SKAGIT WATERSHED COUNCIL

HABITAT PROTECTION AND RESTORATION STRATEGY

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(REVISED)

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Habitat Restoration and Protection Committee
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OVERVIEW

Despite large expenditures of money throughout Washington State, many habitat restoration projects have not resulted in significant increases in salmon populations. In many cases, this is the result of projects addressing the symptoms, rather than the causes of watershed degradation. This restoration strategy was developed as an attempt to insure for the efficient and effective use of public and private money for restoration efforts that will result in a high likelihood of success. The goal of this strategy is to assist and encourage the voluntary restoration and protection of natural landscape processes that formed and sustained the habitats to which salmon stocks are adapted. This strategy is only a part of the effort necessary to restore salmon populations at the river basin scale, and does not address issues of harvest, hatcheries, or hydropower, which are being evaluated by others.

This strategy will:

- Provide criteria for evaluating the likelihood of success of restoration and protection projects
- Allow the Skagit Watershed Council to identify and endorse projects based on a common set of principles
- Focus efforts to areas with the greatest potential for increasing salmon populations
- Enable the Skagit Watershed Council to rank projects based on costs and benefits
- Help landowners in understanding what is necessary to undertake successful restoration projects on a voluntary basis
- Demonstrate to funding agencies that we have a scientifically based restoration and protection strategy that had been adopted by a diverse number of interests throughout the watershed.
- Insure that projects are monitored to evaluate their success

This strategy is not:

- A Regulation that will be imposed on landowners
- A means to prevent anyone from undertaking restoration projects with their own funds
- An implementation plan that requires certain projects be done
- A way to avoid or fully address the requirements of the Endangered Species Act
- The only thing necessary to halt the decline of salmon in the Skagit Basin
- Perfect, and will be updated as new information becomes available

The approach of this strategy is to identify the types of areas within the watershed where salmon historically or currently live, and to identify the natural landscape processes that must be protected or reestablished to insure the successful protection or rehabilitation of habitats to which salmon stocks are adapted. Salmon have adapted to those stream characteristics that exist in areas where there has been little disturbance by the activities of man, and it is upon this basis that this strategy has been developed.. The approach that is used in this strategy is as follows. Stream, river, estuary and wetland segments are identified as one of ten different channel types. If the channel type that exists in a particular segment is similar to what existed historically, it is considered a key habitat type. In these channel types, there is little need for restoration, but a high priority for protection, such as through easements or land acquisition. Channel types that are somewhat degraded due to human disturbances, but still retains some basic elements of its historical feature, are considered important. These areas are primary candidates for restoration, provided that the factors that have caused their decline can be corrected. If the stream segment has been severely altered, it is considered degraded and if it has been disconnected from its original pathway to a main waterway, it is considered isolated. Those stream segments that have physical features not conducive to supporting spawning or rearing of anadromous fish (such as very steep segments) are considered secondary habitats, and will generally have a lower priority for restoration unless they are causing significant impacts downstream.. Much of this document develops a protocol to make these determinations, and to evaluate the physical processes that have resulted in segment specific conditions. Once these determinations are made, a restoration project can be developed or evaluated in terms of the specific disturbance factors rather than based on the value to a single specie. These factors are based on sediment supply, hydrologic processes (quantity and timing of streamflows), riparian functions, and water quality, and fish access. The purpose of restoration projects will be to provide for conditions necessary for natural processes to reestablish these factors at levels similar to those that existed historically. Based on this analysis, each tributary to the Skagit River can be systematically analyzed to determine what projects or measures may be appropriate for restoration or protection actions. Projects will be evaluated or prioritized based on the likelihood of the success of a particular project, and the magnitude of the value of the project, based on a cost effectiveness analysis that has been developed. This strategy provides a common basis for making these evaluations. Habitat modification projects that depend less on restoring natural processes may be appropriate in cases where the causes for degradation cannot be rectified, such as storage dams on the Upper Skagit River, or as interim measures.

A critical element within this strategy is the requirement that monitoring efforts be in place to insure that projects (1)were constructed as proposed (2) are resulting in the habitats that were anticipated as a result of the projects and (3) that the benefits to fisheries resources are being realized. For each project, at least one type of monitoring will be necessary.

In addition to providing a basis for screening and prioritizing projects that might be undertaken as part of Watershed Council activities, this strategy provides a methodology, supported by all Council member organizations, to evaluate projects brought to the Council for endorsement for funding from outside agencies. With this in place, we can have greater certainty that projects proposed through this process will have demonstrable benefits to fisheries resources. The Skagit Watershed Council's approach is one in which restoration and protection measures are evaluated in the context of the entire watershed, rather than on a project by project basis. It allows us to develop proactive, long-term plans in a collaborative and coordinated way throughout the Skagit River Basin, using the best science available, to increase the likelihood of success.

1. INTRODUCTION

The Skagit Watershed Council[1] (SWC) has charged itself[2] with the following objectives:

- "Develop integrated, comprehensive habitat restoration and protection strategies."
- "Develop and implement procedures to ensure information-exchange and evaluation during implementation of restoration strategies."
- "Endorse projects to improve conditions of the watershed and its fish populations based on a collectively agreed-to standard."

To accomplish these objectives, the SWC established committees responsible for different objectives. For the first objective, the SWC formed the Habitat Restoration and Protection Committee to develop comprehensive restoration and protection strategies. In response, the Habitat Restoration and Protection Committee has prepared this document. The first part of this document states the goal that the SWC believes should guide restoration and protection. It reflects the scientific concepts adopted by the council and is stated in Section 2.

Recognizing that there are many ongoing restoration and protection efforts in the Skagit and Samish basins, we next address the question: How does the SWC determine whether a proposed project is consistent with the goal and merits support? In response, we adopt criteria for distinguishing appropriate restoration and protection actions from inappropriate actions (Section 3.1), and for prioritizing appropriate actions so that the best projects are done first (Section 3.2). Additionally, project monitoring and maintenance criteria are listed in Section 3.3, and procedures to implement the screening and prioritization process are listed in Section 3.4.

The last part of this document begins to address the question: How do we protect and restore the Skagit and Samish River basins? In Section 4, we develop a proactive plan based on the scientific concepts and criteria from preceding sections.

The SWC recognizes that there are other non-science issues (e.g., educational, political) important in developing and implementing any successful habitat restoration and protection strategy. However, it was the intent of the Habitat Restoration and Protection Committee to focus this report on developing a strategy based on the relevant scientific concepts for river basin scale restoration and protection. We believe that important political and educational issues should be integrated after the scientific framework has been developed, rather than simultaneously.

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[1] Skagit Watershed Council membership is comprised of a number of groups and individuals concerned with protecting and restoring healthy ecosystems in order to support sustainable fisheries within the Skagit and Samish River basins.
[2] Skagit Watershed Council Charter, adopted June 10, 1997.

This strategy focuses on habitat protection and restoration, and addresses some effects of hydroelectric dams. It is only a part of the effort necessary to restore salmon populations at the river basin scale, and does not address issues of harvest or hatcheries, which are being evaluated by others.

2. THE GOAL

The goal of this habitat restoration and protection strategy is to "assist and encourage the voluntary *restoration*[3] and *protection* of *natural landscape processes* that formed and sustained the habitats to which *salmonid* stocks are adapted."

Justification of this goal is based on our understanding from current literature that natural landscape processes create and maintain the "natural" habitat conditions in which *native* aquatic and riparian species have adapted (e.g., Peterson et al. 1992, Doppelt et al. 1993, Reeves et al. 1995, Ward and Stanford 1995, Beechie et al. 1996, Kauffman et al. 1997).

