with Nooksack early chinook.

**Other Populations**

For other prioritized salmonid populations (WRIA 1 bull trout, WRIA 1 wild-spawning coho), limiting factors and geographic and action priorities have been identified using existing data and best professional judgment. To reduce the risk associated with the reduced scientific certainty for these populations, the following principles have been applied:

*Sequencing of Projects*

Project types should be implemented first that have a high probability of success, low variability (i.e. methods utilized are relatively standardized) among projects, and relatively quick response time, which leads to the following general sequencing (Roni et al. 2002):

1. Protection of areas with high-quality habitat and functional processes;
2. Reconnection of isolated high-quality habitats (e.g., those blocked by culverts);
3. Restoration of habitat-forming processes, especially hydrologic, geologic (sediment delivery and routing), and riparian processes; and
4. Instream habitat enhancement (e.g., additions of wood, boulders, or nutrients).

*Landscape Ecology*

The complex life histories of salmonids require a wide array of habitat types, making it necessary to provide for both life-history stage specific refugia and connecting habitats throughout the watershed. Habitat that retains a high degree of ecological integrity should be protected first, followed by protection and/or restoration of habitats contiguous or near to existing high quality habitats. In the short-term, presence of such refugia should help stabilize the population, while in the long-term, refugia can provide colonists to the rest of the basin (Beechie & Bolton 1999). Further, protection of fully functional habitat is both cheaper and more likely to succeed than restoring degraded habitats (Hoobyar 1999). Nonetheless, the importance of degraded connecting habitats should not be overlooked. For instance, restoration of the lower mainstem Nooksack will be necessary both to ensure connectivity between the upper watershed and the marine environment, but also to recover the considerable loss of diverse rearing habitat that lowland floodplain systems historically provided. A phased approach to restoration may be more appropriate in such habitats, concentrating at first on actions that will change the trajectory towards recovery (i.e., riparian restoration initially emphasizing removal of exotic species and the establishment of a mixed forest canopy before selecting for conifers as a primary riparian stand component). However, the phasing should recognize that ultimately native conifers would probably result in the most desirable restoration trajectory of providing the large volume of LWD needed to create and maintain habitat-forming processes in large channels.

## 6.3 Interim Measures

Depending on the nature of habitat degradation, benefits of process-based restoration may not be realized for years, decades, or even centuries. Interim measures are necessary and appropriate to provide immediate benefit to salmonid populations at critically low abundances.

Habitat modifications (e.g., placing log structures and constructing spawning riffles) have experienced high failure rates in the past (Frissell and Nawa 1992), likely due to failure to consider the ecological and landscape contexts of habitat degradation (Beechie and Bolton 1999). Instream habitat enhancement projects (e.g., engineered log jams, habitat structures, channel creation) or nearshore marine projects (e.g., beach nourishment, eel grass bed re-establishment) may be constructed as interim measures when stocks are critically low. Examples of other interim measures are stream fertilization and carcass deployment, which attempt to return to stream ecosystems marine-derived nutrients, which were historically high due to large anadromous salmonid runs.

However, such projects should both be preceded by detailed assessment and conducted in conjunction with treatment of long-term effects (e.g., riparian revegetation, forest road abandonment, removal of shoreline armoring) that provide for long-term restoration of habitat forming processes. These assessments should consider those biological and physical factors that are beyond the project scope and that may affect the ability to evaluate project effect on improved biological functions.

## 6.4 Protection Projects

Protection of properly functioning habitats is one of the primary goals of the WRIA 1 Salmonid Habitat Restoration Strategy. The underlying objective of protection efforts for the purposes of this strategy is to halt further habitat degradation by preserving those places within WRIA 1 where ecosystem processes are functioning naturally and where existing land-use protections may be lacking. Examples of habitats to be targeted for protection includes places where mature riparian forests provide shade and contribute large woody debris, areas where the river is free to meander and can overflow onto its historic floodplain and, places where off-channel habitats are connected to the river through streams and provide summer and winter rearing habitat for juvenile salmonids.

Protection is important to ensure that refuges of existing salmon habitat will be maintained and not converted to incompatible land uses. Because WRIA 1 early-timed chinook populations are critically low and it may be many years before restoration projects constructed today are able to restore naturally functioning ecosystem processes, the best way to sustain suppressed populations is to protect the most functional remaining habitats. Furthermore, protection of fully functional habitat is both cheaper and more likely to succeed than restoring degraded habitats (Hoobyar 1999).

Protection can be accomplished through a variety of mechanisms including regulation, fee-simple purchase, conservation easements, and through the initiative and stewardship ethic of individual landowners. Each approach brings with it varying degrees of certainty that the affected habitats will remain functional in the long-term. While the preference of many is to rely on either existing regulations and landowner initiative to accomplish habitat protection, it is recognized that more active intervention may be necessary or warranted to accomplish habitat protection and/or restoration.

While other forms of land preservation, such as easements and leases, can be effective ways of protecting habitat, fee-simple (outright) acquisition has the greatest amount of long-term certainty. In addition, purchasing property directly addresses a root cause of habitat degradation by placing a property with functioning habitat into a legal status that declares salmon habitat as the primary land use, preempting other land uses that may be incompatible or destructive to salmon. Acquisition of salmon habitat from willing landowners through a fair market purchase respects a clear WRIA 1 community preference for compensation over regulation. Where major habitat restoration projects are planned, such as removal of a dike or levee, acquisition of affected parcels may be necessary to accomplish the restoration goal without burdening landowners. Protection projects funded under the SRFB, and many other types of grant sources, require encumbering the land with a restrictive deed of right for habitat protection. This perpetual legal encumbrance guarantees a long-term life span for the salmon restoration project.

Land use impacts that are adverse to salmon can be prevented or moderated by regulations. However, zoning, critical areas ordinances, forest practice and shoreline rules, and other land-use related permits are no guarantee that salmon habitat will be protected. Land use rules in place today contain allowances for variances and exemptions. This is politically reasonable because land use rules are written for general situations and cannot be expected to apply to the many unique properties and landscapes found in the natural world. Consequently, land use rules must be flexible to attempt to address the range of private, public, and tribal rights involved. Land use regulations are often constrained by lack of adequate enforcement mechanisms or support for legal action against violators. Currently, land use regulations are triggered when a landowner applies for a permit. Typically violations are investigated only if the local or state government with implementation authority for a given regulation receives a citizen complaint.

*Protection Priorities*

The top priority for protection projects is highly functional habitats that are at risk of land-use disturbance and that have documented use by priority salmonid species within reaches identified as being high priority for protection and/or restoration. A second priority is those lands that are essential to the restoration of natural habitat processes within river reaches identified as priorities for protection and/or restoration. A third priority is those habitat areas adjacent to, or critical for, the continued function of habitats within the proposed protection project area. An example of the latter is steep upland areas adjacent to and with the potential for recruitment of large woody debris to fish bearing waters and which may be very sensitive to land-use disturbance such as roads, timber harvest, or development.

## 6.5 Planning and Coordination

Projects are typically designed and implemented over relatively small temporal and spatial scales, yet there is a need to understand the larger spatiotemporal context, especially if several projects are planned for a sub-basin. Therefore, restoration planning needs to be coordinated at least at the reach, and preferably at the sub-basin, scale. The effort currently under way to restore the Acme to Saxon reach of the South Fork Nooksack should serve as a model for comprehensive reach-level restoration planning with multiple cooperators. Planning steps have included:

1. Identification of restoration objectives for the reach;
2. Reach assessment and analysis;
3. Identification and prioritization of project opportunities; and
4. Individual project design.

## 6.6 Certainty of Success

Reasonable assurances should be provided that a project will be successful in delivering its intended benefits. Certainty of success is improved by the following:

- 1. Level of design that is completed or proposed is appropriate to geomorphic context (i.e., wood jams in larger rivers require more intensive analysis and design than wood placement in small streams);
- 2. Use of methods proven in similar geomorphic settings with similar biological limitations;
- 3. Project applicant has a demonstrated track record with similar projects
- 4. Project works with, not against, geomorphic processes; and
- 5. Site is not within a heavily degraded (i.e., urban or agriculture) setting where there is a high likelihood of persistent adverse anthropogenic impacts.

## 6.7 Cost-Effectiveness

In order to maximize efficient use of limited funds, project cost-effectiveness is an important consideration. Development of formal cost-benefit ratios may be limited by difficulties in quantifying and comparing true costs and realized benefits, but projects should have a reasonable cost relative to the anticipated benefits. If not, project proponents and reviewers should consider whether the same limiting factor could be addressed through alternate project sites, types and designs (SRFB 2002). Also important is the extent to which, and over what time scales, current land use regulations and/or natural habitat recovery will afford similar benefits and with what associated opportunity costs. Project proponents should include a sufficiently detailed description of these factors in the proposal to provide the basis for project evaluation.

## 6.8 Best Available Science

Ecosystem recovery actions that are guided by a strategic plan based on the best available science will have the greatest certainty of success (NST 2003). This Strategy is intended to be a living document, but to be revised and updated as our understanding of local salmonid populations, habitat conditions, and watershed processes improves. Well-designed and implemented monitoring at the project and watershed scale will be critically important to facilitate such adaptive management. Users of this document should check with the Lead Entity (see Appendix E: WRIA 1 Salmon Recovery Resource List) in advance of a given grant cycle to determine if changes have been made.

It is up to the project proponent to provide sufficient documentation that the best available science standard has been applied to the project design. This Strategy, the draft WRIA 1 Salmonid Recovery Plan (in preparation) and other information should be used, as appropriate. A Best Available Science document (see Chapter 365-195-900 WAC) is being produced by Whatcom County under the Critical Areas Ordinance and Shorelines Master Program updates and should be available for use in the SRFB 6$^{th}$ Round in 2005.

## 6.9 Community Values

Whatcom County citizens place a high value on the recovery of salmonid populations and the watersheds upon which they depend. A broad array of water resource interests, including Native American tribes, farmers, diking and drainage districts, environmentalists, fishers, foresters, land developers, non-government water systems, private well owners, water districts, and local, state and federal government agencies, developed this goal for the WRIA 1 Watershed Management Project:

> *To have water of sufficient quantity and quality to meet the needs of current and future human generations, including the restoration of salmon, steelhead, and trout populations to healthy and harvestable levels and the improvement of habitats on which fish rely.*

In addition, the Whatcom County Comprehensive Plan visioning process, landowner participation in the purchase of development rights program for agricultural lands, the diverse membership and participation in organizations such as the Nooksack Salmon Enhancement Association, Nooksack Recovery Team, and Whatcom Land Trust, the Lake Whatcom watershed protection programs, and creation of the Bertrand Creek Watershed Improvement District are all strong indicators of broad community support for watershed and salmon habitat protection and restoration. The various WRIA 1 restoration partners have been successful in working with private landowners to undertake projects that address biological priorities while simultaneously building community understanding, support, and resources to undertake more challenging, complex, or controversial projects in the future.

**Incorporating Community Values into Recovery Projects**

*A Guide to Lead Entity Strategy Development* (SRFB 2003) states: "For strategy development and project selection, community values are best addressed in terms of which restoration and protection actions will be supported by the community, and in what areas."

Rather than identifying which restoration and protection actions are most likely to be generically supported by the community, and focusing on those, this Strategy intends to build support for those actions that are most likely to recover salmon stocks. Activities to build the support of critical stakeholders will vary by project type. For example, an acquisition project would require the support of the affected landowners, which would be best cultivated through one-on-one meetings. On the other hand, an extensive project to place historic-scale logjams might require community meetings, media relations work, and various informational materials, in addition to the agreement of affected landowners.

While not a part of a formal plan, the ability of restoration partners to work closely with affected or interested members of the community has always been an asset in WRIA 1 and has afforded the opportunity to do projects that are supported by those most affected. This Strategy serves the dual purpose of guiding restoration partners to the most biologically important projects for priority species, while at the same time providing guidance on what may be needed to protect or restore habitat functions. The latter allows sound projects to be developed that may have more opportunity for direct community exposure or participation, but which may not be the highest priority for the SRFB funding source.

Other methods to incorporate and build community support for recovery projects include:

- A review team with a broad and diverse citizen membership to help prioritize habitat projects;

- A public education program, anticipated to be described in the draft WRIA 1 Salmonid Recovery Plan;
- Ongoing activities such as the Nooksack Salmon Enhancement Association's Students for Salmon program, the Tenmile Creek Watershed Volunteer Riparian Restoration Project, the Whatcom Conservation District's Stream Teams, and similar projects designed to raise awareness of habitat issues and promote watershed stewardship and attract willing landowners; and
- The support of elected officials from those bodies designating the Lead Entity per RCW 77.85.

This Restoration Strategy focuses on priority species and stocks and on addressing the factors that limit their survival and growth. This leads to the prioritization of certain projects and geographic areas, which do not always coincide with citizen population centers. From a public education standpoint, it may be desirable to make information and images of priority projects readily available via the Internet or other appropriate means. It may also be desirable to have habitat restoration and protection projects near cities and towns, and the guiding principles of this Strategy can be used for selecting projects for lower-priority stocks in funding venues other than SRFB.

# 7. PROJECT GUIDELINES

General sources of information for conducting habitat restoration and protection projects can be found in the peer-reviewed literature (e.g., Roni et al. 2002) and at the following web sites:

- Governor's Salmon Recovery Office: http://www.governor.wa.gov/gsro/publications.htm
- Washington Department of Fish and Wildlife, Aquatic Habitat Guidelines: http://www.wa.gov/wdfw/hab/ahg/
- Salmon Recovery Funding Board: http://www.iac.wa.gov/srfb/docs.htm
- Washington State University Extension - Whatcom County: http://whatcomsalmon.wsu.edu/

Agencies and organizations on the WRIA 1 Salmon Recovery Resource List (Appendix E) may also be available to help assist in project development. Specific project categories and recommended considerations are presented in Appendix F, Attachments F-1 and F-2.

This Strategy will be used as the basis for the evaluation and ranking of all projects submitted to the WRIA 1 Lead Entity for consideration of SRFB funding. It can also be used to guide projects using other funding sources. The intent of this strategy is to encourage habitat protection and restoration projects that are well designed and cost-effective and which provide appropriate technical documentation to demonstrate how the project will protect and restore priority species. Projects that are thorough in design and clearly linked to restoration objectives and priorities may also have the added advantage of successfully negotiating the local, state, and federal permitting processes. It will be essential that project timelines provide for sufficient time for project development, engineering, and acquiring the necessary permits. All instream work and any work involving federal funding is likely to require Federal agency project review, and proposed timelines and designs need to anticipate this.

# 8. SOURCES OF FUNDING

The ability to provide project matching funds, in-kind services, and administrative support has been key to optimizing the grant resources available for salmon recovery. The list below provides an overview of possible sources of funding and match available to project proponents.

- Apply for grants from state/federal agencies and private foundations. The Environmental Finance Center at Boise State University has developed a searchable database of funding sources for watershed restoration (http://ssrc.boisestate.edu/aboutdirectory.asp).
- Solicit technical direction or volunteers in cooperation with skilled local groups such as the Nooksack Salmon Enhancement Association (WDFW's designated regional fisheries enhancement group), Nooksack Recovery Team, or Washington Department of Fish and Wildlife's Watershed Steward (See Appendix E) for WRIA 1.
- Partner with existing public and private infrastructure including technical and administrative staff time and heavy equipment resources.
- Work with landowners and project partners that are able to provide project match through direct coverage of project costs, designation of conservation easements, or donations of materials, equipment time, or scientific expertise.
- Identify local agencies and organizations (e.g., City of Bellingham, Lummi Nation, NSEA, Nooksack Tribe, Whatcom County, Whatcom Conservation District) that may have funding programs (such as the Comprehensive Reserve Enhancement Program through the WCD) or access to less expensive labor crews for projects such as riparian restoration, instream structure placement, and assessing fish passage at road culverts.
- Develop partnerships with businesses or community organizations to provide funding.

# 9. PROJECT RANKING CRITERIA

Project Ranking Criteria are contained in the WRIA 1 CHECKLIST FOR SALMON RECOVERY FUNDING BOARD PROJECTS found in Attachment A. These criteria were developed to provide the framework for the review of SRFB eligible projects. The checklist will be updated as needed for the current SRFB grant cycle. **Applicants for SRFB funding within WRIA 1 are expected to provide a completed copy of the checklist along with their final application materials.** The Lead Entity will review the checklists prior to the application materials being provided to reviewers and will correct any discrepancies identified.

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# APPENDIX A: PROJECT CHECKLIST AND SCORING GUIDANCE FOR WRIA 1 SALMON RECOVERY FUNDING BOARD PROJECTS

*For use in SRFB 6th Round (2005)*

Project Sponsor: ______________________________

Project Name: ______________________________

Reviewer Name: ______________________________

Date: ________________

## Instructions

All projects submitted for funding through WRIA 1 must include a completed copy of *WRIA 1 Project Checklist and Scoring Guidance for Salmon Recovery Funding Board Projects*, along with the other SRFB required application materials (www.iac.wa.gov/srfb/docs.htm). This project checklist and scoring document serves two purposes; it provides guidance for applicants in proposing projects that fit the purpose and goals of the WRIA 1 Salmonid Habitat Restoration Strategy and it provides guidance to the Combined Review Team (CRT) for allocating points to the answers provided in the checklist. Portions of this document relevant to the CRT review process are the gray shaded areas excluding the check boxes. **Note: Project reviewers should first review and confirm that the checklist has been completed accurately and in accordance with the *Strategy.*** Combined Review Team members should make changes to a project's checklist answers where appropriate and assign scores accordingly.

## Changes from the 5th Round

The project scoring guidance has changed slightly from the 2005 5th Round funding cycle. The emphasis has been more strongly put on projects directed at recovery of ESA-listed bull trout and early chinook salmon in the Nooksack basin. Project applicants are also encouraged to review the WRIA 1 Salmonid Recovery Plan (in preparation) actions prior to completing the checklist. A summary of the actions are included in Appendix G, Attachment G-3. A second change is that the North Fork/ Middle Fork and South Fork early chinook stocks have been given equal priority for restoration. A third change is the inclusion of key questions to help assess project impacts on salmon habitat. These questions will allow project reviewers to better understand the goal of the project and its expected outcome. The weighting of the various categories has also changed to emphasize projects that directly address limiting factors in priority geographic areas.

**1. Please check your project type.**

If your project does not fall into any of the following categories, it may be ineligible for SRFB funding. Refer to the corresponding SRFB application documents (Manuals 18b through 18i) for detailed descriptions of project types and eligibility. If your application includes multiple project elements, check the single box for the primary activity. If your project is a combination (acquisition and restoration) project, check the appropriate restoration box. Be sure to use the appropriate application forms for your project. Contact the WRIA 1 Lead Entity Coordinator or the SRFB regional project manager with any questions regarding project type or eligibility.

☐ Acquisition
☐ Non-Capital (assessments & studies)
☐ Estuarine/marine nearshore
☐ Instream habitat
☐ Riparian habitat
☐ Upland habitat
☐ Instream passage/ diversion/ non-capital (barrier inventory & design)

**2. Magnitude of Benefit: Relative Importance of Geographic Area.**

Please mark all boxes that apply referring to Tables C-1 and C-2 in Appendix C as appropriate. Mark only the primary activity type (i.e. either restoration or protection) for each species benefiting from the project. Consistent with the project type above, acquisition that includes restoration should be scored as a restoration project.

| **Species Name** | **Element** | **A** | **B** | **C** | **D** | **E** |
|---|---|---|---|---|---|---|
| Nooksack Early Chinook | If the project contains **restoration** element(s), what is the priority of the geographic area? | ☐ [30] | ☐ [25] | ☐ [20] | ☐ [15] | ☐ [10] |
| | If the project contains **protection** element(s), what is the priority of the geographic area? | ☐ [30] | ☐ [25] | ☐ [20] | ☐ [15] | ☐ [10] |
| WRIA 1 Bull Trout | If the project contains **restoration** element(s), what is the priority of the geographic area? | ☐ [15] | ☐ [12] | ☐ [9] | ☐ [6] | ☐ [3] |
| | If the project contains **protection** element(s), what is the priority of the geographic area? | ☐ [15] | ☐ [12] | ☐ [9] | ☐ [6] | ☐ [3] |

**Applicant Key Questions:**

- Describe the project site and habitat.
- Are there other species that will benefit from the project?