Figure 1 is a conceptual diagram illustrating how watershed controls and natural landscape processes combine to form various habitat conditions. Watershed controls that are independent of land management over the long term (centuries to millennia) and act over large areas (>1 km^2) shape the range of possible habitat conditions in a watershed (Naiman et al. 1992). Examples of independent controls are geology, climate, and watershed size (Figure 1).

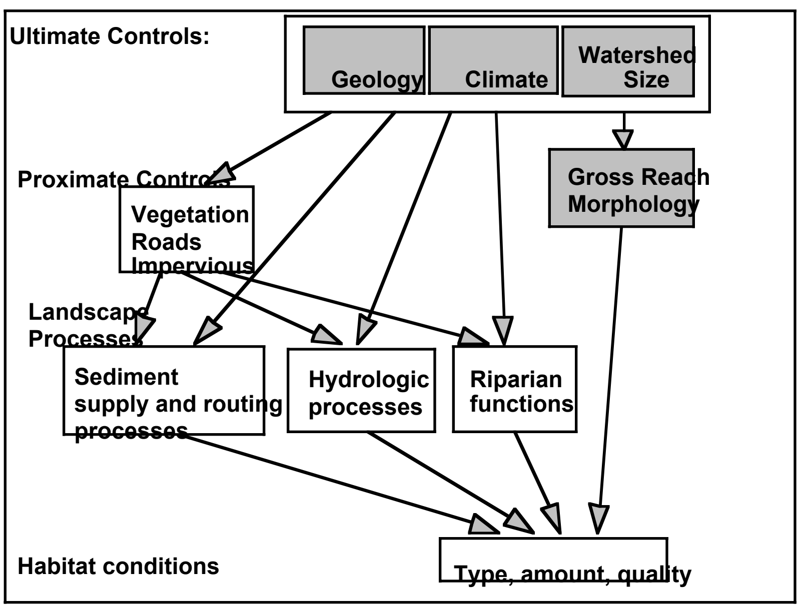

Figure 1. Flow chart depicting interactions between watershed controls and processes[4] resulting in physical habitat conditions. Shaded boxes represent components that are not influenced by land and resource management while unshaded boxes represent components that are influenced by land and resource management (adapted from Beechie 1998).

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[3] Words shown in italic print throughout this report are defined at the end of this report to clarify their specific use.

[4] Pathways for water quality and nutrient cycling are not depicted in this flow chart. However, these processes are important in river basin level restoration and are discussed in Section 3.1.2.

Watershed controls that are affected by land management over the short term (decades or less) act over smaller areas than independent controls, and are partly a function of independent factors (Naiman et al. 1992). Landscape processes create and maintain salmonid habitats streams. They are typically measured as rates, and characterize what ecosystems or components of ecosystems do. For example, sediment or hydrologic processes in a watershed may be characterized by the rates (volume/area/time period) at which sediment or water is <u>delivered to</u> (also referred to as supply) and <u>routed through</u> (also referred to as transport) specific locations of a watershed. Some riparian related processes can be viewed similarly. For example, large woody debris (LWD) "recruitment" is synonymous with the idea of supply while LWD "depletion" is the result of both transport and storage. Natural rates of landscape processes are here defined as those that existed prior to widespread timber harvest, agriculture, or urban development.

We recognize that land use and resource management activities influence natural landscape processes, which result in changed habitat conditions (Figure 1). Therefore, restoration and protection actions should be directed at the habitat-forming process instead of attempting to build specific habitat conditions. Focusing actions on "building" habitat for specific species may be to the detriment of other species and may not be sustainable due to potential conflicts with natural processes.

Restoration and protection actions guided by this goal should

- protect and restore habitat for all salmonid species as well as other native aquatic and riparian dependent species,
- be consistent with *ecosystem management*, and
- be adaptable to new developments in science and restoration technology.

3. SCIENTIFIC FRAMEWORK AND PROCEDURES FOR SCREENING AND PRIORITIZING VOLUNTARY RESTORATION AND PROTECTION PROJECTS

This part of the strategy provides the SWC with criteria for determining whether protection and restoration actions are consistent with the restoration goal (section 3.1), and for determining their priority relative to other proposed actions (section 3.2). It also describes an approach to monitoring of restoration or protection projects (section 3.3), and provides procedures for implementing screening and prioritization (section 3.4 -- currently an incomplete section).

3.1. IDENTIFYING APPROPRIATE ACTIONS: THE INITIAL SCREEN

Land and resource management activities influence natural landscape processes, thereby causing changes to stream habitats. In general, the SWC should support actions that propose to restore or protect these controls and processes. Most often, identification of these controls or processes requires application of watershed analysis[5] concepts.

In the case of degraded habitat conditions, we want to correctly identify and restore the process (or processes) most responsible for altered habitat conditions. For relatively intact habitat, we want to identify and protect from human disturbance the process (or processes) most likely to disturb habitat in the future. In watersheds where many processes are disturbed, multiple restoration action types and locations may be identified. In these cases, we need to know enough about each disturbed process to determine if there is a logical order for completing restoration actions. For example, it would not be wise to attempt restoration of degraded riparian processes in a stream reach where sediment supply is so elevated that riparian treatments cannot be established. Conversely, we need to know when it is reasonable to initiate work on a downstream reach when upstream processes are only mildly disturbed.

For these reasons, we identified "generalized" habitat types for which we are able to identify threshold values for major disturbance types. These thresholds can be used to evaluate whether proposed restoration or protection actions are consistent with the goal and are likely to succeed. Generalized habitat types are described in the next section (Section 3.1.1), followed by a discussion of disturbance types in Section 3.1.2. Together, these discussions provide the basis of whether a potential project is consistent with our goal (shown in tables by project types in Section 3.1.3).

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[5] In this paper, we refer to "watershed analysis" as a scientific framework where the analyst strives to identify:
- natural landscape processes active in a watershed
- effects of land use on natural processes, and
- causal relationships between land use and habitat conditions.

We are not necessarily referring to the formal Washington State Watershed Analysis or Federal Ecosystem Analysis methodologies.

3.1.1 Generalized Habitat Types

The importance of identifying generalized habitat types for watershed restoration is illustrated by Frissell (1993) and Doppelt et al. (1993), where examples of habitat types are listed along with their biotic objective and restoration tactics. To apply this concept in the Skagit and Samish River basins, we derived generalized habitat types based on simple correlations between our understanding of anadromous fish life history strategies and reach level habitat types (approximately 10^2 to 10^4 meters in linear scale). We assume that relationships between fish life stages and habitat for each indicator species analyzed adequately identifies the "habitats to which salmonid stocks are adapted" in an effort to be consistent with our goal stated in Section 2. Our analysis used five species and four life stages to determine generalized habitat types (Appendix 1). Classification systems described in Hayman et al. (1996), Montgomery and Buffington et al. (1997), Peterson and Reid (1984), and Simenstad (1983) were used to define the different reach level habitat types.

Under pristine habitat conditions (i.e., natural disturbances only) we define reach-level habitat types for anadromous fish as either key or secondary (Table 1, column 4). *Key* habitat is critical[6] for at least one life stage combination considered, or is a preferred type by the majority of life stages considered. *Secondary* habitat does not provide critical habitat for any life stage combination considered and is not a preferred type by the majority of life stages considered.

Under disturbed habitat conditions (i.e., both human and natural disturbances) we designated reach-level habitat types as important, degraded, or isolated depending on the degree and type of disturbance (Table 1, columns 2 and 3). *Important* habitat is a disturbed key habitat that still provides significant amounts of production for most life stages considered. *Degraded* habitat is key habitat that is disturbed to such an extent that it does not have significant production or is not preferred by the majority of life stage combinations considered. *Isolated* habitat is not used by anadromous salmonids (no direct biological function) because it is disconnected through anthropogenic blockages such as dikes, tidegates, or impassable road crossings.