**Reviewer Scoring Guidance:**

Enter the maximum circled number (i.e. using the stock that would give the highest points for the geographic area) under *Single Species Benefit* (maximum 30 points).

**Reviewer Score and Comments:**

*Single species benefit score:*

### 3. Magnitude of Benefit: Project Importance

**Restoration Projects.**

Please mark the box(es) that best describes the relative importance of the limiting factor or factors that the project is designed to address. Refer to Appendix B for limiting factor definitions and Tables C-3 and C-4 (Appendix C) for priority level of limiting factors in the geographic area of the project. List the specific limiting factor(s) in the right hand column. A description of the specific aspects of the limiting factor that is addressed should be included in the Applicant Key Questions section.

| | Priority | | | | |
|---|---|---|---|---|---|
| **Species Name** | **1** | **2** | **3** | **4** | **Limiting Factor(s)** |
| Nooksack Early Chinook | ☐ [10] | ☐ [7] | ☐ [5] | ☐ [2] | |
| WRIA 1 Bull Trout | ☐ [10] | ☐ [7] | ☐ [5] | ☐ [2] | |

**Acquisition Projects**
Please mark the box(es) that best describes the quality of the habitat that will be protected. In assigning a quality rating, consider the relevance of the entire property to the salmonid habitat function, i.e. % of property within floodplain/riparian/channel migration zone. Consider also the relevance to the limiting factors referenced in Tables C-3 and C-4 (see Appendix B for limiting factor descriptions). Information to support the rating should be clearly described in the Applicant Key Questions section.

| Species Name | Existing Habitat Quality | | | |
|---|---|---|---|---|
| | **High** | **Moderate** | **Low** | **Poor** |
| Nooksack Early Chinook | ☐ | ☐ | ☐ | ☐ |
| | [10] | [7] | [5] | [2] |
| WRIA 1 Bull Trout | ☐ | ☐ | ☐ | ☐ |
| | [10] | [7] | [5] | [2] |

**Assessments and studies.**
Please mark the box(es) that best describes the importance of the information collected to the implementation of projects that will address the limiting factor or factors in the reach. Consider the following in assigning an importance rating: (1) how important are the limiting factors that the project proposes to address (refer to Tables C-3 and C-4 and Appendix B for definitions)?; (2) will the data be collected at the appropriate scale?; (3) is the study comprehensive, collecting all data relevant for this phase in the sequencing (that will ultimately lead to projects)? Please describe what aspects of the limiting factors will be assessed in the Project Key Questions section.

| Species Name | Importance of Data | | | |
|---|---|---|---|---|
| | **High** | **Moderate** | **Low** | **Poor** |
| Nooksack Early Chinook | ☐ | ☐ | ☐ | ☐ |
| | [10] | [7] | [5] | [2] |
| WRIA 1 Bull Trout | ☐ | ☐ | ☐ | ☐ |
| | [10] | [7] | [5] | [2] |

**Applicant Key Questions:**

- For restoration projects, please describe how the main limiting factor specifically impacts the project reach. Please describe probable causes for the limiting factor.
- For acquisition projects, please describe how protection relates to potential limiting factors present in the geographic area.
- For assessment projects, please describe what aspect of the limiting factor will be measured.

**Reviewer Scoring Guidance:**

Enter the maximum circled number from the *one* relevant table above (i.e., restoration, acquisition, assessments and studies) under the relevant heading below (maximum 10 pts). Note: see Section #4 also.

**Reviewer Score and Comments:**

*Primary Limiting Factors Score:*

## 4. Magnitude of Benefit: Effect on Salmonid Habitat.

**Restoration Projects.**
The project is expected to create positive effects on limiting factors in the following way (see Table C-5). The application should state as explicitly as possible the magnitude of the benefit the project will provide in addressing the identified limiting factor. For example, "Replacement of the blocking culvert with at bridge on XYZ Road will restore full access to "L" miles of historic bull trout habitat."

- ☐ 1. Direct effect at reach-scale (Category 1)
- ☐ 2. Indirect effect and/or sub-basin-scale (Category 2)
- ☐ 3. Little to No Effect (Category 3)

**Acquisition Projects.**
Evaluate the risk of degradation if the project is not funded, considering a plausible degradation scenario under the current regulatory environment (i.e. applicable regulations, current zoning, likelihood of development, enforcement of regulations).

- ☐ 1. High risk (Category 1)
- ☐ 2. Low to Moderate risk (Category 2)
- ☐ 3. Poor to No risk (Category 3)

**Assessments/Studies.**
Evaluate the likelihood that the information collected will lead to projects, considering the following: (1) is the study a feasibility study (i.e. more likely to lead to projects) or will it refine understanding of limiting factors?; (2) is the study well-designed and use standardized methods?; (3) does the study identify or propose to identify specific projects and locations?; (4) how soon will study lead to projects?

- ☐ 1. High likelihood (Category 1)
- ☐ 2. Low to moderate likelihood (Category 2)
- ☐ 3. Poor to no likelihood (Category 3)

**Applicant Key Questions:**

- For projects, describe what aspect of the limiting factors the project will directly address, and the extent to which the project will restore dominant habitat-forming processes. What are the expected measurable outcomes of the project?
- For acquisition projects, describe the specific threats to the area to be protected. Tie the threats to habitat quality measures, and habitat-forming processes.
- For assessment projects, describe why the data is necessary to develop restoration projects.

**Reviewer Scoring Guidance:**
Assign a factor from 0 to 4 (in tenths), which will be multiplied by the number of points assigned in Question #3. Factors should be assigned as follows:

| Effect Category | Point Range |
|---|---|
| Category 1 | 2.6 – 4.0 |
| Category 2 | 1.1 – 2.5 |
| Category 3[2] | 0 - 1.0 |

Using guidance specific to project type, enter factor under *Effect on Salmonid Habitat* below (maximum multiplication factor of 4). Depending on project type, multiply points from Question #3 by *Effect on Salmonid Habitat* above and enter under *Magnitude of Impact Total* (maximum 40 points).

**Reviewer Score and Comments:**

*Effect on Salmonid Habitat Score:*
*Magnitude of Impact Total Score (Effect x Magnitude):*

[2] Assigning a factor of less than 1 will reduce the points assigned in #3.

**5. Project Design: Lifespan of Benefit.**

How long are the intended benefits expected to last? Please refer to Table C-6 for estimated lifespan associated with different restoration techniques. The ranges given in Table C-6 reflect a wide variety of project designs and objectives, presented to help applicants choose one of the categories below. Provide other information that supports your estimate of project lifespan if applicable.

☐ 0-5 years ☐ 6-10 years ☐ 11-50 years ☐ 51-100 years ☐ >100 years

**Applicant Key Questions:**

- Describe the basis for the project lifespan.

**Reviewer Scoring Guidance**

Assign points as follows:

| Lifespan | Point Value |
|---|---|
| 0 – 5 years | 1 point |
| 6 – 10 years | 2 |
| 11 – 50 years | 3 |
| 51 – 100 years | 4 |
| >100 years | 5 |

**Reviewer Score and Comments:**

*Lifespan of Benefit Score:*

**6. Project Design: Timing of Benefit.**

When are the intended benefits expected to accrue (see Table C-6)? The ranges given in Table C-6 reflect a wide variety of project designs and objectives, presented to help applicants choose one of the categories below. [Note: This section will be used by the reviewers to evaluate where an individual project falls within the strategic project sequencing described in the Strategy and for evaluating whether a group of proposed projects contains a strategic mix of projects that meet both interim and long-term habitat restoration priorities.]

☐ 0-5 years ☐ 6-10 years ☐ 11-50 years ☐ 51-100 years ☐ >100 years

**Applicant Key Questions:**

- Describe the basis for the project timing and sequencing.

**Reviewer Scoring Guidance:**
This section is not scored.

**Reviewer Comments:**

### 7. Project Design: Readiness to Proceed.

Is the project ready to proceed?

☐ Yes (Check if the answer is "yes" or "not applicable" to all the questions below).
☐ No (Check if "no" is the answer to any question below).

| Question | Yes | No | N/A |
|---|---|---|---|
| Is there evidence of landowner willingness to proceed with restoration on the property (construction projects) or is there evidence of willingness to sell (acquisition projects)? | | | |
| Is there documentation or evidence of support from relevant agencies (those necessary for project completion)? | | | |
| Is there either sufficient level of design in place or are appropriate design costs written into the funding request? | | | |
| Are necessary permits identified and obtainable? | | | |
| Has public involvement work been initiated? | | | |
| Is the sequencing appropriate within the reach, within the sub-basin? | | | |

**Applicant Key Questions**

- Describe efforts taken to ensure project success.

**Reviewer Scoring Guidance:**
Assign from 0 to 5 points based on sufficiency of answers given.

**Reviewer Score and Comments:**

*Readiness to Proceed Score:*

**8. Project Design: Likelihood of Meeting Project Objectives.**

What is the extent to which the project proponent has appropriate expertise and plans to use well-tested methods with a high likelihood of meeting project objectives? Are the objectives well defined and measurable? Other considerations can include the position of project on recovery trajectory (i.e., protection of functional habitats is more likely to provide benefits than restoration of heavily degraded habitat) and whether or not the project design or approach is clear.

☐ High ☐ Moderate ☐ Low

**Applicant Key Questions:**

- Describe specific successes of project methods.

**Reviewer Scoring Guidance**
Assign points as follows:

| Likelihood of Meeting Objectives | Point Value |
|---|---|
| High | 4 - 5 points |
| Moderate | 2 - 3 |
| Low | 0 - 1 |

**Reviewer Score and Comments:**

*Likelihood of Meeting Objectives Score:*

9. **Project Design: Cost-Effectiveness.**

To what degree are project costs in proportion with similar projects conducted locally or regionally and are they in proportion to the anticipated magnitude of benefit to the salmonid population(s) of interest?

☐ Highly cost-effective ☐ Moderately cost-effective ☐ Not cost-effective

**Applicant Key Questions:**

- Describe your approach for evaluating cost-effectiveness (e.g., leveraging of funds, documentation of similar projects, etc.)

**Reviewer Scoring Guidance**

Assign points as follows, considering the ratio between cost and benefit (amount of habitat):

| Cost Effectiveness | Point Value |
|---|---|
| Highly cost effective | 4 - 5 points |
| Moderately cost effective | 2 - 3 |
| Low cost effectiveness | 0 - 1 |

**Reviewer Score and Comments:**

*Cost-Effectiveness Score:*

**Calculation of Total Score:**

a. Sum all categories for a total project score.
b. Enter sum under ***Total Score*** (maximum 100 points).

**Overall Score and Reviewer Comments:**

| *Total Score:* |
|---|
| |

# APPENDIX B: LIMITING FACTOR DEFINITIONS

## Description of Limiting Factors

For consistency and simplicity, presentation of limiting factors is organized around the EDT Level 3 Survival Factors, including those related to habitat structure (*Channel Stability, Habitat Diversity, Sediment Load, Key Habitat Quantity*), access (*Obstructions*), water quantity and quality (*Flow, Temperature, Oxygen, Chemicals*), and biotic interactions (*Food, Competition with hatchery outplants, Competition with other species, Predation, Pathogens, and Harassment/poaching*).

### Channel Stability

*Channel Stability* refers to the stability of the streambed, banks, and channel shape and location (Lestelle et al. 2004). Although unconfined channels are naturally dynamic environments, increases in natural rates of channel migration, bank erosion, and bedform mobility can lead to destruction of redds, either by scour and/or fill or dewatering, thereby reducing egg incubation survival. Abrupt changes in habitat and flow conditions associated with channel instability may also lead to mortality or downstream displacement of salmonids that are present, such as fry or overwintering juveniles. Debris flows that travel through salmonid habitats have similar if more catastrophic effects. Channel instability can also indirectly affect salmonids by simplifying holding and rearing habitat, through loss of pool habitats and reduced channel structure and complexity.

Causes of channel instability include: (1) increased magnitude and/or frequency of peak flows; (2) decreased flow resistance and in-channel sediment storage due to lack of large wood in the channel; (3) increased coarse sediment supply from mass wasting; (4) increased bank erosion due to loss of riparian vegetation that provides bank stability; and (5) hydromodifications that restrict access of flood flows to the floodplain. Increases in channel instability is also associated with conversion of historic anastomosing channel pattern to a more frequently shifting braided pattern, such as has occurred in the unconfined Forks and upper Mainstem Nooksack River.

### Sediment Load

*Sediment Load* refers to the amount of fine sediment present in or passing through a reach (Lestelle et al. 2004), which can be manifest as high fine sediments in spawning gravels, high turbidity, or increased gravel embeddedness. High levels of fine sediments in spawning gravels can reduce survival to emergence by entombing embryos and reducing dissolved oxygen (Spence et al. 1996) or inhibiting emergence of fry from gravels. Embryo survival declines as percentage of fines (<0.85mm) increases above 11% (Peterson et al. 1992, cited in Spence et al. 1996). High turbidities can either kill, injure, or modify the behavior of rearing and holding salmonids, resulting in increased mortality and/or reduced productivity of habitats. The degree of impact depends on the duration, frequency of exposure, toxicity, temperature, life stage of fish, and natural background turbidity levels (Bash et al. 2001). Potential impacts of elevated turbidities include (1) gill trauma and disruption of osmoregulation, blood chemistry, and reproduction; (2) reduction of feeding efficiency for juvenile salmonids, which are visual predators, thereby reducing growth rates; (3) avoidance of habitats or delays in migration (Bash et al. 2001). Availability of turbidity refugia can help salmonids cope with short-term pulses of high turbidity (Bash et al. 2001). Increased gravel embeddedness can reduce the availability of substrate refugia for overwintering juveniles by reducing interstitial space that can be used during overwinter rearing (Spence et al. 1996). Entry into the substrate has been correlated with stream temperatures declining to 4 to 8°C (Bjornn 1971; Hillman et al. 1987). Indirect effects to salmonids of elevated fine sediment load include: (1) reduction of benthic macroinvertebrate production and thus reduced prey availability for juvenile salmonids (Spence et al. 1996); (2) reduction of hyporheic flow exchange, which can help moderate temperature extremes; and (3) infilling of pools (Spence et al. 1996), which reduces pool depth and thus quality.

Causes of high fine sediment load include: (1) increased fine sediment delivery due to mass wasting and surface erosion from managed forest lands; (2) increased bank erosion due to loss of riparian vegetation that provides bank stability; (3) disconnection of the channel from adjacent floodplain and wetlands, which can store fine sediments during overbank flows; and (4) loss of riparian vegetation that can trap fine sediment from upland runoff and overbank flows by slowing velocities and causing fine sediments to settle out. In agricultural and urban areas, increases in fine sediment delivery can also occur through dredging, surface erosion of cropland, construction sites, and unlined road and irrigation ditches, and bank erosion due to livestock access.

**Habitat Diversity**

*Habitat Diversity* refers to the extent of habitat complexity in the reach, including the presence of structural cover components (Lestelle et al. 2004). Cover provides refuge from predation, high velocities, and harassment or poaching for holding and rearing salmonids. Proximity of cover may also be a factor in selection of chinook spawning habitats (Spence et al. 1996; G. Pess, NWFSC, unpublished data). Complex cover is especially important for juvenile rearing: cover creates hydraulic heterogeneity that can increase feeding efficiency, i.e. an individual fish can reduce energy expenditure by maintaining position in slow current that is adjacent to faster current with higher rate of prey delivery (Fausch 1984); cover can also increase habitat capacity by increasing visual isolation for territorial juvenile salmonids, thus reducing effective territory size (Bjornn and Reiser 1991). Cover can be provided by wood jams, single logs, rootwads, undercut banks, large cobble or boulder substrates, overhanging vegetation, deep water, turbulence or turbidity (Bjornn and Reiser 1991). Another element of habitat diversity is the number and variety of habitat types available in a reach. In natural, unconfined rivers, the interaction of the channel with its forested floodplain, moderated by stable wood jams, created a dynamic mosaic of aquatic habitat types of different scales, including scour pools, stable side channels, braids, sloughs, backwaters, and edge habitats (Sedell and Luchessa 1981; Collins and Montgomery 2002).

Loss of habitat diversity is associated with the following: (1) loss of large in-channel wood; (2) disconnection of the channel from the floodplain due to channel incision or flood control; (3) simplification of bank condition through bank hardening; (4) loss of channel sinuosity through channelization; and (5) debris flows and frequent channel shifting. Large in-channel wood plays an especially important role; causes of decreased wood loading include (1) bank hardening that reduces bank erosion and thus wood recruitment; (2) clearing of floodplain forests that reduces sources of wood recruitment; (3) reductions in upslope and upstream wood sources; (4) historic and ongoing removal of wood from rivers and floodplains; (5) bridges, culverts or other artificial constrictions that interrupt the routing of large wood; and (6) reduced stability of wood jams as a result of smaller, more mobile wood and/or increased velocities associated with channel confinement.

#### Key Habitat Quantity

*Key Habitat Quantity* refers to the quantity, relative to other habitat types, of the primary habitat type(s) used by specific life stages (Lestelle et al. 2004). Habitat capacity, or the number of individuals of a life stage that a reach can support, is a function of both the relative proportion of different habitat types and streamflow, which controls the wetted surface area of the stream channel. Early chinook generally require deep, cool, primary pools with cover for holding, although glides can also be used. Spawning adults prefer pool tailouts, the transitional area between pools and riffles, although spawning also occurs in glides and riffles with appropriate substrate size. Large, deep pools may also be important for spawning; data from a reach of the North Fork Stillaguamish River indicate that more than two-thirds of the redds were located less than 70m from a pool (G. Pess, NWFSC unpublished data). Emergent fry initially seek habitats in slow current, such as shallow stream margins, backwater pools, and other edge habitats, moving into primary pools as they grow; floodplain habitats such as spring seeps and side channels (Castle and Huddle 1996b), and the lower ends of non-natal floodplain tributaries can also be important (Murray and Rosenau 1989), especially as refuges from high flows that can occur early in emergence. During summer, juvenile chinook densities are often highest in primary (main-channel) pools, although backwater pools and glides are also used (Hillman et al. 1987; Dewberry 2003). Overwintering juvenile chinook use primary pools or mainstem channel margins (Morgan and Hinojosa 1996); chinook also use interstitial spaces in the substrate, such as in large cobble riffles (Lestelle et al. 2004), during periods of cold temperature. As with fry, low-gradient tributaries and floodplain habitats may be important in providing refuge from high velocities, turbidity, and bedload movement associated with floods (Murray and Rosenau 1989). Fry that do not rear in freshwater but outmigrate soon after emergence rear in the Nooksack delta or in other WRIA 1 nearshore areas; those that rear in the delta require a system of blind tidal channels and distributary sloughs of various sizes, while those that rear along shorelines require shallow, low-water velocity, fine substrate habitats, such as pocket estuaries and non-natal deltas (K. Fresh, personal communication).

Loss of key habitat is associated with: (1) loss of in-channel wood, which forms and maintains pool habitats; (2) loss of floodplain habitat-forming processes due to channel incision or artificial confinement that disconnects the channel from its floodplain; (3) pool infilling through increased coarse sediment delivery; and (4) loss of mainstem habitat and edge habitat length due to channel straightening, meander cutoffs, and conversion to single channels.

**Obstructions**

*Obstructions* refer to physical structures in the stream channel, such as culverts, dams, tidegates, and floodgates, that impede access to upstream habitats, thereby directly affecting prespawn migrants or fry or parr redistributing to oversummer or overwinter rearing habitats. Full barriers to passage strongly influence a population's spatial structure by eliminating upstream reaches from its spawning and rearing distribution. Abundance may be impacted when individuals that can ascend are delayed and thereby exposed to increased risk of prespawn mortality due to stress, disease, predation, or fishing. Obstructions can also affect productivity: (1) migration delays can reduce reproductive success (e.g. number of redds built); and/or (2) blocked access to abundant stocks such as pink or chum reduces the supply of marine derived nutrients upstream, thus limiting productivity of upstream habitat for rearing (i.e. feeding) life stages.

**Withdrawals**

*Withdrawals* refer to diversions and other water intake structures that facilitate the withdrawal of water from a stream, such as for irrigation. Withdrawals can kill or injure migrating and rearing juveniles due to entrainment or injury on screens. See *Flow* section for impacts of withdrawal on habitat.

**Flow**

*Flow* refers to the amount of stream flow, or the pattern and extent of flow fluctuations, within the stream reach (Lestelle at al. 2004). Stream flow exerts strong influence over salmonid habitat by regulating wetted surface area and thus the amount of available habitat, as well as by controlling the spatial distribution of depths and velocities. Anthropogenic changes to streamflow that affect salmonids include increases in magnitude and/or frequency of peak flows, decreases in magnitude of low flows, and rapid changes in streamflow due to withdrawals.

In addition to generally reducing habitat availability, low streamflows also affect salmonids as follows: (1) impeded upstream migration for prespawn migrants, especially in tributaries; (2) reduced availability of habitat for spawners, which require sufficient depth and velocities in areas with suitable spawning substrate; (3) redd dewatering, since incubating embryos require sufficient intragravel flow to maintain adequate temperature and dissolved oxygen and to eliminate waste; (4) dewatering and/or reduced connectivity of secondary channels and complex edge habitat, affecting fry; and (5) decreased survival of rearing juveniles due to increased vulnerability to terrestrial predators in shallow depths (Bjornn and Reiser 1991). Aggradation of channels and subsequent widening and shallowing from excessive sedimentation can exacerbate low flow concerns. Low streamflows are also associated with degraded water quality, including increased temperatures and concentration of contaminants and reduced dissolved oxygen.

Increases in peak flows can decrease survival to emergence by increasing the potential for redd scour and channel shifting. High velocities associated with peak flows can also lead to downstream displacement of fry or overwintering juveniles, especially in artificially confined channels where the availability of flow refugia is limited. Rapid changes in streamflow, which can occur when water withdrawals are activated or shut off without adequate ramping, are detrimental to downstream salmonids if they cannot respond quickly enough to the change to escape downstream displacement (associated with sudden increases in streamflow) or stranding (sudden drop in streamflow).

Anthropogenic causes of low streamflows include: (1) disconnection of channel from floodplain by channel incision and/or artificial confinement reduces groundwater discharge; floodplain provides storage for overbank flows that recharges the alluvial aquifer; (2) filling of floodplain wetlands reduces storage of overbank flows and upslope runoff, thereby reducing groundwater recharge that supports base flows; (3) ditching and draining of wetlands reduce storage and decrease base flows; and (4) water withdrawals for municipal, industrial or agricultural use. Aggradation and subsequent widening and shallowing of channels as a result of excess sedimentation, especially in the upper watershed, can exacerbate the effects of low flows.

Anthropogenic causes of high or more frequent flood flows include: (1) accelerated runoff due to decreased infiltration rates (e.g. related to impervious surfaces, land clearing, other changes in land cover); and (2) extension of the drainage network (e.g. through forest road building, ditching and drainage of wetlands) has changed the timing of runoff, which can increase peak flows. The effects of flood flows can be exacerbated by artificial confinement and/or channel incision that disconnects the channel from its floodplain, which reduces the available cross-sectional area, thereby increasing average velocity and decreasing the frequency of low velocities. Loss of floodplain vegetation, in-channel wood, and other roughness elements that dissipate high velocities can also reduce the availability of refuges from high flows.

**Temperature**

*Temperature* refers to the temperature regime in the reach, including maximum and minimum water temperatures, as well as spatial variation (Lestelle et al. 2004). Water temperature affects salmonids by influencing mortality, metabolism, growth rates, timing of life history events, biotic interactions, disease resistance, and behavior (Spence et al. 1996). Spatial variation in temperature throughout a reach can be important, as thermally stratified pools or cool tributary or groundwater inputs provide refuge from high temperatures in the reach.

High temperatures can stress holding and spawning fish, which can increase prespawn mortality and vulnerability to disease, or reduce egg survival. High temperatures can also delay or prevent migration upstream to spawning grounds, which can affect spatial structure. High temperatures during incubation can result in earlier fry emergence than under natural conditions, which can increase exposure of fry to larger floods that tend to occur early in their emergence period and lead to involuntary downstream displacement; early emergence can also reduce growth rates, if fry emergence is desynchronized from insect hatches that support rapid growth in spring and early summer (Spence et al. 1996). High temperatures can reduce productivity of oversummer rearing by reducing growth and metabolic efficiency and modifying behavior (Bjornn & Reiser 1991).

Anthropogenic causes of high temperatures include: (1) reduced stream shading due to degraded riparian function; (2) widening and shallowing of channels, which increases surface area for convective heat exchange, due to increased coarse sediment inputs and/or reduced bank stability; (3) reduced groundwater discharge to streams during summer months through impacts to infiltration and groundwater recharge, i.e. from changes to land cover, loss of wetlands, or disconnection of channel from floodplain; and (4) reduced hyporheic exchange[3], which can buffer or reduce high temperatures, due to loss of bedform diversity, siltation of gravels, and/or disconnection of the channel from its floodplain (Poole & Berman 2000).

[3] The hyporheic zone refers to the subsurface zone beneath or lateral to the stream channel (extending into the floodplain) that receives surface flow from stream and river channels (Edwards 1998). Hyporheic flow paths range in size from the streambed scale (e.g. pool and riffle sequence) to meander bend scale (e.g. through mid-channel gravel bars or abandoned channels) to floodplain scale (e.g. where unconfined floodplain reaches that alternate with bedrock-confined reaches; Poole & Berman 2000). Hyporheic exchange at the meander bend scale can buffer high temperatures, while hyporheic exchange at the floodplain scale can buffer or reduce high temperatures (Poole & Berman 2000).

### Other Limiting Factors

The following potential limiting factors are either not considered to significantly impact Nooksack early chinook populations at this time or are indirect effects of factors that do present significant impact:

- *Oxygen* refers to dissolved oxygen concentration within the reach (Lestelle et al. 2004). Low dissolved oxygen concentrations can kill, disrupt physiological processes, and or modify the behavior of salmonids. Low dissolved oxygen in incubating redds, associated with low streamflows and/or high levels of fine sediments, reduces the survival and emergence of fry. Low dissolved oxygen can also can also adversely affect swimming performance of migrating and rearing salmonids and growth rates of rearing salmonids (Bjornn & Reiser 199). Low dissolved oxygen can be associated with high temperatures and low flows; it can also result from nutrient enrichment from agricultural, municipal or industrial waste, which promotes algal growth than can deplete oxygen levels (Spence et al. 1996).
- *Chemicals* include toxic contaminants or toxic water quality conditions, such as heavy metals, low pH, and pesticides (Lestelle et al. 2004). Toxic contaminants can kill, injure or modify the behavior of salmonids, depending on concentration and length of exposure. Sources of toxic contaminants include runoff of agricultural and residential pesticides, municipal and industrial discharges, and stormwater runoff. Riparian buffers and wetlands can filter inputs.
- *Food* refers to the amount, diversity, and availability of food that can support chinook. Decreases in food availability are associated with (1) high fine sediment load, which reduces benthic macroinvertebrate production; (2) decreased spawner abundances and thus reduction in supply of marine derived nutrients that historically represented an important nutrient subsidy for stream systems; (3) degradation of riparian areas: vegetation overhanging the stream supplies terrestrial insects to streams that can be eaten by juvenile salmonids; riparian areas are also a source of organic inputs that support stream productivity; (4) loss of stream productivity due to lack of in-channel wood and other roughness elements that retain and trap organic matter; and (5) disconnection of channel and floodplain.
- *Biotic Interactions.* The presence of hatchery outplants and/or other fish, bird, and/or mammal species can negatively affect chinook through *predation* or *competition* with chinook for food or space. Low flows and lack of instream cover increase risk of predation. Many bacterial, viral, fungal, and microparasitic pathogens are naturally occurring in the wild, including bacterial kidney disease, columnaris, and infectious hepatopoietic necrosis (IHN;(Spence et al. 1996). However, disease outbreaks can occur in hatchery fish that can be transmitted to wild fish; disease outbreaks are also associated with high temperatures, which compromise immune systems. In addition to degrading habitat, humans negatively impact chinook through fishing, redd trampling, *harassment*, or other types of disturbance.

# APPENDIX C: SUPPORTING MATERIAL FOR SRFB PROJECT RANKING CRITERIA

**Table C-1.** Relative importance of geographic areas for combined Nooksack early chinook.

| Geographic Area | Restoration Category[1] | Protection Category |
|---|---|---|
| WRIA 1 Nearshore Marine Areas | B | B[2] |
| Nooksack Estuary | A | A |
| Nooksack R: Downstream of Everson | C | C |
| Nooksack R: Everson to Nugents Corner | B | C |
| Nooksack R: Nugents Corner to Forks | B | B |
| SF Nooksack: Mouth to Jones Cr | A | B |
| SF Nooksack: Jones Cr to Skookum Cr | A | A |
| SF Nooksack: Skookum Cr to Larson's Bridge | A | A |
| SF Nooksack: Larson's Bridge to RM 31 | B | B |
| NF Nooksack: SF to MF confluence | A | B |
| NF Nooksack: MF to RM 43 | A | C |
| NF Nooksack: RM 43 to Racehorse Cr | A | B |
| NF Nooksack: Racehorse to RM 46.7 | A | B |
| NF Nooksack: RM 46.7 to Maple Cr | A | B |
| NF Nooksack: Maple Cr to Boulder Cr | A | A |
| NF Nooksack: Boulder Cr to RM 55.1 | A | C |
| NF Nooksack: RM 55.1 to Glacier Cr | A | A |
| NF Nooksack: Glacier Cr to Nooksack Falls | C | C |
| MF Nooksack: Mouth to Canyon Lk Cr | B | C |
| MF Nooksack: Canyon Lake Cr to Mosquito Lake Rd | C | C |
| MF Nooksack: Mosquito Lake Rd to Diversion Dam | C | C |
| MF Nooksack Diversion Dam | A | E |
| MF Nooksack: Diversion Dam to Ridley Cr | E | E |
| Hutchinson Creek | C | C |
| Skookum Creek | E | A |
| Cavanaugh-Plumbago-Deer Creeks | B | A |
| Kendall Creek | B | D |
| Racehorse and Bear Creeks | B | D |
| Maple Creek | C | C |
| Boulder Creek | C | C |
| Canyon Creek | B | D |
| Cornell and McDonald Creeks | C | C |
| Glacier Creek | C | D |
| Boyd, Deadhorse, and Wells Creeks | D | B |
| Canyon Lake Creek | B | D |
| Peat Bog Creek | E | B |
| Porter Creek | C | D |
| MF Tributaries upstream of Diversion Dam | E | E |

*Source: EDT Reach Priorities (normalized by reach length) , except for WRIA 1 nearshore marine areas which are based on best professional judgment.*

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[1] Categories - from A (highest priority) to E (lowest priority) - had similar magnitude of impacts to population abundance, productivity, diversity index.

[2] Priority rank applies to known forage fish spawning grounds mapped by WDFW (Pentilla 2001).

**Table C-2.** Relative Importance of Geographic Areas for WRIA 1 bull trout.

| Geographic Area | Restoration Category | Protection Category |
|---|---|---|
| North Fork (Canyon Creek to Nooksack Falls) | A | A |
| Wells Creek | A | A |
| "Powerhouse" Creek | A | A |
| "Chainup" and Deer Horn Creeks (USGS name) | A | A |
| Cascade, "Ditch", Deadhorse, Boyd Creeks | A | A |
| Glacier and USFS tributaries: 01.0476, Coal, Falls | A | A |
| Glacier, Thompson, Little, Davis, Deep (uplands) | A | A |
| Gallop and "Son of Gallop" Creeks | A | A |
| Hedrick Creek | A | A |
| Canyon Creek | A | A |
| Boulder Creek | A | A |
| Wildcat Creek, McDonald Creek | A | A |
| Middle Fork upstream from Diversion Dam | A | A |
| Warm Creek, Green Creek | A | A |
| Clearwater Creek | A | A |
| South Fork Nooksack, Deer Creek to Wanlick Creek | A | A |
| Bear Lake outlet creek | A | A |
| Howard Creek | A | A |
| Deer and Plumbago Creeks (USGS names) | A | A |
| Cavanaugh Creek | A | A |
| Wanlick Creek | A | A |
| Skookum and Hutchinson Creeks | A | A |
| WRIA 1 nearshore forage fish spawning areas[3] | C | C |
| North Fork ( Maple Creek to Canyon Creek) | C | C |
| Maple, "West Slide" (01.0422), "Aldrich" (01.0423) | C | C |
| unnamed trib. 0.5 mi. below Boulder Cr. | C | C |
| Fossil Creek (USGS map) | C | C |
| WRIA 01.0425, Cornell and West Cornell Creeks | C | C |
| Middle Fork downstream of Diversion Dam | C | C |
| Wallace Creek | C | C |
| Rocky Creek, Galbraith Creek, Seynour Creek | C | C |
| unnamed RB trib. just above Wallace Creek | C | C |
| Porter Creek, 01.0373, 01.0374, Sisters Creek | C | C |
| Canyon Lake Creek, WRIA 01.0347, 01.0349 | C | C |
| "Peat Bog" Creek, "Bear" Creek (WRIA 01.0353) | C | C |
| 01.0367, Saxon Creek, Edfro Creek, Fobes Creek, | C | C |
| 01.0265, "Johnson Creek" | C | C |
| 01.0290, 01.0291, McGuinnis Creek, 01.0315, 01.0316, | C | C |
| 1.0320, 01.0321, first LB trib.below Wanlick Creek | C | C |
| South Fork from Deer Creek to mainstem | C | C |
| Mainstem Nooksack River | C | C |
| North Fork downstream of Maple Creek | C | C |
| Coho spawning tributaries in WRIA 1 | E | E |

[1]Restoration priorities apply to all ownership, but protection priorities only apply to private ownerships within the geographic area.
[2]A: Known spawning and early rearing areas for Nooksack bull trout; C: presumed spawning and early rearing areas for Nooksack bull trout and mainstem areas foraging, migration, and overwintering areas downstream of known spawning and early rearing areas; E: other foraging, migration and rearing habitat.
[3] Per WDFW maps of forage fish spawning areas (Pentilla 2001)

**Table C-3.** Relative importance of limiting factors within geographic areas for Nooksack early chinook.

| Geographic Area | Channel stability | Habitat Diversity | Temperature | Predation | Competition (other sp) | Competition (hatchery) | Withdrawals | Oxygen | Flow | Sediment load | Food | Chemicals | Obstructions | Pathogens | Harassment | Key Habitat Quantity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WRIA 1 Nearshore Marine Areas | *To be determined.* | | | | | | | | | | | | | | | |
| Nooksack Estuary | 2 | 1 | 4 | 4 | 3 | 2 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | |
| Nooksack R: Downstream of Everson | 4 | 1 | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 3 | |
| Nooksack R: Everson to Nugents Corner | 4 | 2 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | |
| Nooksack R: Nugents to Forks | 3 | 1 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 4 | 3 | 4 | 4 | 4 | 4 | |
| SF Nooksack: Mouth to Jones Cr | 4 | 1 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 4 | 4 | 4 | 4 | 4 | |
| SF Nooksack: Jones Cr to Skookum Cr | 4 | 3 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | |
| SF Nooksack: Skookum Cr to Larson's Bridge | 4 | 3 | 1 | 4 | 4 | 4 | 4 | 4 | 3 | 2 | 4 | 4 | 4 | 4 | 4 | |
| SF Nooksack: Larson's Bridge to RM 31 | 4 | 1 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | |
| NF Nooksack: SF to MF confluence | 3 | 4 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | |
| NF Nooksack: MF to RM 43 | 1 | 1 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | |
| NF Nooksack: RM 43 to Racehorse Cr | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | |
| NF Nooksack: Racehorse to RM 46.7 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | |
| NF Nooksack: RM 46.7 to Maple Cr | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | |
| NF Nooksack: Maple Cr to Boulder Cr | 1 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | |
| NF Nooksack: Boulder Cr to RM 55.1 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 3 | 4 | 4 | 4 | 4 | |
| NF Nooksack: RM 55.1 to Glacier Cr | 3 | 1 | 3 | 4 | 4 | 4 | 4 | 4 | 1 | 2 | 4 | 4 | 4 | 4 | 4 | |
| NF Nooksack: Glacier Cr to Nooksack Falls | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | |
| MF Nooksack: Mouth to Canyon Lk Cr | 3 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | |
| MF Nooksack: Canyon Lake Cr to Mosquito Lake Rd | 3 | 4 | 1 | 5 | 4 | 4 | 4 | 4 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | |
| MF Nooksack: Mosquito Lake Rd to Diversion Dam | 4 | 2 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | |
| MF Nooksack Diversion Dam | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 4 | 4 | |
| MF Nooksack: Diversion Dam to Ridley Cr | 4 | 1 | 4 | 5 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | |
| Hutchinson Creek | 3 | 3 | 4 | 2 | 4 | 4 | 4 | 4 | 2 | 1 | 4 | 4 | 4 | 4 | 4 | |
| Skookum Creek | 2 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | |
| Cavanaugh-Plumbago-Deer Creeks | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | |
| Racehorse and Bear Creeks | 3 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 4 | 4 | 4 | 4 | 4 | |
| Kendall Creek | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | |
| Maple Creek | 3 | 4 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | |
| Boulder Creek | 4 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | |
| Canyon Creek[1] | 1 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 4 | 4 | |
| Cornell and McDonald Creeks | 4 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | |
| Glacier Creek | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | |
| Boyd, Deadhorse, and Wells Creeks | 4 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | |
| Canyon Lake Creek | 4 | 3 | 1 | 4 | 4 | 4 | 4 | 4 | 3 | 2 | 4 | 4 | 4 | 4 | 4 | |
| Peat Bog Creek | 4 | 4 | 1 | 5 | 4 | 4 | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | |
| Porter Creek | 4 | 1 | 1 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | |
| MF Tributaries upstream of Diversion Dam | 4 | 1 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | |

*Note: Magnitude of impact depends on (1) degree to which attribute contributes to productivity loss of a specific life stage relative to historic conditions; and (2) importance of life stage to the population (% life history trajectories affected*productivity loss). Magnitude of impact is integrated (summed) over all life stages that use the reach and over all reaches within the geographic area.*

[1]Barrier was not present when the EDT model was initially run, but was identified later.