Application of the above criteria to the Skagit and Samish River basins yields a mosaic of reach-level habitat patches requiring a range of different restoration tactics. Key habitat should be protected. Both important and degraded habitat should be restored. Isolated habitat should be reconnected. The types of restoration actions needed are dependent on the type and degree of disturbance.

Secondary habitat will not be targeted for restoration under this strategy. That is, we do not intend to "restore" secondary habitat to key habitat. However, it is important to

[6] That is, required for the persistence of a life history type (e.g., estuary rearing chinook).

understand how secondary habitat functions in a watershed in order to protect or restore the other habitat types. For example, the source of degradation may originate in

Table 1. Designation of generalized habitat types based on habitat/species matrix in Appendix 1.

Reach Level Habitat Type	if "disconnected" (human caused)	if "disturbed" (human caused)	if "relatively intact" (pristine)
Tributaries Reaches (channels < 50 meters bankfull width):			
pool riffle	isolated	degraded - important	key
forced pool riffle	isolated	degraded - important	key
plane bed	isolated	degraded	secondary
step-pool/cascade	isolated	secondary	secondary
Main River Reaches (channels > 50 meters bankfull width):			
main channel	isolated	degraded - important	key
off-channel habitat (e.g., ponds, sloughs, side channels, oxbow lakes, etc.)	isolated	degraded - important	key
Estuary:			
estuarine emergent marsh	isolated	unknown[a]	key
blind channel	isolated	unknown[a]	key
subsidiary channel	isolated	unknown[a]	key
main channel	isolated	unknown[a]	key

[a] Our present knowledge does not detect a difference in fish use from estuarine habitats that are relatively undisturbed.

secondary habitat (i.e., the idea of contributing critical areas, discussed in Frissell 1993). in such cases, restoration of processes in secondary habitat areas may be required in order to restore degraded or important habitats that were historically key habitats.

3.1.2 Diagnosis of human caused disturbance

This section discusses human disturbances to landscape processes, and focuses on those disturbances which are likely targets for protection or restoration actions in the Skagit and Samish River basins. We propose threshold levels of disturbance for each process in order to (1) help identify the appropriate process or processes in need of protection or restoration, and (2) evaluate whether restoration is likely to succeed (and therefore should be initiated) in areas where multiple processes are disturbed. Data needs and interim measures for determining the degree of disturbance to processes in the Skagit and Samish River basins are listed in Section 4.

<u>Hydrology</u>

An altered hydrograph may preclude the success of other restoration projects designed to restore habitat conditions for salmonids and other aquatic and riparian dependent species. Reduction of stream flows as a result of surface or groundwater withdrawals can have serious effects on the quantity and quality of aquatic habitat. Withdrawals may not only alter such habitat characteristics as wetted area, depth, and velocity, but may also result in increased fish stranding, higher water temperature, or reduced oxygen and food.

Reduced peak flows as a result of flood control measures change a channel's ability to create and maintain the suite of diverse floodplain habitats to which aquatic species are adapted (Ward and Stanford 1995, Peterson et al. 1992). Increased peak flows result in an increased frequency of channel forming and bed mobilizing flow events, leading to channel destabilization (widening, aggradation, or incision), less complex habitat, and increased bed scour depths significantly affecting salmonid and other aquatic organisms (e.g., Booth and Jackson 1997, Moscrip and Montgomery 1997, Lisle 1989).

The Skagit and Samish River basins are comprised primarily of forested mountain drainages, with fewer lowland drainages (low topographic relief and low elevation). The hydrographs of most low-elevation forested drainages in the Samish and western Skagit basins are dominated by autumn and winter rainfall floods (Beechie 1992). The hydrographs of high elevation drainages in the eastern Skagit basin are typically dominated by spring snowmelt floods. Most areas of the Skagit basin are of intermediate elevation and exhibit both rainfall and snowmelt floods. Lowland basins in the Skagit and Samish Rivers are generally located in the lower valley (rain dominated) and are usually more highly developed by urban and agricultural land use than the forested mountain basins (Lunetta et al. 1997).

<u>Increased Peak Flow in Lowland Basins</u>: Booth and Jackson (1997) showed that altered hydrology is a primary cause of degraded habitat conditions for channels in lowland basins of King County, Washington. When the 2 year flood magnitude under current land use conditions equaled or exceeded the 10 year flood magnitude under "forested" watershed conditions, channels were consistently observed to be degraded. They also found that *impervious area* was a surrogate for identifying degraded streams. Watersheds with impervious area greater than 10% always corresponded to degraded channels and impervious area ≤ 3% corresponded to "exceptional species and habitat diversity and abundance, when compared to aquatic and terrestrial systems of similar size and structure elsewhere in the region (Booth and Jackson 1997)." Other recent studies have also found that indices of urbanization are correlated with disturbed hydrology, degraded habitat conditions, and lower salmonid populations (May 1996, Moscrip and Montgomery 1997).

For lowland basins, we propose using impervious area to evaluate disturbances to the hydrologic regime since hydrologic records are not readily available. Reaches with watershed impervious area ≤ 3% are considered "functioning" with respect to hydrology. Moderately impaired areas have impervious area between 3% and 10%. Impaired areas have impervious area greater than 10%. We would not support restoration of other processes in channels downstream of a basin with > 10% impervious area without evidence that the proposed work will not fail due to increased peak flows.

<u>Increased Peak Flow in Forested Mountain Basins:</u> Human induced causes of increasing peak flows in forested mountain basins are usually related to commercial forestry

practices (the dominant land use in these basins). Two common causes of increased peak flow are hydrologically immature vegetation and forest road drainage (e.g., Montgomery 1993, Washington Forest Practices Board 1995). Hydrologically immature vegetation is that which has relatively low canopy density in winter, allowing increased snow accumulation and melt. Forest road ditches extend the channel network, resulting in more rapid routing of water to main stream channels. As in Washington Forest Practices Board (1995), we assume channels are "degraded" in forested mountain basins when the 2 year flood magnitude under disturbed conditions equals or exceeds the 5 year flood magnitude under natural conditions. (We also note, however, that this threshold is somewhat arbitrary and may vary from location to location.) In general, we would not support restoration of other processes in channels classified degraded without evidence demonstrating that the proposed work will not fail due to increased peak flows.

Decreased Flow in Forested Mountain and Lowland Basins: Where dams or water withdrawals affect the hydrograph, we propose using the Range of Variability Approach (RVA, Richter et al. 1997) to assess whether low stream flows and floods have been reduced to a point such that restoration efforts may be compromised. The RVA methodology proposes that natural stream hydrographs be evaluated empirically, or through synthesized models, and then compared to current instream flow records. RVA results are generally used to set flow management targets, but here we recommend its use for evaluating whether restoration efforts not directed at restoring disturbed hydrology will fail or succeed.

To evaluate low flow disturbance we focus on the annual 7 day minimum flow, which is the average flow during the seven days of lowest consecutive flow each year. Changes of greater than one standard deviation from this average would constitute an unacceptable level of lowering stream flow. Therefore we would not support restoration of other processes in these channels without evidence that the proposed work will not fail due to reduced low flows.

To evaluate lowering peak flow magnitude and frequency, we focus on the annual peak flow, which is the highest daily flow each water year. Changes of greater than one standard deviation from this average would constitute an unacceptable level of change in peak flow magnitude and frequency. Therefore we would not support restoration of other processes in these channels without evidence that the proposed work will not fail due to reduced peak flows.