**Table C-4.** Relative Importance of limiting factors within geographic areas for WRIA 1 bull trout.

| Geographic Area | Channel stability | Habitat Diversity | Temperature | Competition (other sp) | Withdrawals | Oxygen | Flow | Sediment load | Food | Obstructions | Harassment | Key Habitat Quantity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| North Fork (Canyon Creek to Nooksack Falls) | 2 | 3 | | | 3 | | | | | | 4 | |
| Wells Creek | 2 | | | 1 | | | | 4 | | | | |
| "Powerhouse" Creek | | 3 | | | | | | | | 1 | | 3 |
| "Chainup" and Deer Horn Creeks (USGS name) | | | | | | | 2 | | | 1 | | 3 |
| Cascade, "Ditch", Deadhorse, Boyd Creeks | 2 | 2 | | | | | | | | | | 3 |
| Glacier tributaries: 01.0476, Coal, Falls | 3 | | | | | | | | | | | |
| Glacier, Thompson, Little, Davis, Deep Creeks | 3 | 3 | | | | | | | | | | 4 |
| Gallop and "Son of Gallop" Creeks | 2 | 2 | 2 | | | | | 3 | | | | 3 |
| Hedrick Creek | | 3 | 4 | | | | 4 | 3 | 4 | 1 | | 4 |
| Canyon Creek | 1 | 2 | 3 | | | | | 4 | 4 | 1 | | |
| Boulder Creek | 1 | 2 | 3 | | | | 4 | 3 | 4 | | | 2 |
| Wildcat Creek | | 3 | 3 | | | | | 4 | | | | 3 |
| McDonald Creek | 3 | 3 | 3 | | | | | | | | | 3 |
| Middle Fork upstream from Diversion Dam | 3 | 4 | | | | | | 4 | 2 | 1 | | 3 |
| Warm Creek, Green Creek | 3 | 3 | 3 | | | | | | 3 | | | 3 |
| Clearwater Creek | 2 | 2 | 2 | | | | | 3 | 3 | | | 3 |
| South Fork from Deer Creek to Wanlick Creek | 2 | 2 | 2 | | | | | 2 | | | | 2 |
| Bear Lake outlet creek | | 3 | | | | | | | | | | 3 |
| Howard Creek | 1 | 2 | 2 | | | | | 2 | | | | 3 |
| Deer and Plumbago Creeks (USGS names) | 2 | 2 | 3 | | | | | 3 | | | | 2 |
| Cavenaugh Creek | 3 | 2 | 3 | | | | | 3 | | | | 3 |
| Skookum and Hutchinson Creeks | 2 | 3 | 3 | 4 | | | | 3 | | | | 2 |
| North Fork ( Maple Creek to Canyon Creek) | 2 | 3 | 4 | | | | | 3 | | | | 4 |
| Maple, "West Slide"-01.0422, "Aldrich"-01.0423 | 3 | 3 | 3 | | | | | 3 | | | | 2 |
| Unnamed trib. 0.5 mi. below Boulder Cr. | 4 | 3 | 4 | | | | | 4 | | 1 | | 4 |
| Fossil Creek (USGS map) | | | | | | | | | | | | 4 |
| WRIA 01.0425, Cornell and West Cornell Crs | 1 | 1 | 3 | | | | | 2 | 3 | | | 2 |
| Middle Fork downstream of Diversion Dam | 2 | 3 | 2 | | 3 | | 4 | 3 | | | | 4 |
| Wallace Creek, Green Creek | 3 | 3 | | | | | | | 3 | | | 3 |
| Rocky Creek, Galbraith Creek, Seymour Creek | 3 | 3 | 4 | | | | | | 3 | | | 3 |
| Unnamed RB trib. just above Wallace Creek | | | 4 | | | | | 4 | 3 | 1 | | 4 |
| Porter Creek, 01.0373, 01.0374, Sisters Creek | 2 | 2 | 3 | | | | | 2 | 3 | | | 2 |
| Canyon Lake Creek, WRIA 01.0347, 01.0349 | 1 | 2 | 2 | | | | | 3 | | | | 2 |
| "Peat Bog" Creek, "Bear" Creek (WRIA 01.0353) | | | 2 | | | | | 3 | | | | 4 |
| 01.0367, Saxon Creek, Edfro Creek, Fobes Creek, | 3 | 3 | 3 | | | | | 3 | | | | 3 |
| 01.0265, "Johnson Creek" | 4 | 3 | 4 | | | | | 3 | | 1 | | 3 |
| 01.0290, .0291, McGuinnis Cr, 01.0315, .0316 | 3 | 3 | 3 | | | | | 3 | | | | 2 |
| 1.0320, 01.0321, 1st LB trib.below Wanlick Cr | 4 | 4 | | | | | | 4 | | | | 3 |
| South Fork from Deer Creek to mainstem | 3 | 2 | 1 | | 4 | | | 1 | 3 | | | 3 |
| Mainstem Nooksack River | 3 | 1 | 2 | | 3 | | | 3 | | | | 3 |
| North Fork downstream of Maple Creek | 2 | 2 | 3 | | 4 | | | | | | | 3 |
| Coho spawning tributaries in Nooksack drainage | 3 | 2 | 2 | | 2 | 3 | 2 | 2 | | | | 2 |

**Table C-5.** Impacts of different project types on limiting factors. Where actions are similar between reach- and subbasin-scale, the difference is in the scale at which the actions are implemented.

| Limiting Factor | Problem(s) | Reach-scale Actions | | | Subbasin-scale projects | | |
|---|---|---|---|---|---|---|---|
| | | Objective(s) | Direct | Indirect | Objective(s) | Direct | Indirect |
| Channel stability (including delivery and routing of coarse sediment) | High bed shear stress causes bed scour; low spatial variation of bed shear stress reduces availability of refugia; increased erodibility of stream banks due to loss of root cohesion and bank roughness. | Increase channel roughness through increased wood loading and bedform diversity; reduce artificial channel confinement; increase diversity of channel pattern; increase availability and connectivity of refugia (more stable habitats) | Place wood jams; remove or setback levees or riprap; restore or encourage formation of floodplain channels (especially side channels) | Restore degraded riparian zones by removing non-native vegetation and/or establishing native vegetation appropriate for habitat formation; reconnect channels to floodplain | Reduce anthropogenic sources of coarse sediment input by reducing mass-wasting potential; increase wood supply through improved riparian function in tributary watersheds; increase flood storage; improve LWD routing | Reduce frequency and magnitude of peak flows (see peak flows below). | Reduce road network through road abandonment or decommissioning; improve road network through culvert or stream crossing upgrades, improved road drainage; sidecast removal or reduction; restore degraded riparian zones in tributary watersheds; address impacts of channel constrictions (bridges, culverts) to wood routing. |
| Habitat Diversity | Historic removal of riparian forests and in-channel woody debris coupled with increases in anthropogenic sediment sources and flood control activities (channel straightening and bank armouring) has reduced in-channel habitat diversity. | Increase wood loading in reach; increase channel complexity; encourage side channel formation. | Construct wood jams; Restore and connect wetlands and floodplains to the riverine system | Replant degraded riparian zones by reestablishing native vegetation appropriate for habitat formation; selectively thin, remove and prune non-native and invasive vegetation; remove or setback levees or riprap | Protect channel migration corridors and restore large woody debris and recruitment potential to provide for on-going and future restoration of habitat forming processes. Improve routing of wood by addressing channel constrictions caused by bridges, culverts. | Conduct restoration projects similar to reach-scale actions, but implemented at a sub-basin scale. | Apply similar strategy as for channel stability and temperature. |
| Temperatures | High temperatures stress, kill, elicit avoidance or otherwise modify behavior, and/or increase incidence to disease, thereby decreasing growth and survival. Low spatial variation of temperature due to lack of habitat diversity reduces thermal refugia. See also *Withdrawals*, which contribute to high temperatures. | Restore groundwater/hyporheic recharge; increase shading | Increase riparian shading in known or presumed fish bearing streams (including wetlands, small/slow channels); and increase shading of small upslope streams that may not bear fish, but contribute stream flow to fish-bearing waters. | Reconnect floodplain wetlands and off-channel habitats including groundwater fed side-channels, to riverine system; restore floodplain wetlands (especially forested wetlands, where appropriate) | Minimize sub-basin scale increases of impervious surface; protect and restore groundwater (aquifer) recharge areas; Increase riparian shading; reduce anthropogenic sources of coarse sediment that can widen channels and reduce stream shading in debris flow paths. | Replant degraded riparian zones by reestablishing native vegetation appropriate to habitat formation; Selectively thin to accelerate growth of largest trees; interplant conifers where stands are deficient; remove non-native and invasive vegetation | Restore historic wetlands and floodplain connections; implement stormwater standards; reduce mass wasting potential (see Channel Stability) |
| Predation | *Ecological interactions are indirectly affected by changes in habitat quantity and quality.* | | | | | | |
| Competition (other spp) | | | | | | | |
| Competition (hatchery) | | | | | | | |
| Withdrawals | Water withdrawals reduce instream flows, thereby reducing habitat quantity and water quality, including elevation of stream temperatures; unscreened intakes kill or injure fish. | Prevent, avoid, and/or reduce adverse reductions in instream flows as the result of out-of-stream diversions or groundwater withdrawals. | Avoid direct surface water withdrawals during low flow periods critical to priority species and lifestages; screen all intakes; reduce withdrawals where feasible | Manage the timing and magnitude of groundwater withdrawals to prevent adverse impacts on instream flows and to increase instream flows during low flow periods of the water year. | Manage surface and groundwater resources such that ecological flow needs of streams are provided , and to maximize species and lifestage distributions . | Implement instream flow selection and adoption action plan as being developed and adopted by the WRIA 1 Watershed Management Project. | Same as Direct. |

| Limiting Factor | | Problem(s) | Reach-scale Actions | | | Subbasin-scale projects | | |
|---|---|---|---|---|---|---|---|---|
| | | | Objective(s) | Direct | Indirect | Objective(s) | Direct | Indirect |
| Oxygen | | Low dissolved oxygen levels reduce growth and/or survival and/or elicit avoidance and alter other behaviors in adult and juvenile salmonids. | Increase dissolved oxygen by increasing instream flows, reducing nutrient inputs, reducing stream temperatures and by placing LWD to locally increase roughness and turbulence. | Prevent nutrient runoff into streams; Increase wood loading in lowland streams that lack roughness; increase instream flows (see *Withdrawals)*; reduce ponded area behind diversion structures to the minimum necessary | Increase riparian shading (including for wetlands, small/slow channels); Reconnect floodplain wetlands and off-channel habitats including groundwater fed side-channels to riverine system; restore floodplain wetlands (especially forested wetlands, where appropriate); implement agricultural BMP's such as relay crops to reduce nutrient loading to streams. | Increase dissolved oxygen by increasing instream flows; roughness leading to turbulence; reducing nutrient inputs, and reducing stream temperatures | Implement stormwater management and other land-use programs that reduce direct nutrient loading to streams; Retain and encourage restoration of riparian functions at a sub-basin scale. | Same as Direct |
| Flow | Low Flow | Loss of habitat connectivity and access; reduced habitat volume; adult and juvenile stranding; increase water temperatures; decreased general water quality. | Ensure flow levels necessary to meet ecological needs during low flow periods. | Reduce/avoid out-of-stream diversions in important reaches affected by low flows; utilize sub-basin direct tools identified at right. | Enhance/restore wetland storage to increase base flows; reduce upslope sediment inputs that cause stream reach aggradation and subsurface flows | Restore historic hydrograph of the sub-basin; reduce/restore "natural" variability of flows | Put or keep water in stream using innovative tools, such as water banking, water rights lease or purchase, trust water donation, water conservation and reuse, water storage and groundwater recharge | Restore wetlands, reconnect and revegetate floodplains; restore historic sediment regime of streams. |
| | Peak Flows | High bed shear stress leads to redd scour, channel shifting and, in some instances, incision; reduction in availability and distribution of low velocity refugia during peak flow events; net export of large woody debris from upstream areas either out of channel (overbank), onto bridges, or to marine environment. | Increase availability of low flow and stable habitat refugia during peak flow events | Create overflow paths for flood flows to distribute peak flows onto the floodplain; restore access to low flow refugia through improving connectivity to existing floodplain habitats; place wood jams to increase channel roughness and to dissipate energy. | Reconnect floodplain to riverine system via levee removal or setback; restore active channel geometries and elevation in reaches that have historically incised by using LWD placement or other techniques | Restore natural range of variability of peak streams flows. | Restore hydrologic connectivity b/n streams and wetlands and/or floodplains; Remove and relocate dikes, levees and other structures | Removal of roads; reduce road drainage to streams (re-establish more natural slope hydrology) through reducing pirating of water, interception of subsurface flows, and impervious surfaces. Reduce manmade drainage network in historical wetlands, improve retention of waters during high discharge periods. |
| Sediment load (fine) | | Fine sediment can infiltrate gravel bedded streams resulting in egg mortality, entombment of alevins and fry, reduced availability of overwinter interstitial refugia, and/or reduced macroinvertebrate production and diversity; high suspended sediment levels (i.e. turbidity) reduces feeding opportunities, causes gill damage, and/or elicits avoidance or otherwise modifies behavior by adult and juvenile salmonids. | Reduce delivery of fine sediments to streams. | Implement in-channel projects that address geologic process such as deep-seated slope failure, landslide toe erosion, bank erosion, ; employ relay crops and appropriate buffers to prevent surface erosion at its source or trap soil eroded from agricultural lands. | Improve floodplain connectivity through dike removal or breaching; re-vegetate riparian zones and floodplains; install frequent cross drains for ditch relief (including on non-forestry roads) rather than routing ditch waters substantial distances then directly delivering to streams Install adequate construction phase erosion control; revegetate and schedule activites for dry season; fence livestock out of riparian areas. | Reduce anthropogenic sources of fine sediment that are detrimental to aquatic life and water quality. | Removal of roads, reduce road drainage to streams, provide frequent ditch relief so waters can infiltrate and avoid interception and pirating of waters that then route suspended sediment and pollutants to streams, increase graveled road surface material thickness and/or hardness with crushed rock or paving, traffic reduction (unpaved roads) ; Fence livestock out of riparian areas, avoid overgrazing, plant cover crops, disconnect ditch network from fallow fields during wet periods | Removal of roads, reduce road drainage to streams, culvert or stream crossing upgrades, sidecast removal or reduction ; avoid land management activities on unstable slopes |

| Limiting Factor | Problem(s) | Reach-scale Actions | | | Subbasin-scale projects | | |
|---|---|---|---|---|---|---|---|
| | | Objective(s) | Direct | Indirect | Objective(s) | Direct | Indirect |
| Food | Habitat degradation (increased fine sediments, loss of wood and other habitat elements, impaired water quality, reduced overhanging vegetation and instream flows) reduces macroinvertebrate production and diversity; decline of historically abundant salmonid stocks has reduced food source (juveniles feed on eggs or carcasses directly; decaying carcasses also significantly enhance stream productivity). | Restore nutrient inputs , LWD, water quality and water quantity characteristic to healthy aquatic systems. | Restore nutrients lost to the food chain due to salmonid decline (e.g., carcass placement). Restore salmon access to blocked habitat and improve habitat productivity. | Increase habitat complexity with wood placement (improves organic matter retention); restore water quality to maintain macroinvertebrate species richness. Restore healthy riparian conditions to provide LWD, macroinvertebrate food sources (leaves etc.), and overhanging vegetation (to increase terrestrial invetebrate drop into streams). | Restore nutrient inputs , LWD, water quality and quantity characteristic to healthy aquatic systems. | Carcass placement | Restore water quality through reducing pollutants, restoring riparian conditions and reducing fine sediment loading. Restore salmon access to obstructed habitat, and improve habitat productivity |
| Obstructions | Man-made obstructions block fish access to historically available habitats. | Restore unimpeded upstream and downstream access to the full range of historic habitat types and locations. | Remove or replace undersized, overly steep or perched culverts, as well as diversion dams, floodgates, tidegates. . Adequately maintain all fishways. Promote bottomless pipes or bridges over culverts in gravel bedded streams. Replace floodgates and tidegates with structures that restore passage and address major flooding concerns | Incorporate fish habitat needs into long-term transportation planning; manage growth wisely to reduce need for new roads; construct new or relocate existing roads to minimize overlap with most productive fish habitats. | | | |
| Riparian | Land use activities have degraded riparian function, including stream temperature moderation, bank stability, wood recruitment, detritus inputs, and fine sediment and nutrient filtration. | Restore riparian functions within channel migration areas. Restore recruitment zones and processes by relocating manmade structures and related infrastructure to restore channel migration opportunities | Replant degraded riparian zones by reestablishing native vegetation that will provide LWD of a size proportionate to the stream size (including conifers for large streams and rivers). Selectively thin, remove and prune non-native and invasive vegetaion; Install and maintain fencing or fish friendly stream crossing structures to prevent livestock access to riparian zones and streams | Discourage landowner use of non-native plant species with invasive tendencies including knotweed, butterfly bush, blackberry, and Scotch broom;provide education about the need for controlling invasive species on private property | Restore riparian functions (e.g. shading, detritus inputs, small and large woody debris, soil cohesion).at the subbasin-scale.. | Replant degraded riparian zones by reestablishing native vegetation; Selectively thin sub-dominants and hardwoods to increase conifer density and growth, remove and prune non-native and invasive vegetaion; Install and maintain fencing or fish friendly stream crossing structures to prevent livestock access to riparian zones and streams | Discourage landowner use of non-native plant species with invasive tendencies including knotweed, butterfly bush, blackberry, and Scotch broom, and education about the need for controlling invasives on private property |
| Floodplain | Stream and river reaches have been disconnected from the adjacent floodplain as the result of levees, dikes, and riprap, thereby reducing availability and connectivity of floodplain habitats. Floodplain habitats have been degraded by removal of riparian vegetation and draining and channelization of wetlands to promote drainage of | Restore and connect wetlands and floodplains to the riverine system in order to promote restoration of habitat forming processes and functions. | Restore and connect wetlands and floodplains to the riverine system through setting back levees and dikes, and relocating infrastructure out of channel migration areas. Restore degraded floodplain habitats through riparian restoration; wood placement, etc.. | Encourage landuse activities that will not require extensive flood protection or that will tolerate local climate and soil conditions including seasonal inundation or deposition of flood borne sediment. | Restore and connect wetlands and floodplains to the riverine system in order to promote restoration of habitat forming processes and functions. | Include the restoration and connection of wetlands and floodplains to the riverine system in integrated sub-basin restoration and flood hazard reduction planning. Replace bridges, culverts and other crossing structures to not interrupt routing of wood, water and sediment; set back levees and dikes and relocate existing | |

| Limiting Factor | Problem(s) | Reach-scale Actions | | | Subbasin-scale projects | | |
|---|---|---|---|---|---|---|---|
| | | Objective(s) | Direct | Indirect | Objective(s) | Direct | Indirect |
| | adjacent lands. | | | | | infrastructures where possible, out of the historical channel migration areas | |
| Estuarine | Access to historic estuarine habitats has been blocked by dikes and levees; estuarine areas have been filled, drained, or otherwise degraded (i.e. loss of wood, vegetation); tidegates limit the extent of estuarine area; upstream activitiess negatively impact estuaries (i.e. reduced instream flows, increased fine sediments, degraded water quality). | Restore access to historic estuarine habitats and improve habitat structure, water quality and other inputs (e.g. detritus) essential to highly functional estuarine habitats. | Reconstruct or restore the tidal channels that have been disconnected from the river delta and estuarine system. | Plant or restore native estuarine or marine nearshore vegetation such as eel grass or kelp; Remove or modify tide gates to restore natural flushing within the estuaries; Remove or breach dikes to restore natural tidal exchange | Reduce upstream impacts to estuarine habitats (reduce anthropogenic sources of fine sediment, improve instream flows, water quality and inputs of wood and detritutus through riparian restoration, improved wood routing. | See relevant Freshwater Limiting Factor sections. | |
| Nearshore marine | Shoreline armaments have altered the supply and transport of sediment, affecting nearshore habitat structure (bathymetry, diversity) and productivity (including forage fish spawning); dredging and impaired water quality degrades eelgrass and other habitats; overwater structures impede migration pathways; historic nearshore habitats have been dredged and/or filled. | Restore habitat structure and functions essential to the recovery of WRIA 1 salmonids and the habitats and species on which they depend. | Improve water quality in nearshore marine environment; remove or minimize placement of overwater structures that impede migration pathways; restore historic bathmetry; place wood.; restore connectivity to embayments; restore non-natal estuaries. | Improve forage fish spawning through beach nourishment where practical; Plant or restore native estuarine or marine Nearshore vegetation such as eel grass, or kelp and other macro-algaes; reduce dredging/filling of nearshore marine habitats to the extent possible. | Restore shoreline processes that result in the habitat structure and functions essential to the recovery of WRIA 1 salmonids and the habitats and species on which they depend. | Remove/modify shoreline armaments to restore flow of sediment and water; Reconnect habitat b/n bays and rivers to provide migration routes for salmon (ring of pearls) | |

**Table C-6.** Typical response time, duration, variability of success, and probability of success for common restoration techniques (Beechie et al. 2003, modified from Roni et al. 2002).

| Restoration type[a] | Specific action | Years to achieve response | Longevity of action (years) | Variability of success among projects | Probability of success |
|---|---|---|---|---|---|
| *Reconnect habitats* | Culverts | 1-5 | 10-50+ | Low | High |
| | Off channel | 1-5 | 10-50+ | Low | High |
| | Estuarine | 5-20 | 10-50+ | Moderate | Moderate to high |
| | Instream flows | 1-5 | 10-50+ | Low | High |
| *Roads and land use* | Road removal | 5-20 | Decades to centuries | Low | High |
| | Road alteration | 5-20 | Decades to centuries | Moderate | Moderate to high |
| | Change in land use | 10+ | Decades to centuries | Unknown | Unknown |
| *Riparian restoration* | Fencing | 5-20 | 10-50+ | Low | Moderate to high |
| | Riparian replanting | 5-20 | 10-50+ | Low | Moderate to high |
| | Rest-rotation or grazing strategy | 5-20 | 10-50+ | Moderate | Moderate |
| | Conifer conversion | 10-100 | Centuries | High | Low to moderate |
| *Instream habitat restoration* | Artificial log structures | 1-5 | 5-20 | High | Low to high[b] |
| | Natural LWD placement | 1-5 | 5-20 | High | Low to high[b] |
| | Artificial log jams | 1-5 | 10-50+ | Moderate | Low to high[b] |
| | Boulder placement | 1-5 | 5-20 | Moderate | Low to high[b] |
| | Gabions | 1-5 | 10 | Moderate | Low to high[b] |
| *Nutrient enrichment* | Carcass placement | 1-5 | Unknown | Low | Moderate to high |
| | Stream fertilization | 1-5 | Unknown | Moderate | Moderate to high |
| *Habitat creation* | Off channel | 1-5 | 10-50+ | High | Moderate |
| | Estuarine | 5-10 | 10-50+ | High | Low |
| | Instream | See various instream restoration techniques above | | | |

[a] The first three categories of restoration (reconnect isolated habitats, roads and land use, and riparian restoration) are considered process-based or passive restoration, the last three (instream, nutrient enrichment, and habitat creation) are considered enhancement or active restoration.
[b] Depends on species and project design.