Sediment

Most of the supply of sediment to stream channels in forested mountain basins is generated by three types of processes: mass wasting (landsliding), surface erosion, and soil creep (see Paulson 1997 for review). Mass wasting and surface erosion can be significantly affected by forest management activities, whereas forest management effects on soil creep have not been measured. Forest management effects on mass wasting have the greatest effect on the supply of coarse sediment to stream channels because much of the sediment produced by mass wasting is > 2 mm diameter (Paulson 1997), although fine sediments (< 2 mm diameter) are also delivered by mass wasting. By contrast, surface erosion produces mostly fine sediment with virtually no contribution of coarse sediment (Paulson, unpublished data). Finer sediments from surface erosion and mass wasting tend to be transported through the stream network as wash load and suspended load (Beschta 1987), having relatively little effect on channel morphology compared to the effects of coarser bed load. Sediment > 2 mm diameter tends to travel as bed load, and has relatively large effects on channel morphology as it moves through the network at the rate of a few hundreds to a few thousands of meters per year (Madej and Ozaki 1996).

Sediment that is supplied to stream channels by mass wasting is either stored in or transported through the stream network. An understanding of how sediment is routed through the network is important for determining where sediment will have the greatest effect on salmonid habitat, and for determining which areas of potential mass wasting have the greatest likelihood of affecting habitat. From field data, one can gain an understanding of how sediment is stored or routed through different parts of the stream network in a watershed. In general, field data for this type of assessment include documenting the volumes (based on field measurements) and timing (based on aerial photo interpretation) of stored sediment, as well as the particle sizes of stored sediment in different types of storage sites (e.g. channel bed, bars, flood plain). These data can then be used to interpret where sediment is stored in the channel network, and what sizes of sediment are transported through various stream segments.

Changes in the sediment supply to stream channels have several effects on salmonid habitat characteristics, including effects on the habitat capacity of the stream and effects on salmonid survival (e.g., Collins et al. 1994, Chapter 6). Large increases in coarse sediment supply tend to fill pools and aggrade the channel (e.g., Lisle 1982), resulting in reduced habitat complexity and reduced rearing capacity for some salmonids (e.g., Collins et al. 1994). Large increases in total sediment supply to a channel also tend to increase the proportion of fine sediments in the bed (Dietrich et al. 1989), which may reduce the survival of incubating eggs in the gravel and change benthic invertebrate production.

Sediment supply in forested mountain watersheds typically averages less than 100 $m^3/km^2/yr$ from mass wasting (Sidle et al. 1985), although a few watersheds may have forested rates exceeding 100 $m^3/km^2/yr$ (Paulson 1997). Because the lower sediment supply rate is common in the majority of forested watersheds, we assume that it represents the natural rate of sediment supply in watersheds of the Skagit River basin. Therefore, the diagnostic for distinguishing areas of high (or disturbed) sediment supply from those of low (or natural) sediment supply is the average annual rate of sediment supply (estimated by constructing a sediment budget[7]). Where sediment supply is less than 100 $m^3/km^2/yr$, the habitat in all downstream reaches is considered to be "functioning" with respect sediment supply. Where sediment supply exceeds 100 $m^3/km^2/yr$, we consider all downstream habitats to be "impaired" with respect to sediment supply. For these cases, (1) sediment supply in the watershed should be restored to "functioning" levels before downstream reaches are worked on, or (2) evidence should be presented demonstrating that the basin's current sediment supply rate does not exceed its estimated "natural" rate, or (3) evidence demonstrating that the proposed work will not fail due to increased sediment supply should be presented.

In lowland basins, mass wasting is not a dominant sediment supply process. Increased fine sediment supply to channels are directly related to urban, livestock grazing, and agricultural land use. We assume that increased sediment supply in these basins can be corrected when restoring riparian, hydrologic, or floodplain processes. Although we have no diagnostic threshold for fine sediment, we anticipate that the index of biotic integrity (described on page 14), will adequately assess locations where fine sediment significantly affects aquatic biota.

Riparian

Late-seral forest conditions occupied a large proportion of the Pacific Northwest landscape prior to Euroamerican settlement, and salmonid stocks were healthy and diverse at that time (Peterson et al. 1992). Therefore, in developing diagnostics that help distinguish between key, important, and degraded habitats, we assume that salmonids are adapted to stream conditions found in late-seral forests. This assumption is supported by an extensive body of literature demonstrating the importance of riparian forest functions for salmonid populations. For example, changes in riparian forest conditions produced by fire, stream bank erosion, or forest management can alter large woody debris (LWD) recruitment to streams, which in turn alters the habitat characteristics of streams (e.g., Bilby and Ward 1991). Loss of riparian forests reduces potential LWD recruitment for several decades (Bilby and Ward 1991), leading to declining LWD abundance in the first few decades and sustained low LWD abundance between 50 and 100 years after the disturbance (Murphy and Koski 1989). A change in LWD abundance alters fish habitat characteristics such as pool spacing, pool area, and pool depth (Montgomery et al. 1995, Beechie and Sibley 1997, Abbe and Montgomery 1996), and this alteration of habitat

[7] Diagnostics of high sediment supply in the channel are more difficult to identify. Residual pool depth is arguably one of the most sensitive indicators of high sediment supply (e.g., Lisle 1982), yet there are currently no published studies that show landscape-level patterns of residual depth as a function of sediment supply. Also, other variables, such as obstruction height of pool forming LWD influence the residual depth of pools (e.g., Hansen Watershed Analysis 199, Beamer et al. 1998). However, Nelson (in preparation) shows that reaches in basins with high sediment supply tend to have shallower pools than reaches in basins with low sediment supply. Pool depths in these high supply reaches are typically within the range of variability of pool depths in low supply reaches, but the depths are all near the low end of the range. Analysis of the data are not yet complete, so residual depth is not yet useful as a diagnostic in this strategy. However, final analyses are due in 1998.

characteristics causes changes in the salmonid carrying capacity of a stream (e.g., Hicks et al. 1991).

Our quantitative criteria for diagnosing riparian forest conditions in non-migrating channels is based on data collected in watersheds with late-seral riparian forests. Non-migrating channels are those where the historic riparian forest characteristics would reflect a non-fluvial disturbance regime (e.g., fire). Riparian characteristics for migrating channels are included in the following section related to floodplains.

Montgomery et al. (1995) showed that 96% of stream reaches with channel slope ≤ 4% in late seral forests (old growth) had LWD abundance greater than 0.4 LWD/m, with a median value of 0.8 LWD/m (Figure 2). Because low gradient (≤ 4%) channels with >0.4 LWD/m typically have the forced pool-riffle morphology (Montgomery et al. 1995), we can also say that 96% of low gradient late-seral reaches have the forced-pool riffle morphology that salmonids favor (i.e., "key" habitat designation in Table 1). We then assume that late-seral forests produce the distribution of LWD abundance shown in Figure 2, and that any riparian forest with a lower potential recruitment will produce a proportionally lower LWD distribution.

When a riparian forest is able to produce more than 80% of the potential late-seral LWD, we can say that it is likely to produce a LWD distribution that will result in 76% forced pool-riffle (or 24% plane bed) channels over the long term (Figure 3). Forested buffers of 40 meters or more (each side) are capable of producing 80% or more of the potential late-seral recruitment, so streams with forested buffers greater than 40 meters wide are considered "functioning" habitat for LWD recruitment (Figure 4). When the riparian forest can produce 50% to 80% of the potential late-seral recruitment (i.e., buffer width between 20 and 40 meters), riparian functions are considered to be "moderately impaired". At buffer widths less than 20 meters, riparian functions are considered "impaired" (Figure 4).