# ATTACHMENT D: SUPPORTING MATERIAL FOR NON-SRFB PROJECTS

**NOTE:** The tables included in Appendix D reflect the best information available at the time they were constructed and are considered incomplete. The tables will be updated as new information becomes available.

**Table D-1.** Relative Importance of Geographic Areas for Nooksack late-timed chinook[1].

| Geographic Area | Restoration Category | Protection Category |
|---|---|---|
| WRIA 1 Nearshore Marine Areas | A | A[2] |
| Nooksack Estuary | A | A |
| Nooksack River to Forks confluence | B | B |
| Tenmile Creek | C | C |
| Bertrand Creek | C | C |
| Fishtrap Creek | C | C |
| Kamm Creek | C | C |
| Anderson Creek | C | C |
| Smith Creek | C | C |
| Other Fall Chinook Habitats | E | E |

[1] This table reflects the best information available at the time they were constructed and are considered incomplete. The table will be updated as new information becomes available.
[2] Priority rank applies to known forage fish spawning grounds mapped by WDFW (Pentilla 2001).

**Table D-2.** Relative Importance of Geographic Areas for WRIA wild-spawning coho[1].

| Geographic Area (see footnotes for additional criteria) | Restoration Category | Protection Category | |
|---|---|---|---|
| North Fork upstream from and including Glacier Creek to Nooksack Falls, as well as coho streams tributary to the reach. | A[2] | A[3] | C[4] |
| Middle Fork Nooksack and coho streams tributary to the Middle Fork. | A[2] | A[3] | C[4] |
| South Fork Nooksack upstream of RM 16, as well as coho streams tributary to that reach. | A[2] | A[3] | C[4] |
| Main Stem: Tenmile, Bertrand, Fishtrap, Anderson, Smith Creeks; South Fork: Hutchinson, Skookum, Nessets slough complex; North Fork: Bell, Coal, Racehorse Creeks, Bear Creek slough complex | B[5] | B[6] | |
| Nooksack River upstream to Middle Fork; South Fork upstream to Saxon Rd. | B | B[7] | |
| Breckenridge, Saar, North Fork Johnson, and Dakota Creeks | C | C | |
| Other wild coho spawning or rearing areas. | E[2] | E[3] | |

[1] This table reflects the best information available at the time they were constructed and are considered incomplete. The table will be updated as new information becomes available.

[2] Priority rank applies to degraded, low-gradient (<2%) coho use areas within these streams and reaches.

[3] Priority rank applies to properly functioning **high** coho use areas within these streams and reaches that are not hydromodified and have high LWD recruitment potential (Coe 2001).

[4] Priority rank applies to properly functioning **moderate** coho use areas within these streams and reaches that are not hydromodified and have high LWD recruitment potential (Coe 2001).

[5] Historically and/or currently productive but degraded, gravel-dominated, low gradient (<2%) coho tributary areas with demonstrated consistent strong coho use.

[6] Historically and/or currently productive, properly functioning, gravel-dominated, low gradient (<2%) coho tributary areas with demonstrated consistent strong coho use.

[7] Priority rank applies to mainstem areas that are not hydromodified**.**

**Table D-3.** Relative Importance of limiting factors within geographic areas for Nooksack late-timed chinook.

| Geographic Area | Sediment | Floodplain | Flow | Riparian | Obstructions |
|---|---|---|---|---|---|
| WRIA 1 Nearshore marine areas | *To be determined in future revisions to Version 2.3* | | | | |
| Nooksack Estuary | | | | | |
| Nooksack River: Mouth to Anderson Creek | 3 | 2 | 4 | 1 | *Identified high priority blockages (through calculation of Priority Index)* |
| Nooksack River: Anderson Creek to South Fork | 1 | 3 | 4 | 2 | |
| Tenmile Creek | 1 | | 3 | 2 | |
| Bertrand Creek | 2 | | 3 | 1 | |
| Fishtrap Creek | 1 | | 3 | 2 | |
| Kamm Creek | 2 | | 3 | 1 | |
| Anderson Creek | 1 | | 4 | 3 | |
| Smith Creek | 1 | | 3 | 2 | |
| Other Fall Chinook Habitats | *Depends on stream; to be determined as data becomes available.* | | | | |

**Table D-4.** Relative Importance of limiting factors within geographic areas for WRIA 1 wild-spawning coho.

| Geographic Area | Floodplain | Riparian | Flow | Obstructions |
|---|---|---|---|---|
| North Fork upstream from and including Glacier Creek to Nooksack Falls, as well as coho streams tributary to the reach . | 2 | 1 | 5 | *Identified high priority blockages (through calculation of Priority Index)* |
| Middle Fork Nooksack and coho streams tributary to the Middle Fork. | 2 | 1 | 5 | |
| South Fork Nooksack upstream of RM 16, as well as coho streams tributary to that reach. | 2 | 1 | 4 | |
| MS: Tenmile, Bertrand, Fishtrap, Anderson, Smith Creeks; SF: Hutchinson, Skookum, Nessets slough complex; NF: Bell, Coal, Racehorse Creeks, Bear Creek slough complex | 2 | 1 | 2 (Mainstem tribs) | |
| Nooksack River upstream to Middle Fork; South Fork upstream to Saxon Rd. | 1 | 2 | 4 | |
| Breckenridge, Saar, North Fork Johnson, and Dakota Creeks | 3 | 1 | 2 | |
| Other wild coho spawning or rearing areas. | *depends on stream* | | | |

# APPENDIX E: WRIA 1 SALMON RECOVERY RESOURCE LIST

*Updated March 2004*

Numerous non-profit and governmental organizations are currently working cooperatively in watershed and salmon recovery within Water Resource Inventory Area 1. The listing below is intended to help guide members of the community that are interested in salmon recovery towards available resources. This does not constitute an endorsement of any group on the part of Whatcom County. The list may not reflect all the groups currently active.

**Non-profit Organizations**

| | |
|---|---|
| 1. *Nooksack Recovery Team*<br>P.O. Box 28598<br>Bellingham, WA 98228-0598<br>(360) 384-2340<br>(360) 319-0628<br>Jim Hansen, Board President | 2. *Nooksack Salmon Enhancement Association*<br>2445 E. Bakerview Rd.<br>Bellingham, WA 98226<br>(360) 715-0283<br>(360) 715-0282 (fax)<br>Wendy Scherrer, Executive Director |
| 3. *Whatcom Land Trust*<br>P.O. Box 6131<br>Bellingham, WA 98227<br>(360) 650-9470<br>Gordon Scott, Conservation Director | 4. *Skagit Watershed Council*<br>407 Main Street, Suite 205<br>PO Box 2856<br>Mount Vernon, WA 98273<br>(360) 419-9326<br>www.skagitwatershed.org<br>Shirley Solomon, Executive Director |
| 5. *Skagit Fisheries Enhancement Group*<br>P.O. Box 2497<br>Mount Vernon, WA 98273<br>Call: 360.336.0172<br>Fax: 360.336.0701<br>Allison Studley | 6. *Shared Strategy for Puget Sound*<br>1411 4th Ave., Suite 1015<br>Seattle, WA 98101<br>(2060 447-3336<br>Carol MacIlroy, Watershed Liaison |

**Government Agencies**

| | |
|---|---|
| 1. *City of Bellingham*<br>Department of Public Works<br>Environmental Resources Division<br>City Hall<br>210 Lottie Street<br>Bellingham, WA 98226<br>(360) 676-6961<br>Clare Fogelsong, Superintendent | 2. *Lummi Nation*<br>Natural Resources Department<br>2616 Kwina Road<br>Bellingham, WA 98226<br>(360) 384-2267<br>(360) 384-4737 (fax)<br>Merle Jefferson, Executive Director<br>Jim Hansen, Restoration Coordinator |
| 3. *Nooksack Tribe*<br>Natural Resources Department<br>P.O. Box 157<br>Deming, WA 98244<br>(360) 592-5176 | 4. *United States Forest Service*<br>Mt. Baker Ranger District<br>810 State Route 20<br>Sedro Woolley, WA 98284<br>(360) 856-5700 |

| | |
|---|---|
| (360) 592-5753 (fax)<br>Bob Kelly, Director<br>Alan Soicher, Restoration Coordinator | Jon Vanderheyden, District Ranger<br>Roger Nichols, Watershed Specialist |
| 5. *Washington State Department of Ecology*<br>Nooksack Field Office<br>1204 Railroad Avenue, Suite 200<br>Bellingham, WA 98225<br>(360) 738-6250<br>Mark Henderson, Water Quality Specialist<br>Barry Wenger, Shorelines Specialist | 6. *Washington State Department of Fish and Wildlife*<br>Watershed Stewardship Team<br>(360) 676-2003<br>Steve Seymour, Watershed Steward |
| 7. *Washington State University Extension*<br>1000 N. Forest Street, Suite 201<br>Bellingham, WA 98226<br>(360) 676-6736<br>(360) 738-2458 (fax)<br>Craig MacConnell, Chair | 8. *Whatcom Conservation District*<br>6975 Hannegan Road<br>Lynden, WA 98264<br>(360) 354-2035<br>(360) 354-4678 (fax)<br>George Boggs, District Manager |
| 9. *Whatcom County Department of Public Works Water Resources Division*<br>322 N. Commercial St, Suite 110<br>Bellingham, WA 98225<br>(360) 676-6876<br>(360) 738-2468 (fax)<br>John N. Thompson, ESA Coordinator | 10. *Port of Bellingham*<br>1801 Roeder Ave/PO Box 1677<br>Bellingham, WA 98225<br>676-2500<br>671-6411 (fax)<br>Mike Stoner, Environmental Director |
| 11. *Bellingham Bay Pilot Project – Habitat Action Team*<br>C/o Christy Schmidt Wyborny<br>Floyd Snider McCarthy, Inc.<br>83 South King Street, Suite 614<br>Seattle, WA 98104<br>voice: 206.292.2078 ext. 1016<br>fax: 206.682.7867<br>Brian Williams, WDFW, HAT Chair<br>(360) 466-4345 ext. 250 | 12. *Skagit County Public Works Department*<br>1111 Cleveland Ave<br>Mount Vernon, WA 98273-4215<br>(360) 336-9333<br>Jeff McGowan, Salmon Habitat Specialist |

**Citizen Committees**

| |
|---|
| 1. *Marine Resources Committee*<br>2. *Shellfish Protection Districts*<br>3. *Combined Review Team*<br>Whatcom County Water Resources Division<br>322 Commercial St., Suite 110<br>Bellingham, WA 98225<br>(360) 676-6876<br>(360) 738-2468 (fax)<br>1 & 2. Erika Stroebel, Sr. Resources Planner<br>3. John N. Thompson, Sr. Resources Planner |

# 65 APPENDIX F: WRIA 1 LEAD ENTITY APPLICATION TIMELINES

## 2005 WRIA 1 /Salmon Recovery Board Grant Application Timeline

| | |
|---|---|
| **May 6** | **SRFB 6th Round Manuals available at http://www.iac.wa.gov/srfb/docs.htm** |
| **June 3** | **2005 (6th) Round SRFB Grant Notification.** Notice of WRIA 1 local applicant workshop date and key project development dates. |
| **June 13** | **Revised WRIA 1 Salmonid Habitat Restoration Strategy and project ranking criteria available.** |
| **June (transmitted to SRFB June 13)** | **SRFB Review Panel Strategy Review.** The SRFB Review Panel provides reviews and draft written comments on strategies to WRIA 1 Lead Entity. |
| **June 15** | **SRFB Application Workshops.** SRFB Staff will hold an application workshop for northern Puget Sound, 9:00 am to Noon at the Mount Vernon Police Station to assist potential applicants with completing the forms. |
| **June 17** | **WRIA 1 Applicant Workshop.** WRIA 1 applicant workshop to explain appropriate use of the WRIA 1 Salmonid Habitat Restoration Strategy, provide advice on strategy, and coordination between projects. |
| **June 23** | **WRIA 1 Applicant Concept Letter of Intent.** A letter of intent describing project concept due to WRIA 1 Lead Entity Coordinator by close of business (4:30 pm). Letters will be used by Lead Entity Steering Committee to evaluate initial fit to strategy and allow time for a "fix-it" loop to strengthen projects prior to formal project plan and submittal. |
| **July (week of July 25-29)** | **SRFB Review Panel Project Review.** The Review Panel is available, upon request, to meet with WRIA 1 Lead Entity and project applicants, visit project sites, prepare draft written comments on all projects and note projects of concern. Site visits may be scheduled for the week of July 25-29. |
| **August 10** | **WRIA 1 Applications Due Date.** Applications are due to the WRIA 1 Lead Entity Coordinator by close of business (4:30 pm). |
| **August 12** | **WRIA 1 Lead Entity Coordinator distributes copies of applications to WRIA 1 reviewers.** |
| **August 17** | **WRIA 1 Applicant Presentations.** Applicants present project overview to WRIA 1 reviewers. |
| **August 22** | **WRIA 1 Project Review and Ranking.** |
| **September 13** | **WRIA 1 Salmon Recovery Board Approval.** WRIA 1 Salmon Recovery |

| | |
|---|---|
| | Board evaluates results of review, discusses, and approves a ranked project list. |
| **September 30** | **WRIA 1 Project List & Applications Due.** WRIA 1 Lead Entity forwards a strategy and its summary, a prioritized project list and the ranking criteria (if not contained in the strategy) to the SRFB, and all applications and related materials via PRISM. |
| **October 3-28** | **SRFB Staff Reviews Applications.** SRFB staff reviews applications for completeness and eligibility. SRFB Grant Managers may contact Lead Entity and applicants for additional information as they review project applications. Fish passage and nearshore technical review teams will review passage and nearshore projects. |
| **October 5-28** | **SRFB Review Panel Strategy Review**. The Review Panel prepares written evaluations of all strategies. |
| **November 1-17** | **SRFB Review Panel Project Review.** The Review Panel prepares draft written evaluations of all projects to identify projects of concern. |
| **November 7-11** | **WRIA 1 Presentation Preparation.** WRIA 1 Lead Entity Steering Committee will meet during the first full week of November to review Lead Entity staff draft presentation in preparation for formal presentation of project list and fit with strategy. |
| **November 21-December 2** | **Lead Entity Presentations**. WRIA 1 Lead Entity provides formal presentation on the strategy and project list with evaluations to the SRFB Review Panel. |
| **December 5-7** | **SRFB Review Panel & SRFB Staff Draft Report.** SRFB Review Panel and SRFB Staff develop preliminary conclusions and recommendations and send a draft report to the Lead Entities. |
| **December 7-14** | **Lead Entities Review Draft Report.** Lead Entities review and provide comments to the SRFB Review Panel and SRFB Staff on the draft report. |
| **December 15-16** | **SRFB Review Panel and SRFB Staff Finalize Report.** SRFB Review Panel and SRFB Staff finalize their conclusions and recommendations. |
| **December 19-30** | **Public Comment Period.** Public may review and comment on the SRFB Review Panel and SRFB Staff conclusions and recommendations. |
| **January 5-6, 2006** | **SRFB Allocates Funding.** SRFB adopts project lists and allocates funding in an open public meeting. |
| **February-April 2006** | **SRFB Staff Conducts Successful Applicant Workshops and Issues Project Agreements.** |

# APPENDIX G: ADDITIONAL GUIDANCE

# ATTACHMENT G-1: PROJECT CATEGORIES AND RECOMMENDED CONSIDERATIONS

Project categories have been excerpted (with some modification) from: JNRC (Joint Natural Resources Cabinet). 2001. *Guidance on Watershed Assessment for Salmon* (http://www.governor.wa.gov/gsro/watershed/watershed.pdf). This information may be used by project applicants to help guide project scoping and proposal development. Please note that the information in this attachment is informational only and may not be entirely consistent with the most current SRFB guidance. Please check the SRFB website for the most current SRFB guidance materials: http://www.iac.wa.gov/srfb/default.asp

I. ACQUISITION

A. Acquisition of fee ownership

1. Description: Acquisition of fee title or perpetual easements for high quality functioning estuarine, nearshore, freshwater aquatic, floodplain, and riparian habitat.
2. Benefits to salmon are increased if:

- Watershed assessment has identified high priority areas in need of preservation to protect high quality salmon habitat.
- On-site habitat-forming processes are relatively intact (riparian system consists of mature trees, channel can migrate over floodplain, floodplain capable of long-term sediment, high-flow, and nutrient storage).
- Upslope habitat-forming processes are intact or mostly intact.
- Watershed upstream of acquisition is in protected status.
- Future land use change upstream of site will not substantially alter habitat-forming processes.

B. Acquisition of water rights

1. Description: Acquisition of water rights for instream flow.
2. Benefits to salmon are increased if:

- Need for water rights acquisition has been identified through the WRIA 1 Watershed Management Project.
- Watershed assessment has identified the lack of instream flow as a priority issue adversely affecting salmon productivity.
- Instream flow studies demonstrate habitat benefits with purchased flow increment.
- Acquired water will be available to provide habitat considered to be a limiting factor for one or more salmon life stages.
- Watershed has stream flows and water withdrawals monitoring in place.

C. Acquisition of utilization or access rights

1. Description: Acquisition of easements for access, development, mineral, and timber rights.
2. Benefits to salmon are increased if:

- Watershed assessment has identified the acquisition as a high priority to protect high quality salmon habitat.
- The easement protects several habitat parameters and provides long-term conservation of the acquisition.
- Upstream habitat-forming processes are intact or mostly intact.
- Future land use change upstream or on-site will not substantially alter habitat-forming processes or important habitat features.
- Watershed upstream of acquisition is in protected status.

II. INSTREAM DIVERSION

A. Fish By-pass/Fish screen (gravity and pump)

1. Description: Installation or upgrade of intake screen/bypass facilities at existing water diversions, to prevent entrainment.
2. Benefits to salmon are increased if:

- Watershed assessment has identified human-caused problems at water diversions, which are impeding migration of adult and/or juvenile salmon and/or causing entrainment of juveniles.
- Installation meets current fish exclusion standards, design methods, and guidance (WDFW or NMFS screening criteria) for all species potentially encountered at diversion site.
- Effective operation and maintenance program is in place.

III. INSTREAM PASSAGE

A. Bridge

1. Description: A water-crossing (over-water structure) that retains or restores natural channel conditions, maintains ecological connectivity; avoids geologically unstable areas; considers cumulative impact for direct loss of habitat; and minimizes streambank vegetation disturbance.
2. Benefits to salmon are increased if:

- The structure does not result in a constriction (narrowing) of the river channel.
- The structure does not impede the downstream transport of LWD and sediment.

- The floodplain at the bridge site is allowed to function naturally.
- Bridge design precludes run-off (and pollutants) from directly entering the channel.
- Riparian vegetation loss is minimized.

B. Culvert Improvements

1. Description: The removal and/or installation of either a new or replacement of a stream culvert (including hanging culverts) to provide efficient passage of adult and juvenile salmon, and improve stream function.
2. Benefits to salmon are increased if:

- Priority Index has been calculated for the dam indicating that it is a high priority barrier to fix, *or* Watershed assessment has identified specific barriers that preclude or restrict access to historic salmon habitat, and/or cause loss of habitat connectivity.
- Design/installation meets current WDFW fish passage design methods and guidance.
- Upstream watershed hydrology is relatively stable.
- Downstream channel bed is relatively stable.
- Upstream sediment inputs are within natural range of variability.
- Future land use change upstream of site will be minimal and anticipated increases in peak flows are incorporated into culvert design.
- Project has been evaluated and prioritized according to the severity of the passage problem, amount/quality of habitat upstream, potential species interactions, and species use.
- Culvert is not installed in salmon spawning area during a time when salmon utilize the area.
- An effective maintenance program is in place.
- Culvert design precludes run-off (and pollutants) from directly entering the stream channel.
- Riparian vegetation loss is minimized.

C. Dam Removal

1. Description: Work at small dams to remove impediments to salmon and sediment passage.
2. Benefits to salmon are increased if:

- Priority Index has been calculated for the dam indicating that it is a high priority barrier to fix, *or* watershed assessment has identified specific barriers as a causal mechanism for loss of habitat connectivity and prioritizes fish passage barriers that preclude access to historic salmon habitat.

- The up- and downstream channel bed is relatively stable.
- Disposition of sediment build-up behind the dam has been properly addressed.
- Feasibility studies have considered/addressed the potential for scouring after removal.

D. Diversion Dam

1. Description: Replacement or modification of a diversion dam to improve passage of salmon.
2. Benefits to salmon are increased if:

- Priority Index has been calculated for the dam indicating that it is a high priority barrier to fix, *or* watershed assessment has identified fish passage as a limiting factor at the structure.
- Design/installation of improvements meet current WDFW fish passage design methods and guidance.
- An effective operation and maintenance program is in place.
- Adequate instream flow is available year-round to operate passage facilities.

E. Fishways and Log/Rock Control Weirs

1. Description: Structures or systems designed to facilitate fish passage including salmon attraction features, barrier dams, entrances, auxiliary water systems, and exits. Log or rock weirs/structures placed in the streambed to influence stream functions such as flow, gradient, sediment, or bed elevation. Culverts (even if "fish friendly") are not considered fishways.
2. Benefits to salmon are increased if:

- Watershed assessment has identified specific barriers as the cause to loss of habitat connectivity and access to historic salmon habitat.
- Structure designed to WDFW design standards, methods, and guidance.
- Alternatives assessment has been conducted.
- Upstream hydrology and sediment processes are within natural range of variability.
- Downstream channel bed is relatively stable.
- Future land use change upstream of site will be minimal and anticipated increases in peak flows are incorporated in design.
- Potential upstream species interactions are assessed and addressed.
- An effective operation and maintenance program is in place.

- Adequate instream flow is available year-round to operate passage facilities

## IV. INSTREAM HABITAT

### A. Bank Stabilization

1. Description: Stabilization of a streambank to minimize erosion and sedimentation.
2. Benefits to salmon are increased if:

- Watershed assessment has identified sedimentation from streambank erosion as a limiting factor for salmon.
- Bio-engineering solutions are implemented that incorporate LWD into design.
- Natural habitat-forming processes and floodplain function are not precluded by the stabilization.
- Potential up- and downstream impacts of stabilization are assessed and addressed.
- Revegetation to create a functional riparian zone is a component of the project.

### B. Carcass Placement

1. Description: Placement of salmon carcasses in streams to enhance nutrient levels in the stream ecosystem.
2. Benefits to salmon are increased if:

- Watershed assessment has identified marine nutrient deficiency as a limiting factor
- Project meets WDFW *Fish Health Guidelines and Protocols*, and WDFW *Guidelines for Distributing Salmonid Carcasses to Enhance Stream Productivity in Washington State*.

### C. Channel complexity and off-channel habitat

1. Description: Reconnection of pre-existing or new high quality off-channel habitat that does not require a formal fish passage facility; includes improving or creating new habitat for salmon rearing and spawning.
2. Benefits to salmon are increased if:

- Watershed assessment has identified alteration in the routing of water and resulting loss of channel complexity, and loss of off-channel habitat as a limiting factor for salmon.
- Upstream habitat-forming processes are relatively intact.
- Downstream channel bed is relatively stable.

- Upstream hydrology and sediment processes are within natural range of variability.
- On-site habitat-forming processes are intact (riparian system surrounding the off-channel habitat consists of mature trees, channel can migrate over floodplain, floodplain capable of long-term sediment, high-flow, and nutrient storage).
- Project addresses the spatial and temporal habitat needs limiting identified salmon life stages.
- Future land use change upstream of site will be minimal and anticipated seasonal flow patterns are considered in project design.
- Fish access to reconnected habitats is provided by normal hydrologic regime.
- Long-term landowner agreement has been secured.

D. Channel reconfiguration

1. Description: Projects that attempt to create a new - or redesign an existing - specific habitat type (pools, spawning habitat, etc.), or influence or redirect the flow, pattern or hydraulics of a stream to reduce or increase erosive forces acting on a stream bank or stream bed, including deflectors, barbs, and vanes.
2. Benefits to salmon are increased if:

- Watershed assessment has identified the need for habitat creation/construction to satisfy short-term habitat requirements for salmon, while habitat-forming processes are being restored.
- Upstream hydrology and sediment processes are relatively intact and within the natural range of variability; there is an adequate understanding of habitat-forming processes to ensure the project will remain functional over time.
- Downstream channel is relatively stable.
- Future land use change upstream of site will not degrade habitat-forming processes.
- Project addresses the spatial and temporal habitat needs limiting identified salmon life stages.
- Project is designed and conducted by experienced design and construction personnel.
- Projects are located in groundwater discharge areas away from the most active channel.

E. Complex log jams *(see also Attachment E-3)*

1. Description: Construction of in-channel engineered log jam (ELJ) complexes in large rivers.

2. Benefits to salmon are increased if:

- Project addresses an identified limiting factor for the reach.
- Upstream hydrology and sediment processes are relatively intact, and within the natural range of variability.
- Project maintains channel conveyance of sediment and water, and dispersal of large wood.
- Appropriate level of analysis is in place (*see Attachment E-3*). Design is carefully developed and project implemented by qualified professionals experienced in ELJ placement.
- An effective maintenance program is in place.

F. Dike removal or setback

1. Description: Dike breaching, setback, or removal that reestablishes on-site habitat-forming processes (delivery and routing of water, sediment, nutrients, and wood) to an estuary or floodplain that restores floodplain or estuarine function, including the restoration of off-channel habitats.
2. Benefits to salmon are increased if:

- Watershed assessment has identified removal/relocation of riprap, dikes/levees and associated fill as a priority target for restoring natural floodplain and estuarine processes.
- Project reestablishes full floodplain function and access to historic off-channel habitats.
- Riparian vegetation is reestablished.
- Natural dendritic channels or surface water patterns are reestablished to avoid potential stranding of salmon.
- Hydrology is restored to estuarine or freshwater wetlands behind dikes.

G. Mass wasting

1. Description: In-channel projects that address geologic processes such as deep-seated slope failures, toe erosion, or landslides.
2. Benefits to salmon are increased if:

- Watershed assessment has identified the need to address specific in-channel habitat-forming processes to improve salmon habitat and productivity, and the project will be designed and implemented to address the cause.
- Assessment has been completed to insure that potential adverse impacts to other habitat-forming processes are identified and understood.

H. Roughened Channel

1. Description: Projects that increase coarseness and texture in the stream channel using natural streambed materials to reduce water velocity and facilitate salmon passage.
2. Benefits to salmon are increased if:

- Upstream hydrology and sediment processes are relatively intact.
- There is an adequate understanding of habitat-forming processes to ensure the project will remain functional over time.
- Floodplain conditions allow lateral channel movement, LWD deposition/accumulation, and increase in channel complexity.

I. Spawning Gravel Placement

1. Description: Introduction of appropriate salmon spawning substrate to the channel, including bed control structures.
2. Benefits to salmon are increased if:

- Project is located out of normal floodplain and has a groundwater source.
- Fine sediment sources are limited or being addressed.
- Instream flow is adequate to transport fine sediment through project.
- Upstream hydrology and sediment processes are relatively intact and within the natural range of variation.
- There is an adequate understanding of habitat-forming processes to ensure the project will remain functional over time.

J. Wetland Restoration

1. Description: The reestablishment of natural or more natural habitat-forming processes within historic freshwater and estuarine wetland areas.
2. Benefits to salmon are increased if:

- Watershed assessment has identified wetland degradation as a core element in the alteration of habitat-forming processes in the sub-watershed.
- If reestablishment of terrestrial or submerged aquatic vegetation is needed, native species must be used.
- Upstream watershed hydrology is relatively stable.
- Groundwater inputs to wetland are assessed and, when significant, within a natural range of variability.
- Project addresses the spatial and temporal habitat needs of identified salmon life stages.
- Upstream sediment processes are within the natural range of variability.
- Future land use change upstream of site will not degrade habitat processes.

- Perpetual easement is acquired to ensure long-term benefit.

K. Woody debris placement

1. Description: Placement of woody debris in smaller stream channels or riparian areas to provide increased channel complexity, retain gravels, increase the quality and frequency of pool habitats, and provide cover for salmon.
2. Benefits to salmon are increased if:

- Watershed assessment has identified the need for the placement of LWD to satisfy short-term habitat requirements for salmon, while habitat-forming processes are being restored.
- Upstream hydrology and sediment processes are relatively stable and within the natural range of variability.
- Downstream channel is relatively stable.
- Riparian area deficiencies that limit natural LWD supply and delivery are being addressed.
- Future land use change upstream of site will not alter restoration of habitat-forming processes.
- Project is designed and performed by experienced design and construction personnel.
- LWD size and placement mimics natural accumulations functioning in the channel or in the reference reach.

V. RIPARIAN HABITAT

A. Livestock Fencing Crossing

1. Description: Installation and maintenance of fencing or a "fish friendly" (non-barrier) stream crossing structure (e.g., bridge) to prevent livestock access to the stream and riparian zone.
2. Benefits to salmon are increased if:

- Watershed assessment has been completed, identifying livestock grazing as a primary cause of riparian loss and/or stream channel degradation in the sub-watershed.
- Project includes native riparian vegetation plantings where natural native plant presence is reduced or lost.
- Fenced riparian width is adequate to provide full riparian function; riparian width should include the channel migration zone, where applicable.
- Livestock watering sources are provided outside of the riparian zone.
- Agreement is developed or perpetual easement is acquired to ensure long-term protection that addresses both length of protection and allowable activities in the riparian area.

B. Riparian vegetation planting

1. Description: Planting native riparian trees and shrubs in areas of the riparian zone that have been cleared for more intensive land uses to restore natural habitat-forming processes (delivery and routing of water, sediments, nutrients, wood, and heat).

2. Benefits to salmon are increased if:

- Watershed assessment has identified riparian deforestation as a primary cause of changes to habitat-forming processes in the sub-watershed.
- Native species are used in revegetation, including conifers where appropriate.
- Riparian plantings are staged to establish early successional trees/shrubs first; late successional species added after growing conditions for them are established.
- Riparian width is adequate to provide full riparian function; riparian width should include the channel migration zone, where applicable.
- Surficial aquifer associated with alluvial deposits of the stream floodplain is being maintained at levels that can support riparian reestablishment.
- Perpetual easement is acquired to ensure long-term benefit.

C. Plant thinning, removal and control

1. Description: Selective thinning, removal, or pruning of non-native, and/or invasive vegetation on a site for the purpose of restoring the site as salmon habitat.

2. Benefits to salmon are increased if:

- Watershed assessment has identified delivery and routing of wood as a priority process in need of restoration in the sub-watershed.
- Native species are used in revegetation.
- Riparian width is adequate to provide full riparian function; riparian width should include the channel migration zone, where applicable.
- Perpetual easement is acquired to ensure long-term benefit (LWD recruitment is realized).

D. Road abandonment/ decommissioning

1. Description: Removal of roads that are vulnerable to failure due to design or location in relation to unstable soils, and cause sedimentation to a water body.

2. Benefits to salmon are increased if:

- Watershed assessment has identified roads as a primary source of sediment and habitat degradation in the sub-watershed.

- Road decommissioning restores natural drainage across the prior road corridor.
- All disturbed soil is revegetated with native species.
- Project complies with current USFS/DNR standards and criteria for road decommissioning.
- Project is conducted by experienced construction crew.

E. Road erosion control

1. Description: Management actions implemented to reduce risk of sedimentation from surface erosion from roads or the risk of road failure and resulting mass wasting events.
2. Benefits to salmon are increased if:

- Watershed assessment has identified forest roads as a primary source of sediment and habitat degradation in the sub-watershed.
- All surface water collected in road ditches is redirected as subsurface flow on the down-slope side of the road.
- Project complies with current USFS/DNR standards and criteria for road erosion control.

F. Stormwater attenuation

1. Description: Detention, treatment, and infiltration of surface water runoff from impervious surfaces (e.g., roads, buildings, parking lots), to restore and maintain natural hydrology in the sub-watershed.
2. Benefits to salmon are increased if:

- Watershed assessment has identified runoff from impervious surfaces as a primary cause of hydrologic and nutrient process alteration in the sub-watershed.
- Stormwater attenuation approximates natural rates of surface water and groundwater delivery to the stream channel.
- Project complies with ECY stormwater guidelines and best management practices for western Washington.

VI. ESTUARINE/MARINE NEARSHORE HABITAT

A. Dike breaching/removal

1. Description: Removing or breaking through all or part of a manmade dike to restore natural tidal exchange in an historical estuarine environment like a river delta.
2. Benefits to salmon are increased if:

- Removal/breaching provides access to habitat historically used by salmon and prey species.

- Natural tidal regime is reestablished.
- Unimpeded access and egress is provided.

B. Estuary planting

1. Description: Planting or restoring native estuarine or marine vegetation to improve fish habitat, including eel grass bed or kelp forest reestablishment.
2. Benefits to salmon are increased if:

- Watershed assessment and/or shoreline inventories identify loss of eelgrass or kelp as a limiting factor.
- Water quality and sediment influx to the estuary are adequate to support reintroduction of marine vegetation.
- Plantings are within areas known to support eelgrass or kelp forests in the past.
- Project location is away from jetties or other artificial structures that provide habitat for fish species that prey on salmon.

C. Shoreline restoration

1. Description: Reestablishment of natural or more natural delivery and routing of beach sediment, retention of detritus and nutrients in the nearshore area, restore benthic production, and restore forage fish spawning areas. Includes removing contamination or structures/bulkheads, removing invasive or nonnative vegetation, and planting native vegetation.
2. Benefits to salmon are increased if:

- Watershed assessment has identified alterations in the delivery and routing of Nearshore sediments as a core factor in the loss or degradation of nearshore habitat.
- Project reestablishes native plant species in the nearshore riparian zone.
- Project is consistent with assessment work that identifies jetties, bulkheads, and other structures having the greatest effect on the delivery of sediment to the nearshore area and the routing of that sediment through the drift cell.

D. Tidal channel reconstruction

1. Description: Reconstruction or restoration of tidal channels removed from the confluence of a river delta and estuarine system.
2. Benefits to salmon are increased if:

- Natural tidal prism and flushing can be reestablished.
- Sediment influx to tidal channels is within the natural range of variability for the watershed.

- Hydrologic regime is within the natural range of variability for the watershed.
- Project location is away from artificial structures that provide habitat for fish species that prey on salmon.

E. Tide Gate Removal

1. Description: Removal of tide gate(s) and restoration of natural tidal flushing within the estuarine environment.
2. Benefits to salmon are increased if:

- Unimpeded fish access can be reestablished.
- Habitat provides the necessary life history needs for rearing salmon and their prey species.
- Habitat-forming processes that maintain habitat are functioning adequately.

# ATTACHMENT G-2: RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION OF ENGINEERED LOG JAMS (ELJ)

Source:
Duboiski, M., M. Ramsey, G. Pess, and K. Bauersfeld. 2000. Report to the Salmon Recovery Funding Board on the Engineered Log Jam (ELJ) Workshop. December 1, 2000. http://www.iac.wa.gov/Documents/SRFB/Log_Jam_Report.pdf.

## 1. Definition

Engineered log jams (ELJs) are "experimental in-stream flow control structures based on the architecture of naturally occurring stable log jams in large river systems. ELJs are permanent structures that are designed to mimic natural log jams, contain key pieces of wood large enough to alter the course of the river channel, and capture additional wood".

## 2. Recommendations

Relative to wood placement in smaller streams, ELJ projects require considerably more design and funding to achieve the desired habitat benefit. The following are recommended of ELJ projects: (1) clearly stated and measurable objectives; (2) project monitoring that is linked to project objectives, with commitment to monitor at least 10 years; (3) appropriate level of geomorphic, biological and engineering analysis (see below); and (4) fully documented design and construction.

## 3. Analysis Needs

The following analysis questions should be addressed before ELJ construction:

*Pre-Project Questions*

a) *Geomorphic*

*Both historic and current data should be compiled at a reach and watershed scale for the following questions:*

- What is the relative sediment supply (increasing and/or decreasing)?
- What are the hydrologic conditions (increasing and/or decreasing flood frequencies)?
- What is the wood supply/delivery (increasing and/or decreasing)? These could be qualitative or quantitative statements and should include the status of riparian conditions.
- What are the current wood characteristics (frequency, size, species, distribution & location)?
- What are the human safety factors (quantitative or qualitative statements)?
- Where is the channel migration zone and what is the magnitude and frequency of movement?

- What are the change(s) in land-use? What is the location, quantity, and type of hydro-modification that occurs upstream, downstream, and within the project reach?

Both historic and current data should be compiled at a reach and watershed scale for the following questions:

- Have longitudinal profiles been developed?
- Have cross-sections been taken?
- Have photo points been taken?
- What are the riparian conditions (wood counts)?What are the human safety factors?
- What are the flow characteristics?

b) *Engineering*

The following questions should be answered when designing ELJs:

- What type of natural jams are you trying to emulate?
- What is the design and stability of your key members of the ELJ?
- How do potential changes in channel conditions affect recreational use of and public infrastructure within the stream reach?
- What is the risk of catastrophic failure of the ELJ?

c) *Biological*

Both historic and current data should be compiled at a reach and watershed scale for the following questions:

- Has the habitat been inventoried and mapped (reach only)?
- What is the general fish use, by species and life stage(s)? Is this existing data or gathered data?
- Both historic and current data should be compiled at a site scale for the following questions:
- Where do fish spawn and rear within project site?
- What is the biological hypothesis?
- How does project benefit fish survival?

*Post-Project Questions*

*a) Geomorphic*

*Data should be compiled at a site and reach scale for the following questions:*

- Are all the original objectives being met?
- How does the short & long term stability of the ELJ affect the site, and the upstream and downstream channel conditions? This may include positive and/or negative responses to the following: sediment storage and routing,

flood storage and routing, connection & creation of side-channels, wood storage and routing.

*b) Engineering*

Data should be compiled at a site and reach scale for the following questions:

- Are all the original objectives being met?
- What is the short & long term stability of the ELJ(s)?
- How is recreational use and public infrastructure affected by the short & long term stability of the ELJ(s)?

*c) Biological*

*Data should be compiled at a site and reach scale for the following questions:*

- Are all the original objectives being met?
- How does the short & long term stability of the ELJ(s) affect fish usage, and aquatic (primary productivity) and riparian conditions?
- How does the short & long-term stability of the ELJ(s) affect habitat conditions?
- How does the short & long term stability of the ELJ(s) affect nutrient storage and routing?

*Information Gathering Techniques*

*d) Geomorphic*

- Aerial photos analysis of historic channel shifts and identify the channel migration zone;
- Topographic maps to determine elevations at the site and reach scale (survey);
- Wood tagging and tracking to determine the frequency and magnitude of potential wood movement and accumulations;
- Discharge estimates from a nearby gage station (discharge);
- Oblique photos to show pre and post project conditions.

*e) Engineering*

- Hydraulic modeling (site & reach specific);
- Cross-sections [pre-project, as-built, post-project,
- Long-term post-project change in channel conditions (see topographic and geomorphic surveys above)].

*f) Biological*

- In-stream habitat surveys (maps referenced to benchmarks);
- Juvenile and adult fish surveys (snorkel, observations – carcass counts, redd surveys, adult counts);

- Benthic sampling; riparian habitat surveys (inventory changes and responses).

# ATTACHMENT G-3: NEAR-TERM (10-YEAR) RESTORATION PROJECTS

## Abstracted from WRIA 1 Salmonid Recovery Plan

In this section, we present near-term restoration projects by geographic area for Nooksack early chinook. These projects were identified as a part of the WRIA 1 salmon recovery planning effort and will be included in the WRIA 1 Salmonid Recovery Plan. Geographic areas presented in this section are aggregations of the reaches and geographic areas defined for EDT.