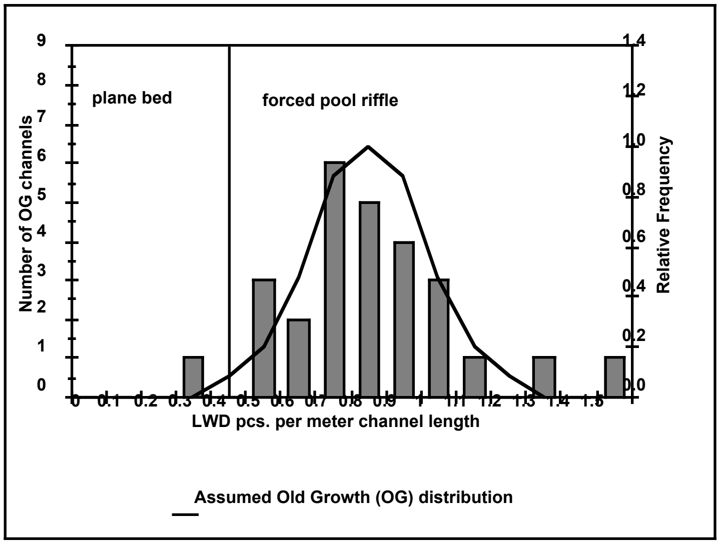


Figure 2. Frequency distribution of large woody debris pieces per channel length (LWD/m) for low gradient channels in old growth forest (gray bars). Heavy line represents a normal distribution approximating the frequency distribution of LWD/m. Data from Montgomery et. al. (1995).

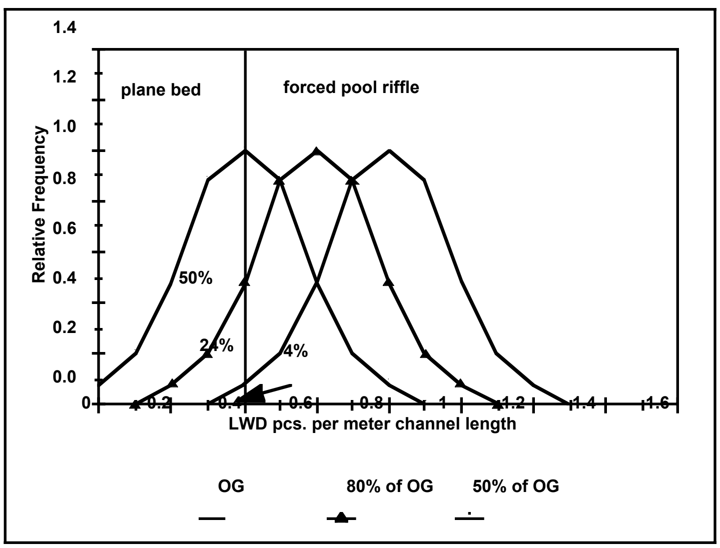


Figure 3. Relative frequencies of channels that exhibit plane bed or force pool riffle morphology under old growth (OG), 80% of old growth, and 50% of old growth forest conditions.

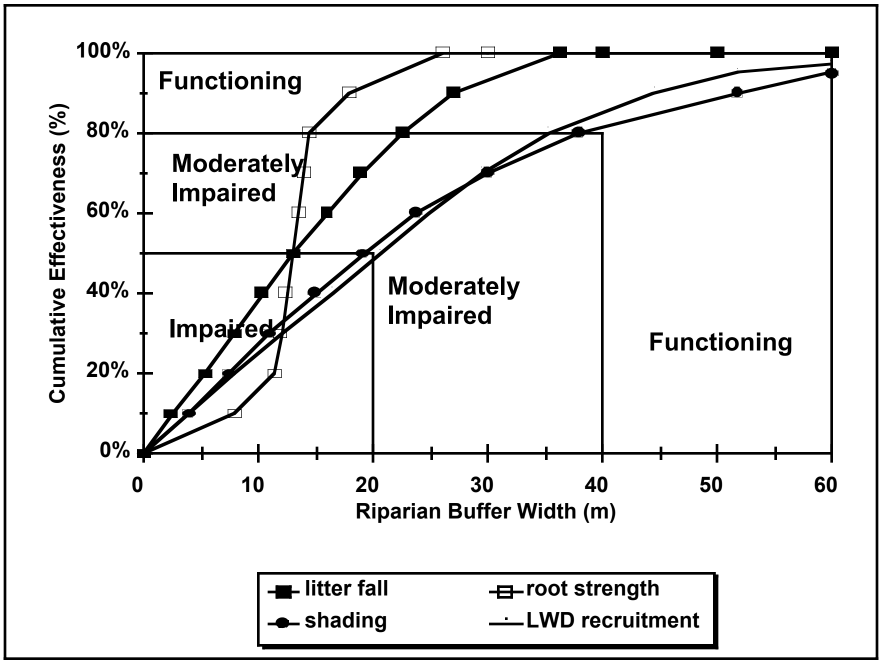


Figure 4. Designation of riparian functions for non-migrating channels based on riparian buffer width using stand characteristics of 200 year old Douglas Fir under site II growing conditions (curves modified from Forest Ecosystem Management Assessment Team 1993).

All actions that protect and restore riparian processes are considered consistent with our goal and likely to succeed if (1) watershed level processes (hydrology or sediment) influencing the reach are not considered "degraded" or (2) watershed level processes considered "degraded" are restored simultaneously.

Floodplain

Floodplain modification is a disturbance type related to hydrology, sediment, or riparian processes. That is, disturbed floodplains change a stream reach's ability to supply, transport (convey) or store one or more of the inputs water, sediment, and wood. For example, a floodplain disturbance such as a levee may prevent channel avulsion during peak flows (a natural hydrologic event) which creates and maintains off channel habitat (one of our "key" habitats, Table 1). Stream bank hardening (hydromodification) will prevent channel migration reducing LWD recruitment and bank erosion. Hydromodification typically narrows and steepens channels increasing both sediment and water transport rates.

All actions that protect and restore floodplain areas are considered consistent with our goal and likely to succeed, if (1) watershed level processes (hydrology or sediment) influencing the reach are not considered "degraded" or (2) watershed level processes considered "degraded" are restored simultaneously.

(**This section is not complete.** We still need to determine what level of disturbance constitutes "impaired" and "functioning" floodplain processes, including the riparian forest functions within channel migration zones. Hayman et al. (1996) showed that mainstem channels dominated by hydromodification exhibited less diversity in edge habitat types and less edge habitat area than non-hydromodified reaches. Analysis of Skagit System Cooperative's hydromodification inventory of the main channel reaches of the Skagit River basin may provide the basis for identifying threshold levels of this disturbance.)

Isolated habitat

Isolated habitat is disconnected from existing aquatic habitat utilized by anadromous salmonids. Habitat is isolated through anthropogenic blockages such as dikes, tidegates, or impassable road crossings. Therefore, restoration actions that remove these blockages are considered consistent with our goal and likely to succeed, if (1) watershed level processes (hydrology or sediment) influencing the reach are not considered "degraded" or (2) watershed level processes considered "degraded" are restored simultaneously.