For the purposes of this Plan, Nooksack early chinook habitats were divided into the following:

- *Lower North Fork*: North Fork Nooksack, from South Fork confluence (RM 36.6) to Glacier Creek (RM 57.6)
- *Upper North Fork*: North Fork Nooksack, from Glacier Creek (RM 57.6) to Nooksack Falls (RM 65.1)
- *North Fork tributaries*[4]: Racehorse Creek; Bear Creek; Maple Creek; Boulder Creek; Canyon Creek; Cornell Creek; McDonald Creek; Glacier Creek; Boyd Creek; Deadhorse Creek; Wells Creek
- *Lower Middle Fork*: Middle Fork Nooksack, from mouth to Mosquito Lake Rd. bridge (RM 5)
- *Upper Middle Fork*: Middle Fork Nooksack, from Mosquito Lake Rd. bridge (RM 5) to Ridley Creek (RM 17.4)
- *Middle Fork tributaries*[5]: Canyon Lake Creek; Peat Bog Creek; Porter Creek; Clearwater Creek; Sisters Creek; Warm Creek; Wallace Creek
- *Lower South Fork*: South Fork Nooksack, from mouth to Skookum Creek (RM 14.3)
- *Upper South Fork*: South Fork Nooksack, Skookum Creek (RM 14.3) to upper extent chinook distribution (RM 31)
- *SF tributaries*[6]: Hutchinson Creek; Skookum Creek; Cavanaugh Creek; Plumbago Creek; Deer Creek
- *Lower Mainstem*: Mainstem Nooksack, Lummi River distributary (RM 4.5) to Everson (RM 24)
- *Upper Mainstem*: Mainstem Nooksack, Everson (RM 24) to South Fork confluence (RM 36.6)

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[4] Specified tributaries presented as modeled in EDT; not all tributary reaches that can support early chinook were modeled, although major tributary habitats are included.

[5] Specified tributaries presented as modeled in EDT; not all tributary reaches that can support early chinook were modeled, although major tributary habitats are included.

[6] Specified tributaries presented as modeled in EDT; not all tributary reaches that can support early chinook were modeled, although major tributary habitats are included.

- *Mainstem tributaries: Tenmile Creek, Bertrand Creek, Fishtrap Creek, Kamm Creek, Scott Ditch, Anderson Creek, Silver Creek, Smith Creek, McCauley Creek, Mitchell Creek.*
- *Estuary*: Nooksack/Lummi Estuary from Lummi River confluence to mudflats
- *Bellingham Bay:*
- *Other WRIA 1 Nearshore Areas*

*Lower North Fork*

The proposed actions for the lower North Fork include:

- Riparian planting of the channel migration area for wood recruitment
- Riparian planting for shading benefits
- Construction of stable in-stream wood structures
- Protection of existing in-stream wood
- Monitoring of forest practice activities
- Relocation of stream-adjacent roads and infrastructure

*Riparian planting of the channel migration area for wood recruitment*

Riparian planting throughout the channel migration area of the North Fork and its tributaries will encourage long-term recovery of wood recruitment to the channel. Priorities for planting should be given to areas where the wood recruitment function is currently classified as "low" (Duck Creek, Assoc. 2001), is located where the channel can access the wood through channel erosion, but lies in a protected enough location that the trees can grow to a substantial size.

*Riparian planting for shading benefits*

Riparian planting in the Lower North Fork is expected to highly improve both the maximum monthly and spatial variation of the water temperature in the river. It is expected that upstream shading will have modest downstream benefits to stream temperature, as the water warms more slowly as it loses elevation.

*Construction of stable in-stream wood structures*

Restoration opportunities also exist to construct stable accumulations of wood in unconfined, low gradient reaches of the North Fork Nooksack. These reaches should be prioritized because wood is more likely to persist in the lower energy sections of the river. Further, these are the reaches with the greatest potential for habitat diversity as the channel migrates across the floodplain, creating secondary channels and potentially floodplain islands. There may be restoration opportunities in the channel to address the legacy effects of channel instability by constructing stable habitat features in the low gradient, unconfined reaches of the North Fork Nooksack. Since the channel actively migrates across the channel migration area, projects will need to treat the entire width of the channel migration area to ensure habitat stability into the future. In-stream restoration projects that focus on stabilizing bars and narrowing the active channel area in unconfined reaches will address channel widening in response to elevated sediment load.

*Upper North Fork*

The proposed actions for the upper North Fork include:

- Large-scale LWD placement
- Riparian restoration to improve wood delivery to the channel
- Riparian restoration to improve channel shading
- Set back infrastructure from the channel

*Large-scale LWD placement*

The primary objective of wood placement in the upper North Fork is to slow wood transport through the river and trap the mobile debris on stable wood structures in unconfined reaches. Much of the unconfined area of the upper North Fork has already been treated by the U.S. Forest Service and currently being monitored for effectiveness. It is expected that the wood accumulations will help stabilize bars in the channel and slow the process of channel migration and avulsion. In reaches where channel incision has degraded habitat, the increased flow resistance of the wood in the channel is expected to slow the incision and improve floodplain connectivity. It is expected that several of these projects could be implemented to provide a variety of habitat values to the channel. Over a longer timeframe as the logjams grow and stabilize, this project is designed to directly address habitat diversity and key habitat quantity for adult holding and spawning in the upper North Fork. Large-scale wood placement in sections of the upper North Fork Nooksack is expected to fully restore wood function in the channel. This will have a high impact on the formation of pools, pool tail-outs and backwater pools. The structures would also be expected to have a minor impact on off channel habitat and a negligible impact on the formation of beaver ponds. The creation of more pools with complex cover will have a high impact on benthic community richness, a moderate impact on harassment of fish, as well as a minor impact on the retention of salmon carcasses. Spatial variation of temperature is expected to see an improvement from better interaction of pools with groundwater. During high flow, the project would be expected to moderately increase channel width, with a negligible impact on minimum width. The impact of the project on high flow, low flow and intra-annual flow variability would be a negligible benefit.

*Riparian restoration to improve wood delivery to the channel*

By restoring and protecting riparian areas adjacent to the river, this project seeks to reduce bed scour, sediment impacts, and provide more diverse habitat over the long term. By proper management of timberlands, the channel is expected to see moderate decreases in bed scour, embeddedness and fine sediment, as well as a high impact on turbidity. The improvements in pools, backwaters pools, pool tail-outs and beaver ponds are expected to be high with a better functioning riparian ecosystem. A functioning riparian ecosystem is also expected to increasing the minimum (moderate impact) and maximum (high impact) channel width. The riparian functions and woody debris levels of the channel would both have an extreme benefit from the project. It is expected that improving the interface between the terrestrial and aquatic environments would have a moderate impact on salmon carcass retention. Wood delivered to the channel in the upper North Fork would be expected to eventually be transported into the lower North Fork reaches, improving downstream habitat over a longer timeframe.

*Riparian restoration to improve channel shading*

Riparian planting in the Upper North Fork is expected to highly improve both the maximum monthly and spatial variation of the water temperature in the river. It is expected that upstream shading will have modest downstream benefits to stream temperature, as the water warms more slowly as it loses elevation.

*North Fork Tributaries*

The proposed actions for the North Fork tributaries include:

- Riparian restoration to improve wood delivery to the channel
- Riparian restoration to improve channel shading
- Canyon Creek fish passage improvement
- Canyon Creek habitat restoration

*Riparian restoration to improve wood delivery to the channel*

By restoring riparian areas adjacent to the river, this project seeks to reduce bed scour, sediment impacts, and provide more diverse habitat over the long term. By proper management of timberlands, the channel is expected to see moderate decreases in bed scour, embeddedness and fine sediment, as well as a high impact on turbidity. The improvements in pools, backwaters pools, pool tail-outs and beaver ponds are expected to be high with a better functioning riparian ecosystem. A functioning riparian ecosystem is also expected to increasing the minimum (moderate impact) and maximum (high impact) channel width. The riparian functions and woody debris levels of the channel would both have an extreme benefit from the project. It is expected that improving the interface between the terrestrial and aquatic environments would have a moderate impact on salmon carcass retention. In more confined reaches of tributaries wood can provide an important sediment storage function in the channel, as it creates lower gradient steps in the channel. Addition of recruited wood to the North Fork tributaries will have a longer-term benefit to habitat conditions below the confluence as the wood is slowly transported down to the mainstem North Fork River. Protection of in-channel wood will ensure that the functions that recruited wood provide will be maintained. Priorities for wood recruitment should be given to places were the channel has access to the riparian zone infrequently enough that the trees can grow to a sufficient size to provide functional “key pieces” to the channel.

*Riparian restoration to improve channel shading*
Riparian planting in the North Fork tributaries is expected to highly improve both the maximum monthly and spatial variation of the water temperature in the various creeks. Priorities should be given to narrower channels, which can more quickly be shaded by smaller trees.

*Canyon Creek fish passage improvement*
As necessary, and consistent with longer-term restoration plan for lower Canyon Creek (see below), short-term improvements will be made to the barrier at RM 0.3 to ensure that early chinook can access upstream habitat.

*Canyon Creek habitat restoration*
Canyon Creek restoration focuses on dike setback, large woody debris placement, as well as riparian restoration. The project is expected to remove the impacts of the rock revetment on the alluvial fan of Canyon Creek, and fully restore the historic channel width. The project will have a moderate impact on wood function in the channel, including the formation of pools through the treated reach. Riparian function will be restored to a moderate degree, with shading benefits to the maximum temperature and the spatial variation of the temperature, which currently exceeds water quality standards. The project will complement upstream sediment management and landslide stabilization work that was recently completed by the USFS.

*Lower Middle Fork*

The proposed actions for the lower Middle Fork include:
- Upland forest management
- Riparian timber managed lands
- Riparian planting of the channel migration area for wood recruitment
- Riparian planting for shading benefits

*Upland forest management*
This action continues the program to upgrade or decommission forest roads on state and federal forests and eliminates logging of unstable slopes in the Middle Fork watershed. It is expected that this action will continue to reduce anthropogenic sediment sources to the river and changes in flow caused by forest management.

*Riparian planting of the channel migration area for wood recruitment*
Riparian planting throughout the channel migration area of the Middle Fork and its tributaries will encourage long-term recovery of wood recruitment to the channel. Priorities for planting should be given to areas where the wood recruitment function is currently classified as “low” (Duck Creek, Assoc. 2001), is located where the channel can access the wood through channel erosion, but lies in a protected enough location that the trees can grow to a substantial size. Wood recruited to the channel in this reach would benefit downstream reaches of the lower North Fork Nooksack as well.

*Riparian planting for shading benefits*

Riparian planting in the Lower Middle Fork is expected to highly improve both the maximum monthly and spatial variation of the water temperature in the river. It is expected that upstream shading will have modest downstream benefits to stream temperature, as the water warms more slowly as it loses elevation.

*Large-scale LWD placement*

The primary objective of wood placement in the lower Middle Fork would be to slow wood transport through the river and trap the mobile debris on stable wood structures in unconfined reaches. It is expected that the wood accumulations will help stabilize bars in the channel and slow the process of channel migration and avulsion. It will also help form and maintain side channels and other floodplain habitats. While this reach has not yet been assessed for specific restoration actions and priorities, it is expected that several of these projects could be implemented to provide a variety of habitat values to the channel. Over a longer timeframe as the logjams grow and stabilize, this would help address habitat diversity and key habitat quantity for adult holding and spawning chinook. This will also help form and maintain pools, pool tail-outs and backwater pools.

*Upper Middle Fork*

The proposed actions for the upper Middle Fork include:

- Restore Passage at Middle Fork Diversion Dam
- Establish and manage for sufficient instream flow at the Middle Fork Diversion Dam
- Upland forest management
- Riparian timber managed lands

*Restore Passage at Middle Fork Diversion Dam*

The project includes the installation of a fish ladder and water intake screen at the Middle Fork Diversion Dam. It is expected that the project will allow passage for all anadromous species into the upper Middle Fork basin.

*Middle Fork Tributaries*

No near-term projects were prioritized.

*Lower South Fork*

The proposed actions for the lower South Fork include:

- Upland forest management through Forest and Fish, Northwest Forest Plan, including forest road maintenance and monitoring, riparian management, and avoidance of unstable slopes
- Protect existing function through CAO/SMP

- Acquisition of priority habitats
- Large-scale LWD placement
- Restoration of channel migration area
- Riparian restoration to improve wood delivery
- Riparian restoration to improve riparian shading
- Set back infrastructure from the channel
- Wetland restoration to improve baseflow, temperature maintenance

*Acquisition of priority habitats*

Continued protection of priority habitat in the lower South Fork will continue through a variety of programs including purchase, acquisition of conservation easements, and voluntary enrollment in the Conservation Reserve Enhancement Program. It is expected that by protecting existing refuge areas in the lower South Fork, restoration activities can work to connect and expand high quality habitat. Acquisition sites further facilitate restoration actions on the property.

*Large-scale LWD placement*

Building on the results of the Acme-Saxon In-stream Assessment (LNR, NNR 2002) and the Acme to Confluence Assessment (NNR 2005), several areas for in-stream wood placement were identified and prioritized. It is expected that several of these projects could be implemented to provide a variety of habitat values to the channel. This project is designed to directly address habitat diversity and key habitat quantity for adult holding and spawning in the lower South Fork. The project will also have benefits to channel stability. Large-scale wood placement in sections of the lower South Fork Nooksack is expected to fully restore wood function in the channel. This will have an extreme impact on the formation of pools, pool tail-outs and backwater pools. The structures would also be expected to have a minor impact on off channel habitat and a negligible impact on the formation of beaver ponds. The creation of more pools with complex cover will have a high impact on benthic community richness, a moderate impact on harassment of fish, as well as a minor impact on the retention of salmon carcasses. Maximum temperature and spatial variation of temperature is expected to see an improvement from better interaction of pools with groundwater and by providing refuge habitat in known cool water influence areas. During high flow, the project would be expected to moderately increase channel width, with a negligible impact on minimum width. The impact of the project on high flow, low flow and intra-annual flow variability would be a negligible benefit.

*Restoration of channel migration area*

By removing constraints to channel migration in the lower South Fork, it is expected that the negative habitat effects associated with hydro-modifications would be reversed in treated reaches. Further, the projects would be expected to have a moderate influence on low flow, high flow and intra-annual flow variation. These benefits would be realized by allowing the channel better access to its floodplain.

*Riparian restoration to improve wood delivery to the channel*

By restoring riparian areas adjacent to the river, this project seeks to reduce bed scour, sediment impacts, and provide more diverse habitat over the long term. By proper management of timberlands, the channel is expected to see moderate decreases in bed scour, embeddedness and fine sediment, as well as a high impact on turbidity. The improvements in pools, backwaters pools, pool tail-outs and beaver ponds are expected to be high with a better functioning riparian ecosystem. A functioning riparian ecosystem is also expected to increasing the minimum (moderate impact) and maximum (high impact) channel width. The riparian functions and woody debris levels of the channel would both have an extreme benefit from the project. It is expected that improving the interface between the terrestrial and aquatic environments would have a moderate impact on salmon carcass retention. Addition of wood to the lower South Fork will have a longer-term benefit to habitat conditions below the confluence as the wood is slowly transported out of the South Fork and into the mainstem Nooksack River.

*Riparian restoration to improve channel shading*

Riparian planting in the Lower South Fork is expected to highly improve both the maximum monthly and spatial variation of the water temperature in the river.

*Wetland Restoration to improve baseflow and temperature maintenance*

In the Lower South Fork, extensive wetlands occupied the floodplain of the channel. The largest of these is the Black Slough wetland, near Van Zandt, which likely provided substantial summer inflow to the river before much of it's area was converted to agriculture. The slough currently has a slight cooling effect on the South Fork that could likely be improved with restoration. In other places, drainage ditches have reduced the capacity of floodplain wetlands, such as the Foxglove wetland complex near Acme, and changed the outflow of the wetland. Restoration efforts focused on restoring natural hydrology will greatly improve wetland function in the lower South Fork.

*Upper South Fork*

The proposed actions for the upper South Fork include:

- Upland forest management through Forest and Fish, Northwest Forest Plan, including forest road maintenance and monitoring, riparian management, and avoidance of unstable slopes
- Priority habitat acquisition
- Large-scale wood placement
- Decrease river-adjacent sediment inputs to South Fork Mainstem
- Riparian restoration to improve channel shading and wood delivery to the channel

*Upland Forest Management- Forest roads*

Forest road management is expected to improve habitat impacts from high winter flow and sediment generated from road failures. Road management in the South Fork basin is expected to show a moderate reduction in interannual variability in high flow and low flow and intra-annual flow pattern. These changes should be associated with a minor reduction in fine sediment, embeddedness and turbidity. Changing the flow patterns should also have a moderate impact on reducing bed scour.

*Priority Habitat Acquisition*

Acquisition and protection of the floodplain will allow natural recovery of habitat-forming processes, such as channel migration and riparian functions. This acquisition will also facilitate near-term restoration projects, such as those described under the 10-year implementation strategy. The upper South Fork is considered a high priority for preservation.

*Large scale LWD placement*

This project is designed to directly address habitat diversity and key habitat quantity for fry colonization in the upper South Fork. The project will also have benefits to channel stability. Large-scale wood placement in sections of the upper South Fork Nooksack is expected to fully restore wood function in the channel. This will have an extreme impact on the formation of pools, pool tail-outs and backwater pools. The structures would also be expected to have a minor impact on off channel habitat and a negligible impact on the formation of beaver ponds. The creation of more pools with complex cover will have a high impact on benthic community richness, a moderate impact on harassment of fish, as well as a minor impact on the retention of salmon carcasses. The project is further expected to result in a high reduction of bed scour and a minor improvement in gravel embeddedness and fine sediment impacts. Maximum temperature and spatial variation of temperature is expected to see a minor improvement from better interaction of pools with groundwater. During high flow, the project would be expected to moderately increase channel width, with a negligible impact on minimum width. The impact of the project on high flow, low flow and intra-annual flow variability would be negligible. Since the logjams will be an engineering tool to meet habitat objectives, the number of structures in a reach is expected to vary depending on the goals of the project. Based on a previous wood placement project that met similar habitat limitations as those described for the upper South Fork Geographic Area, we estimate 10 logjams per mile across the channel migration zone would be necessary. The expected length treated for the upper South Fork is 10 miles of channel.

*Decrease river-adjacent sediment inputs to South Fork Mainstem*

This project is designed to directly address sediment impacts on sediment impacts on egg incubation by applying source controls to major sediment sources in the upper South Fork. It is expected that reducing sediment delivery from landslides will have a minor impact on reducing embeddedness and fine sediment, but will have a moderate impact on reducing turbidity in the river. It is expected that the project will also minor impact on pools and pool tail-out abundance, which have been lost to filling. The project is expected to have a negligible benefit to wood levels in the channel. These projects would be expected to improve fine sediment conditions in the lower South Fork Geographic Area.

*Riparian restoration to improve wood delivery to the channel*

By restoring riparian areas adjacent to the river, this project seeks to reduce bed scour, sediment impacts, and provide more diverse habitat over the long term. By proper management of timberlands, the channel is expected to see moderate decreases in bed scour, embeddedness and fine sediment, as well as a high impact on turbidity. The improvements in pools, backwaters pools, pool tail-outs and beaver ponds are expected to be high with a better functioning riparian ecosystem. A functioning riparian ecosystem is also expected to increasing the minimum (moderate impact) and maximum (high impact) channel width. The riparian functions and woody debris levels of the channel would both have an extreme benefit from the project. It is expected that improving the interface between the terrestrial and aquatic environments would have a moderate impact on salmon carcass retention. Wood delivered to the channel in the upper South Fork would be expected to eventually be transported into the lower South Fork reaches, improving downstream habitat over a longer timeframe.

*Riparian restoration to improve channel shading*

Riparian planting in the Upper South Fork is expected to highly improve both the maximum monthly and spatial variation of the water temperature in the river. It is expected that upstream shading will have modest downstream benefits to stream temperature, as the water warms more slowly as it loses elevation.