Water quality

Water quality is an important factor affecting the health and productivity of salmon in the Skagit River basin. Numerous land use practices contribute to water quality degradation, and the success of future salmon habitat restoration efforts in the basin depends partly on the success of efforts to identify and address the sources of water quality problems. While comprehensive water quality data for the Skagit River basin is limited, particularly in the upper basin, recent water quality investigations in the lower basin (Entranco 1993; DOE 1997; Bulthius 1993) document significant water quality problems in the mainstem of the Skagit River as well as its tributaries and sloughs. A number of streams and sloughs in the Skagit River basin contain segments with 303(d) listings due primarily to fecal coliform, temperature, and dissolved oxygen standard violations.

Some of the key findings of the recent water quality studies include: 1) Violations of water quality standards for temperature and dissolved oxygen throughout the lower Skagit River basin, primarily in tributary creeks and sloughs. Results point to the South Fork Skagit River as a critical location for DO problems in the river. (Entranco 1993 and DOE 1997); and 2) Widespread violations of water quality standards for fecal coliform bacteria and turbidity in streams tributary to the lower Skagit River, in the North and South Forks, and in the sloughs (Entranco 1993 and DOE 1997).

In addition to point sources of pollution such as discharges from sewage and water treatment plants, nonpoint sources of pollution in the basin include agricultural practices, forest management activities, urban runoff, highway runoff, inadequate septic systems, landfills, wild animals and birds (DOE 1997; Entranco 1993). In this section, we provide further discussion of potential sources of water quality problems in the basin, and explain the screening methods we will use to identify problems that may limit or preclude successful salmon restoration efforts.

We base these initial watershed-level screens on the dominant land uses in the basin - agriculture, urbanization, forest management, and rural/residential - recognizing that more refined screens will likely be needed on a reach-level basis as individual projects are studied for feasibility. Proactive efforts to address water quality problems in the basin will be discussed in the Action Plan portion of the Strategy.

Background: Agricultural Lands

Agricultural impacts on salmonid resources in western Washington are primarily related to habitat loss or degradation due to land use conversion, diking and ditching, impacts of grazing on streambanks, loss of riparian vegetation, sedimentation of streambed from cropland erosion, and nonpoint source pollution from various agricultural practices such as animal waste management and fertilizer/pesticide application (Palmisano 1993). Animal management practices that contribute to nonpoint source pollution include improper pasture management, direct livestock access to streams and ditches, and improper waste management (SBWMC 1995). Crop farming practices that contribute to water quality problems include tilling too close to ditch banks, lack of vegetative winter cover, late season v-ditching for drainage, and improper application of agricultural chemicals (SBWMC 1995). A limited number of studies in the Puget Sound area have shown that the primary water quality effects of dairy waste are reduction in dissolved oxygen; increases in ammonia, nitrate, and phosphate; and increased turbidity, total suspended solids, and coliform bacteria (Palmisano 1993). Excessive stream temperatures is another potential side effect of agricultural production due primarily to removal of riparian vegetation, return flows from irrigation, and ditching. Information on the impact of fertilizer and pesticide runoff from agricultural lands in aquatic habitats of western Washington is limited in part because of the high cost of sampling and analysis for these potentially toxic compounds. Conversely, the relative abundance of information on parameters such as dissolved oxygen, temperature, bacteria, and pH is due in part to the relative ease and low expense of sampling and analysis for these parameters.

In the Skagit River basin, agriculture is a critical part of the area's economy and one of the principal land uses, particularly in the lower basin. The area produces a wide variety of commercial crops and is one of the major dairy producers in the state with more than 60 commercial dairy farms and more than 90,000 acres designated for agricultural use in Skagit County (Skagit County 1997). Results from the limited number of investigations in the lower Skagit River basin mentioned above indicate that dissolved oxygen and temperature are the two best documented water quality parameters that: 1) have likely been impacted by agricultural practices and land use conversions; and 2) may be limiting salmonid productivity in the lower Skagit River basin. Excessive stream temperatures and low oxygen levels can be fatal to salmonids, particularly during sensitive life stages. High levels of fecal coliform bacteria are also common in the agriculturally dominated lower basin. While bacteria by itself is not likely a factor for decline of salmonids, it is better used as an indicator of nutrient enrichment to the ecosystem from agricultural and domestic sources. These sources include confined animal feeding operations, dairy waste management, cattle grazing and watering, as well as domestic sources such as failing septic systems and sewage discharges. The same practices that have led to the bacteria standard violations may be causing other water quality problems such as increased fine sediment deposition in streams in agricultural areas. Animal waste can be a source of nutrients that can alter the chemical balance of aquatic systems by increasing algal growth and reducing dissolved oxygen critical to salmonid species (SBWMC 1995). Animal waste also can contain toxic levels of ammonia.

While areas with known water quality problems such as high bacteria levels can be used to identify potentially impaired areas in the agricultural portion of the basin, existing data alone is not sufficient to capture all potential problems. Therefore, we plan to use existing data in combination with land use indicators (see ***Tables 1,2, and 4***) such as locations of dairy farms to help identify areas that may limit or preclude successful habitat restoration efforts. The screening section for agricultural lands below contains further discussion of the screening methods we will employ for identifying water quality impaired areas in the agricultural areas.

Background: Urban/Developed Lands

Major impacts of urbanization upon aquatic habitats for salmonids and other aquatic species include: 1) increases in surface water flow, 2) reduction in infiltration to groundwater, 3) increased risk of water quality degradation, 4) increases in flooding and erosion potential, and 5) habitat degradation and destruction. Impaired water quality conditions due to the effects of urbanization may preclude the success of restoration projects designed to restore habitat conditions for salmonids.

While the sources of water quality problems in urbanized areas are varied and complex, the degree of loading of contaminants into urban streams has been shown to be a function of the percentage of watershed imperviousness (Schueler 1987). In urban streams the higher loadings translate into water quality problems, such as

- Turbid water
- Nutrient enrichment
- Bacterial contamination
- Organic matter loads
- Toxic compounds
- Temperature increase, and
- Trash/debris.

A number of studies have looked at the effects of urbanization on aquatic habitat conditions. The University of Washington, King County Surface Water Management, King County Natural Resources Department, Washington Department of Ecology, the USEPA Region 10 and a variety of others have focused on the effects of urbanization as measured by percent imperviousness upon the physical, biological, and chemical conditions in Puget Sound lowland streams and freshwater wetlands. These investigations have shown significant relationships between watershed conditions and aquatic habitat variables, particularly hydrology (as discussed earlier in the Strategy) and biological communities (i.e., benthic index of biological integrity or B-IBI). Horner et al. (1996) found that physical and biological measures of lowland Puget Sound stream quality "were seen to change most rapidly from levels lightly affected by urbanization as total impervious area increased to 5-8 percent." They concluded that "altered watershed hydrology was at the source of the overall changes observed" (Horner et al. 1996).

With respect specifically to water and sediment quality, Horner et al. (1996) found "water quality measures and concentrations of metals in sediments did not ... change much over the urbanization gradient until imperviousness approached 50 percent. Even then water column concentrations did not surpass aquatic life criteria, and sediment concentrations remained far below freshwater sediment criteria." (Horner et al. 1996). They further concluded that "as urbanization increases above the 60 percent impervious level, with pollutant concentrations rising rapidly at that point, it is likely that the role of water and sediment chemistry will become more important biologically."