*South Fork Tributaries*

The proposed actions for the South Fork tributaries include:

- Riparian restoration to improve wood delivery to the channel
- Riparian restoration to improve channel shading

*Riparian restoration to improve wood delivery to the channel*

By restoring riparian areas adjacent to the river, this project seeks to reduce bed scour, sediment impacts, and provide more diverse habitat over the long term. By proper management of timberlands, the channel is expected to see moderate decreases in bed scour, embeddedness and fine sediment, as well as a high impact on turbidity. The improvements in pools, backwaters pools, pool tail-outs and beaver ponds are expected to be high with a better functioning riparian ecosystem. A functioning riparian ecosystem is also expected to increasing the minimum (moderate impact) and maximum (high impact) channel width. The riparian functions and woody debris levels of the channel would both have an extreme benefit from the project. It is expected that improving the interface between the terrestrial and aquatic environments would have a moderate impact on salmon carcass retention. In more confined reaches of tributaries wood can provide an important sediment storage function in the channel, as it creates lower gradient steps in the channel. Addition of wood to the South Fork tributaries will have a longer-term benefit to habitat conditions below the confluence as the wood is slowly transported down to the mainstem South Fork River.

*Riparian restoration to improve channel shading*
Riparian planting in the South Fork tributaries is expected to highly improve both the maximum monthly and spatial variation of the water temperature in the various creeks. Priorities should be given to narrower channels, which can more quickly be shaded by smaller trees.

*Upper Mainstem*

The proposed actions for the upper Mainstem include:

- Riparian and floodplain habitat acquisition
- Riparian restoration for shading in the Upper Mainstem Area
- Riparian restoration for wood recruitment in the Upper Mainstem Area
- Levee setback and removal of bank protection along the Upper Mainstem Nooksack
- Large wood placement

*Riparian and floodplain habitat acquisition*
This action includes locating opportunities to purchase and restore floodplain habitat. Acquisition will be achieved using a combination of conservation easements and purchases. It is expected that the action will facilitate future restoration actions such as levee setbacks and bank protection removal.

*Riparian restoration for shading in the Upper Mainstem Area*
Riparian planting in the upper mainstem is expected to highly improve both the maximum monthly and spatial variation of the water temperature in the river. It is expected that upstream shading will have modest downstream benefits to stream temperature. The focus of the planting will be on cooling smaller sloughs and side channels, which will more quickly achieve a full canopy. These smaller channels will be the highest priority for planting.

*Riparian restoration for wood recruitment in the Upper Mainstem Area*
Riparian planting throughout the channel migration area of the upper mainstem will encourage long-term recovery of wood recruitment to the channel. Priorities for planting should be given to areas where the wood recruitment function is currently classified as "low" (Duck Creek, Assoc. 2001), is located where the channel can access the wood through channel erosion, but lies in a protected enough location that the trees can grow to a substantial size. Wood recruited to the channel in this reach would benefit downstream reaches of the lower North Fork Nooksack as well.

*Levee setback and removal of bank protection along the Upper Mainstem Nooksack*

Setting back levees and removing bank protection should provide a variety of habitat benefits to the upper mainstem Nooksack River. The action is expected to improve floodplain connectivity and restore channel migration where it is limited by bank protection.

*Large wood placement*

This action focuses on the placement of large woody debris to provide deep, complex pools and help restore the historic anastomosing channel form above the town of Everson. Wood structures will be sited to protect maturing mid-channel bars and allow vegetation to colonize the sites. The structures will also provide deep and complex pools, which will be ideal habitat for migrating and holding adults, as well as out-migrating juveniles.  The structures would be sited across the channel migration area to meet a variety of habitat objectives, such as bar stabilization and pool development. The number of structures will ultimately be related to the habitat objectives identified for the reach.

*Lower Mainstem*

The proposed actions for the lower Mainstem include:

- Early action projects that integrate floodplain management with habitat recovery: Bertrand Creek area; Whiskey-Schneider Creek area
- Implementation of Best Management Practices on urban and agricultural lands
- Restore mainstem channel complexity
- Systematically integrate flood planning with habitat recovery

*Integrate floodplain management with habitat recovery: Bertrand Creek area*

Integrate flood hazard management with salmon recovery (i.e. pursue opportunities to setback levees for multiple benefits). Nooksack River between Fishtrap and Bertrand creeks has been identified as potential location for levee setback for flood hazard management. Integrate flood hazard with fish habitat restoration by creating side channel sloughs, off-channel wetlands and riparian vegetation. Include large scale LWD placement with project to promote instream complexity.  Increase channel width and complexity. Restore channel meander and connection to off-channel wetlands. Provide clear water habitat in the lower river for juvenile chinook rearing.

*Integrate floodplain management with habitat recovery: Whiskey-Schneider Creek area*

Integrate flood hazard management with salmon recovery (i.e. pursue opportunities to setback levees for multiple benefits). Nooksack at Whisky and Schneider creeks has been identified as potential location for levee setback for flood hazard management. Integrate flood hazard with fish habitat restoration by creating side channel sloughs, off-channel wetlands and riparian vegetation. Include large scale LWD placement with project to promote instream complexity.  The objectives of the project is to increase channel width and complexity, restore channel meander and connection to off-channel wetlands and provide clear water habitat in the lower river for juvenile chinook rearing.

*Implementation of Best Management Practices on urban and agricultural lands*
Implement BMP's re: filter strips, stormwater management, pesticide application in agricultural and urban areas. Decrease input of toxic contaminants, nutrients, fine sediments; increase riparian filtration.

*Restore mainstem channel complexity*
Placement of wood along river margins; anchored to piling wing walls or other instream structures. Structures placed to increase channel complexity along bank of river at multiple locations. LWD to improve complexity along edge of channel, increase habitat quality for juvenile rearing.

*Mainstem Tributaries*

The proposed actions for the mainstem tributaries include:

- Restoration of tributary slough habitat to provide flood refuge for fry and overwintering juveniles in the lower mainstem.
- Small-scale riparian restoration through CREP, voluntary stewardship, or community-based programs that do not compete with early chinook projects.
- Establish and manage for instream flows through Watershed Management Project.
- Implement best management practices to maintain water quality for downstream habitats.
- Restore fish passage using funding sources specifically targeted for fish passage improvements.
- Implement Forest and Fish rules (applies to Smith and Anderson Creek watersheds).

*Whiskey-Schneider Creek restoration*
Multiple lower tributary slough habitat restoration. Whiskey Creek: remove flood gate, daylight slough/creek, improve channel to expand habitat and connect flood plain wetlands. Schneider Creek: remove / relocate flood gate to connect Keefe Lake Complex to river. Improve Lower mainstem habitat complexity by restoring tributary slough habitat.

*Kamm Creek restoration*
Small-scale riparian restoration with a few CREP projects; restore Northwood wetland. Increase riparian shading, overhanging vegetation and leaf litter (improve benthos production, water temperatures but narrow buffer width, small-scale treatment so limited improvement in riparian function). Primary benefit to late timed chinook and coho utilizing off-channel habitat. Include side-channel/slough habitat to benefit juvenile rearing early timed chinook.

*Fishtrap Creek restoration*

Limited riparian improvement expected given existing land use, but some CREP likely. Set back levee on 2 mile reach between Guide and River road. Increase riparian shading, overhanging vegetation and leaf litter (improve benthos production, water temperatures but narrow buffer width, small-scale treatment so limited improvement in riparian function). Primary benefit to late timed chinook and coho utilizing off-channel habitat. Include side-channel/slough habitat to benefit juvenile rearing early timed chinook.

*Bertrand Creek restoration*

Bertrand CIDMP/Watershed Improvement District to facilitate limited riparian improvement - anticipate some small-scale improvement (I.e. narrow buffer width, smaller vegetation) over 30% of length. Set Back BC levees on lower 0.5 mile of channel to increase slough habitat area/complexity. Increase riparian shading, overhanging vegetation and leaf litter (improve benthos production, water temperatures but narrow buffer width, small-scale treatment so limited improvement in riparian function).

*Tenmile Creek restoration*

Community-based restoration with Tenmile Creek partnership - anticipate 20-30' riparian buffer over ~70% of length. Increase riparian shading, overhanging vegetation and leaf litter (improve benthos production, water temperatures but narrow buffer width, small-scale treatment so limited improvement in riparian function). Primary benefit to late timed chinook and coho utilizing off-channel habitat. Include side-channel/slough habitat to benefit juvenile rearing early timed chinook. Consider improving channel complexity / open water habitats in 1.5 miles of Barrett lake.

*Anderson Creek restoration*

Active and passive riparian restoration possible in lower reaches. Increase riparian shading, overhanging vegetation and leaf litter (improve benthos production, water temperatures but narrow buffer width, small-scale treatment so limited improvement in riparian function)

*Anderson Creek fish passage*

Regular maintenance of fishway to ensure passage. Restore full passage to upper Anderson Creek

*Smith Creek restoration*

Active riparian restoration possible. Increase riparian shading, overhanging vegetation and leaf litter (improve benthos production, water temperatures but narrow buffer width, small-scale treatment so limited improvement in riparian function).

*Estuary*

The proposed actions of the estuary include:

- Restore riverine-tidal blind channel network: Marietta Slough
- Restore riverine-tidal blind channel network: Marietta Slough
- Setback levees on LB of river between Slater Road and Ferndale
- Restore channel complexity

*Restore riverine-tidal blind channel network: Marietta Slough*

Setback levees on LB of river between mouth of river and Slater Road, and seaward dikes.

*Restore riverine-tidal blind channel network: Tennant Wetland*

Project proposes to enhance floodplain tributary channels by redesigning the channel, introducing wood and planting riparian vegetation on Tennant Creek. This creek drains the wetlands on the eastern side of the floodplain of the mainstem downstream of Ferndale.

*Setback/ remove levees on LB of river between Slater Road and Ferndale*

Levee setback and removal will encourage floodwater and sediment deposition on the estuarine floodplain above Slater Road. Slater Road will be raised to accommodate flooding and infrastructure will be protected. It is expected that the project will enhance wetland functions on the floodplain and encourage more flow into the Tennant Creek area.

*Restore channel complexity*

Placement of wood along river margins; anchored to piling wing walls or other instream structures. Structures placed to increase channel complexity along bank of river at multiple locations. LWD to improve complexity along edge of channel, increase habitat quality for juvenile rearing.

*Bellingham Bay/ WRIA 1 Nearshore*

No near-term projects were prioritized.

**Table 5.1:** Habitat targets for Nooksack early chinook freshwater habitats.
(Note: Apply to or adjacent to early chinook habitats, except Watershed Conditions, which apply to watershed upstream.)

| Category | EDT Attribute | Definition | Target | |
|---|---|---|---|---|
| Access | Migration Obstructions[1] | Obstructions to fish passage by physical barriers. | None, or existing obstructions allow full upstream and downstream passage of juveniles and adults . | |
| Channel Conditions | Fine Sediment[1] | Percentage of fine sediment (<0.85mm) | Riffles | < 11% |
| | Embeddedness[1] | Extent that larger cobbles or gravel are surrounded by or covered by fine sediment | Riffle and tailout habitat units (where cobble, gravel substrates occur). | < 25 % covered by fine sediment |
| | Wood Debris[1] | Large Wood Function | Complex array of large wood pieces (>50cm diameter) but fewer cross channel bars and fewer pieces of sound large wood due to less recruitment than historic conditions; large wood, jams are a prevalent influence on channel morphology. | |
| | | Large woody debris (LWD, i.e., pieces >0.1 m diameter and >2m in length) density in pieces per channel width (CW, i.e., average wetted width during high flow month that is less thank bankfull) | CW <25 ft | 2 to 3 |
| | | | CW 25 - 50 ft | 2 to 4 |
| | | | CW 50 - 150 ft | 3 to 7 |
| | | | CW 150 - 400 ft | 10 to 20 (excluding large jams), plus large jams where accumulations occur. |
| | | | CW >400 ft | 8 to 15 (excluding large jams), plus large jams where accumulations occur. |
| | Bed Scour[1] | Average depth of bed scour during annual peak flow event over ~ a 10-year period. | Spawning areas (i.e., in pool-tailouts and small cobble-gravel riffles) | Frequent scour of depths < 10 cm. |
| | Quantity and Quality of Pools[1] | Pool Frequency (pools per mile) | Width 5' | 184 |
| | | | Width 10' | 95 |
| | | | Width 15' | 20 |
| | | | Width 20' | 56 |
| | | | Width 50' | 26 |
| | | | Width 75' | 23 |

| Category | EDT Attribute | Definition | Target |
|---|---|---|---|
| | | | Width 100' 18 |
| | | Pool Quality | Pools > 1 meter depth (holding pools) with good cover and cool water, minor reduction of pool volume by fine sediment |
| Floodplain Conditions | Hydromodifications[1] | Extent that man-made structures constrict flow (e.g., bridges) or restrict flow access to floodplain (e.g., streamside roads, riprap, levees); extent of ditching or channelization. | Stream channel is fully connected to the floodplain although very minor structures may exist that do not result in flow restriction or constriction. |
| | Floodplain Connectivity[2] | Ability of flood flows to access floodplain | Off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession. |
| | Habitat Type – Off Channel[1] | Off-channel habitats, as a proportion of the total wetted area | Use historic conditions as reference |
| Riparian Conditions | Riparian Function[1] | Degree to which riparian function has been altered within the reach. | > 70% of functional attributes present |
| | Riparian Buffer Width and Composition[3] | Width of riparian zone measured horizontally from the channel migration zone on each side of the stream; species composition and stand age of vegetation. | >150 ft or site potential tree height (whichever is greater) *and* dominated (>70%) by mature conifers unless hardwoods were dominant historically |
| Water Quantity | Annual Variation in Peak Flow[1] | Relative change in average peak annual discharge, as inferred from historical flow data or indicator metrics. | Peak annual flows typical of an undisturbed watershed of similar size, geology, orientation, topography, and geography; OR <20% change in Q2yr based on historical record |
| | Intra-Annual Variation in Peak Flow[1] | Intra-annual flow variation during the wet season (i.e., "flashiness") as indicated by flow data or watershed condition metrics (e.g., road density, % impervious surface). | Storm runoff response (rates of change in flow) typical of undisturbed watershed of similar size, geology, orientation, topography, and geography; OR <5% reduction in average TQmean compared to the undeveloped watershed state. |
| | Annual Variation in Low Flow[1] | Relative change in average daily flow during the normal low flow period, as indicated by historical flow data or inferred from watershed metrics. | Average daily low flows expected to be comparable to an undisturbed watershed of similar size, geology, and flow regime (or the pristine state for the watershed of interest); OR <20% change in the 45 or 60-day consecutive lowest average daily flow. |

<table>
<tr><th>Category</th><th>EDT Attribute</th><th>Definition</th><th colspan="4">Target</th></tr>
<tr><td></td><td>Diel Variation in Flow[1]</td><td>Average diel variation in flow level during a season or month.</td><td colspan="4">Slight to low variation in flow stage during an average 24-hr period during season or month. This pattern typical of routine slight to low ramping condition associated with flow regulation, averaging <2 inches change in stage per hour.</td></tr>
<tr><td rowspan="15">Water Quality</td><td>General Water Quality[2]</td><td>Includes all water quality parameters regulated through the Clean Water Act that affect salmonids.</td><td colspan="4">Low levels of contamination from agricultural, industrial, and other sources; no excess nutrients; no 303-d listed reaches.</td></tr>
<tr><td rowspan="10">Temperature - daily maximum[4]</td><td rowspan="10">Maximum water temperatures (7-day average of daily maximum) within the stream reach during the period should not exceed:</td><td></td><td>Incubation</td><td>Juvenile Rearing</td><td>Adult Migration</td></tr>
<tr><td>Chinook</td><td>11 - 12</td><td>14.2 - 16.8</td><td>14.2 - 16.8</td></tr>
<tr><td>Coho</td><td>9 - 12</td><td>14 - 17</td><td>14 - 17</td></tr>
<tr><td>Chum</td><td>10.5 - 12</td><td>N/A</td><td>Insuff. Data</td></tr>
<tr><td>Pink</td><td>10 - 12</td><td>12.5 - 14.5</td><td>12.5 - 14.5</td></tr>
<tr><td>Sockeye</td><td>10.5 - 12</td><td>12 - 16</td><td>13 - 14.5</td></tr>
<tr><td>Steelhead</td><td>13 - 14</td><td>16.5 - 17.5</td><td>16 - 17</td></tr>
<tr><td>Bull Trout/Dolly Varden[a]</td><td>5.5 - 6.5</td><td>10 - 12</td><td>14 - 17</td></tr>
<tr><td>Rainbow Trout</td><td>9 - 12</td><td>15.5 - 18</td><td></td></tr>
<tr><td>Cutthroat Trout</td><td>10 - 11</td><td>13 - 15.5</td><td>14.5 - 17.5</td></tr>
<tr><td>Temperature - spatial variation[1]</td><td>Water temperature variation within the reach as influenced by inputs of groundwater.</td><td colspan="4">Intermittent sites of groundwater discharge into surface waters and total quantity of groundwater discharge not a major source of flow in reach.</td></tr>
<tr><td>Dissolved Oxygen[1]</td><td>Average dissolved oxygen within the water column.</td><td colspan="4">>8 mg/L</td></tr>
<tr><td>Turbidity[1]</td><td>The severity of suspended sediment episodes within the stream reach (Scale of Severity, or SEV[3]).</td><td colspan="4">SEV Index ≤ 6; Occasional episodes with low to moderate concentrations (<250 mg/L) of suspended sediment. Concentrations are sublethal, although slight behavioral modification may occur.</td></tr>
<tr><td>Pollutants[1]</td><td>The extent of dissolved heavy metals and other toxic pollutants within the water column.</td><td colspan="4">No toxicity expected due to dissolved heavy metals to salmonids under prolonged exposure (1 month exposure assumed).</td></tr>
</table>

| Category | EDT Attribute | Definition | Target |
|---|---|---|---|
| Watershed Conditions | Mass Wasting | Occurrence of mass wasting events (e.g., debris flows, shallow-rapid landslides). | No evident impact of land use on the frequency and magnitude of mass wasting events that deliver sediment to streams. |
| | Road Network Impacts | Measures of the impact of the road network to the stream system, e.g., the length of road network per unit watershed area, number stream crossings per unit channel length, proportion of stream network with stream-adjacent roads. | Road Density[3]: <2 mi/mi$^2$; other thresholds to be developed based on best available science. |
| | Increase in Drainage Network[2] | Extension of stream network by land use practices, e.g., ditching/draining of wetlands, road ditches that intercept precipitation or groundwater flow and deliver directly to stream network | Zero or minimum increases in active channel length correlated with human-caused disturbance. |
| | Riparian Areas[3] | Condition of riparian areas adjacent to stream reaches upstream of but hydrologically connected to Nooksack early chinook habitats | Streams more than 2 ft bankfull width: >100 ft buffer width dominated by mature trees of historically dominant species<br><br>Streams* less than 2 ft bankfull width: >50 ft buffer width dominated by mature trees of historically dominant species<br><br>*Applies to streams for which wood is important in sediment storage. Research is underway locally to characterize such streams. |
| | Hydrologic Maturity[3] | Proportion of watershed area with forest stands aged 25 or more | >60% |
| | Impervious Surface Area[3] | Percentage impervious surface in the watershed (e.g., calculated by applying effective impervious surface % to land use/land cover types and averaging over watershed | ≤ 3% |

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| Ecological Interactions | Salmon Carcasses[1] | Relative abundance of anadromous salmonid carcasses within watershed that can serve as nutrient sources for juvenile salmonid production and other organisms. | Very abundant -- on average 400 carcasses/mile of main channel habitat |

[1] Source: Blair, G. 2001. Puget Sound PFC Rules. May 2001 Memorandum. Mobrand Biometrics, Vashon, WA.

[2] Source: USFWS. 1998. A Framework to Assist in Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Bull Trout Subpopulation Watershed Scale. February 1998.

[3] Source: Smith, C. 2002. Habitat Condition Standards (Table 13) *in* Salmon and Steelhead Habitat Limiting Factors in WRIA 1, the Nooksack Basin. July 2002. Washington State Conservation Commission. Lacey, WA. *Note: Standards for good conditions were used.*

[4] Source: Hicks, M. 2000. Preliminary Review Draft Discussion Paper Evaluating Standards for Protecting Aquatic Life In Washington's Surface Water Quality Standards Temperature Criteria. Washington State Department of Ecology, Water Quality Program, Watershed Management Section. Olympia, Washington.