In the Skagit River basin, agriculture and forest management are the dominant land uses but commercial and residential development have affected and will continue to affect salmonid resources of the basin, particularly as the population of the area increases. Sedro-Woolley, Mount Vernon, and Burlington are the major population centers in the basin. Recent water quality sampling in the basin documents several potential impacts from urbanization. Heavy metals were detected at various locations at concentrations that exceeded criteria for the protection of freshwater aquatic life (Entranco 1993). The study concluded that "since there are no heavy industrial waste discharges to the Skagit River, highway and urban runoff and landfill sites are the most likely sources of metals contamination" in the lower basin (Entranco 1993). To identify potentially impaired areas of the basin due to these and other sources associated with urbanization, we plan to use impervious surface data as a landscape level screen. However, we recognize that impervious surface data alone cannot capture the many sources of water quality problems in the urbanized areas of the basin. We plan to use existing data in combination with land use indicators (see ***Tables 1,2, and 3***) such as locations of landfills to help identify areas that may limit or preclude successful habitat restoration efforts. The screening section for urban lands below discusses several of these other potential sources.

Background: Forested Lands

In general most water quality impacts to salmonid habitat in the forested areas of western Washington are to water quality parameters such as temperature, dissolved oxygen, sedimentation, streamflow, groundwater recharge, turbidity, and pH. There is a great deal of information on the causes of these water quality impacts, as well as the association between these parameters and salmonid productivity and health (e.g., Salo and Cundy 1987, Meehan 1991). For instance, the association between the removal of riparian vegetation and stream temperatures is well studied, as is the association between stream temperature and salmonid survival and productivity (Hicks et al 1991; Beschta et al., 1987). Excessive stream temperatures and increased sediment supply caused by certain forest management activities (e.g., harvest in the riparian zone, road building, inadequate culvert sizing and erosion control) are important factors affecting salmonid productivity throughout the Pacific Northwest. Some of this information is discussed in previous sections of this document on sediment supply, hydrology, and riparian conditions.

Forested lands dominate much of the Skagit River basin with logging and timber management an important part of the area's history and economy. Forested lands account for nearly a third of Skagit County's total land area of 1.1 million acres (Skagit County 1997). While the disturbances that most likely limit salmon productivity in the forested areas of the Skagit River basin have been discussed elsewhere in the Strategy, we recognize that there are other disturbances such as herbicide/pesticide application and mining operations that may also, in certain circumstances, preclude or limit successful salmon habitat restoration. We plan to use existing data in combination with land use indicators (***see Tables 1,2, and 5***) such as locations of mining operations to help identify areas that may limit or preclude successful habitat restoration efforts. The screening section for water quality impairment in forested lands focuses on these other disturbances.

Background: Rural/Residential Lands

In general, nonpoint sources of water quality pollution associated with rural areas include: agricultural practices on both commercial and small scale farms, residential activities (e.g, use of land and garden chemicals, disposal of pet and household wastes, on-site septic systems, etc.), stormwater runoff, construction activities, and poor harvest and site management of private woodlots (Padilla Bay/Bay View Watershed Action Plan, 1995. The rural/residential land area within the Skagit River basin includes a wide range of land uses including commercial and noncommercial agriculture, commercial or industrial development, private woodlots, low and high density residential development. The majority of land uses and associated water quality problems found in the rural/residential portion of the basin are also found in the other land use categories discussed above. For this reason we will use the land use indicator tables (***Tables 2-5***) developed for the other three land use categories in combination to screen for potential water quality impairment in the rural areas rather than develop a fourth land use table. We recognize that this land use represents a significant portion of the basin as well as an important factor in the cumulative impacts to water quality in the basin.

Screening Methods

Framework Used for Screening

The water quality screen attempts to capture important water quality disturbances in the basin and is consistent with the overall approach of the Strategy to identify and address, if needed, the causes of disturbances that may significantly affect salmon rather than treat only the symptoms. This screen complements other screens in the Strategy such as altered hydrology and sediment supply that deal directly with those important aspects of overall water quality.

The approach uses a combination of existing water quality data and land use information with the understanding that information is often incomplete and determinations will need to be made on a case-by-case basis whether more information is required. ***Figure 1*** summarizes the fundamental approach we use to help determine if a proposed restoration action is advisable with regard to water quality.

In general, proposed projects will be screened to determine if there are existing water quality problems that may significantly impact salmonids at the project location and what may be the most important sources of these problems. The objective here is to encourage projects that will be successful, address the sources of significant problems, and do not expend time, effort, and money where there is little chance of benefit to the habitat-forming processes that support salmon in the Skagit River basin.

Projects determined to be consistent with the goals of the Strategy (for water quality) will, for the most part, fall into one of three categories:

1) water quality data and land use information indicate that there are no significant water quality problems with respect to salmonid health and productivity; or
2) water quality and/or land use information indicate that there are significant problems but that the problems are being addressed or will be addressed in a reasonable time frame; or
3) the proposed project is addressing the source(s) of water quality problems at the project location (e.g., riparian planting) or on the watershed-level scale (e.g., forest road closures).

Projects determined to be inconsistent with the goals of the Strategy with respect to this screen will primarily be cases where:

1) significant water quality disturbances are affecting the site, and
2) neither the project nor other actions are taking place within a reasonable time frame to correct the disturbance.

If a significant water quality problem is found during the screening process, (e.g., excessive in-stream temperatures) it is not necessary that the problem be fully corrected (i.e., stream temperature is lowered) before a restoration action can proceed. Rather, the project may be modified to include actions that improve water quality or information is documented that adequate measures are or will be in place to correct the problem in a reasonable time frame. A reasonable time frame to address water quality problems will have to be determined on a case-by-case basis depending on the nature of the problem(s) and the restoration action proposed. However, a general guide is that the time frame will depend on a reasonable rate of recovery for the specific disturbance based on the best available science. For example, recovery from a point source problem such as a leaking pipe would be expected to be substantially shorter than re-growth of a healthy riparian zone. In the case of the leaking pipe, we would want that corrected before or at the same time as the project. In the case of the restoration site needing a healthy riparian zone, the project could proceed when necessary riparian projects are done.

In terms of data collection for the screen, we recognize that each proposed restoration action may not require the same level of information or scrutiny and that the scale of the screening effort should be consistent with the scale of the restoration action. We also recognize that project proponents in many cases may not be able to conduct the screening investigations that may be needed due to lack of resources or technical ability. It is not the purpose of the screens to make project proponents responsible for addressing water quality problems, but rather simply to identify where these problems may exist and help determine if the problem significantly affects salmon and, ultimately, if the specific restoration action is advisable given the available water quality and land use information.

Criteria Used for Screens

Table 1 summarizes the screen for water quality impairment based on existing water quality data. The screens for water quality impairment based on point sources and land use indicators are summarized below and in ***Tables 2-5***. We recognize that many point sources and land use practices can exist throughout the basin and are not limited to specific geographic areas. For example, agricultural or urban land uses may exist in a largely forested or rural section of the basin. While the screens are developed to provide guides to identifying potential water quality problems wherever they may occur in the basin, we have organized them by general land use categories for simplicity.

In most cases, review and/or collection of water quality data will focus on the following parameters, which are known to have impacts on salmonid health and survival and are relatively easy and inexpensive to measure: temperature, dissolved oxygen, pH, turbidity, and fecal coliform bacteria. Washington state's freshwater criteria for these parameters are shown in ***Table 6***. Many other water quality parameters (e.g., toxic compounds in surface water and sediment, ammonia+nitrate nitrogen, total phosphorous, total nitrogen, total suspended solids) may have significant effects on salmon or be indicative of potential problems. It is the intent of the land use indicators (discussed below and summarized in ***Tables 2-5***) to capture these potential problems that may or may not be captured by existing water quality data. Specific parameters other than the five mentioned above that have state criteria may be a focus of more in-depth screening depending on the restoration action proposed and the information gathered during the initial screening.

Urban, developed, and rural/residential areas

One of the most important land use indicators of water quality degradation for the urbanized areas of the basin is percent impervious area (as discussed above). For initial screening purposes, we assume that areas with less than 50% impervious area have a low likelihood of water quality (i.e., water/sediment chemistry) impairment based on Horner et al. (1996). Where impervious area is between 50% and 60% of the drainage area, water quality is considered moderately impaired. Water quality is considered impaired when impervious area exceeds 60% of the drainage basin. We recognize that the hydrology and biological functioning of streams are likely impaired at much lower percentages of impervious area (i.e., moderately impaired at 3% - 10% impervious area, and impaired at > 10% impervious area). Please refer to the altered hydrology section of this document for more information on this screen. We chose to maintain the distinction between the thresholds for hydrology and water/sediment chemistry in order to more accurately assess the types of potential problems that may hinder the success of restoration actions. For example, we can conclude for a location with 15% impervious area that hydrology and biological functioning is likely impaired but water quality as measured by water and/or sediment chemistry is not. By contrast, an area with 70% impervious area is likely impaired for both hydrology and water quality.

In addition to percent impervious area, we have listed in ***Table 3*** other potential land use indictors of water quality degradation common to the urbanized and/or developing areas of the basin. These include information on known point or nonpoint sources such as combined sewer overflows (CSOs), NPDES-permitted discharge locations, stormwater discharge locations, landfills or solid waste disposal sites, failing or inadequate septic systems, hazardous waste sites, and golf courses.

For individual project screening as well as for the watershed-level Strategy Application, potential problem areas will be located on maps and used in conjunction with water quality data to determine potentially impaired areas. Where we identify potentially impaired areas, it may be necessary to gather additional water, sediment or biological community quality data (e.g., B-IBI) before the disturbance can be positively identified and addressed. The threshold for the need for additional data collection will depend on the type of project and level of effort proposed, as well as the quality and quantity of the available data. Proactive efforts and recommendations to address sources of water quality degradation in the urbanized portions of the basin will be discussed in the Action Plan portion of the Strategy.

Agriculture

We have not identified a suitable landscape-level screen, such as impervious surface, for the agriculturally dominated areas of the basin, so we intend to use existing water quality data as well as a variety of land use information, including:

- Areas zoned for agriculture production (commercial and non-commercial) in the basin
- Locations of pump stations, drainage ditches, irrigation return flows, and tributaries
- Locations of dairy farms and any associated data on animal units, BMPs, waste management, etc.
- Locations of NPDES discharge locations and associated data
- Agricultural use inventory
- Riparian buffer widths
- Established farm plans in basin, where available.
- Locations of failing septic systems and other sources of organic matter loading.

This screen does not assume that a water quality problem exists simply because a certain land use activity is found adjacent to a project area or habitat. The land use screen is meant as a guide to help determine where potential problems may exist based on known associations (e.g., water quality investigations, published literature, etc.) between certain land uses common to agricultural areas and water quality impacts. As the land use tables indicate, further investigation may be necessary to determine the significance of the water quality impacts and how or if identified problems should be addressed. ***Tables 2 and 4*** provide a guide for identifying water quality impaired areas in the agriculturally-dominated areas of the basin based on land use information.

Forestry

We believe that the methods we have adopted elsewhere in the Strategy to assess watershed and reach level disturbances due to hydrologically immature vegetation, riparian buffer width, streamflow changes, and sediment supply capture most of the disturbances that can cause impaired water quality in the forested areas of the Skagit River system. The riparian screen using stream buffer widths is probably the most useful landscape level screen for the forested areas. Impaired quality is unlikely when forested stream buffers are greater than 40 m (132 feet) wide (Knutson and Naef, 1997). This width is sufficient to protect stream temperature and to filter out virtually all fertilizers or pesticides before they enter the stream. Water quality is potentially moderately impaired when buffer widths are between 20 m (66 feet) wide and 40 m (132 feet) wide. Some fertilizers and pesticides may pass through the buffer to the stream, and stream temperatures may be moderately affected. Water quality is potentially impaired when stream buffers are less than 20 m (66 feet) wide. Stream temperatures may increase significantly and fertilizers or pesticides are likely to reach the stream. Please refer to the riparian, sediment supply, and hydrology screens for further discussion of these major disturbances for the forested portions of the basin.

However, we recognize that there are other disturbances not captured by the riparian buffer, hydrology, and sediment supply screens that may cause significant water quality problems in the forested areas of the basin including highway runoff, hazardous waste spills, inadequate septic systems, mining, landfills, developed recreation areas, etc. Table 5 provides a guide to some of these disturbances and some actions that would be recommended if a proposed restoration project would be affected by these disturbances.

TABLE 1: Screen for Water Quality Impairment based on Water Quality Data

Screening Measure	Response Actions
303(d) Listed Segment or segment proposed for listing	Identify source or possible source of problem; determine need for additional data; determine if problem may significantly limit salmon production; provide information showing significant problem(s) are or will be addressed in reasonable time frame.
Documented exceedance(s) of state water and/or sediment quality standards *	
Sampling data indicates history of low DO, high temperature, or other water/sediment/toxicity problems including fish kills*	
Data indicate no significant problems	Identify adjacent land uses and check response actions in land use tables below; identify specific data gaps and seek upstream data.
No data available	

* Usual water quality parameters include: dissolved oxygen, temperature, pH, turbidity, and fecal coliforms

TABLE 2: Screen for Water Quality Impairment based on Location of Point Sources of Pollution

Screening Measure	Response Actions
Adjacent/downstream from NPDES-permitted discharge location	Review existing water quality data; determine need for additional data; determine if problem may significantly limit salmon production; provide information showing significant problem(s) are or will be addressed in reasonable time frame.
Adjacent/downstream from combined sewer overflow location	
Adjacent downstream from other known point source discharge, incl. stormwater outfall	
Adjacent/immediately downstream of pump station, irrigation/drainage ditch	
Adjacent/immediately downstream of known hazardous waste spill	Water/sediment chemistry may be impaired; sampling for contaminant(s) of concern may be advised to determine significance of problem.

TABLE 3: Screen for Watery Quality Impairment in Urbanized/Developed Areas of Basin Based on Land Use Information

<table>
<tr><th>Screening Measure</th><th>Response Actions</th></tr>
<tr><td>0-10% impervious area</td><td>Refer to altered hydrology screen.</td></tr>
<tr><td>10-50% impervious area</td><td>Assume impaired hydrology and biological functioning and possible degraded water/sediment chemistry conditions. Review existing water quality data; determine need for additional data; determine if problem may significantly limit salmon production; provide information showing significant problem(s) are or will be addressed in reasonable time frame.</td></tr>
<tr><td>50%-60% impervious area</td><td>Assume impaired hydrology and biological functioning and moderately impaired water/sediment chemistry. Project would likely need substantial justification.</td></tr>
<tr><td>>60% impervious area</td><td>Assumed impaired hydrology, biological functioning, and water quality. Project likely not advised unless addressing sources of problem(s) directly.</td></tr>
<tr><td>Adjacent/downstream from landfill/solid waste/hazardous waste disposal site</td><td rowspan="3">Review existing water quality data; determine need for additional data; determine if problem may significantly limit salmon production; provide information showing significant problem(s) are or will be addressed in reasonable time frame.</td></tr>
<tr><td>Adjacent/downstream from golf course/developed recreation area</td></tr>
<tr><td>Adjacent/downstream from area with evidence of inadequate septic system</td></tr>
</table>

TABLE 4: Screen for Water Quality Impairment in Agriculturally Dominated Areas of the Basin by Land Use Information

Screening Measure	Response Actions
Adjacent/immediately downstream of commercial dairy farm	Review existing water quality data; determine need for additional data; determine if problem may significantly limit salmon production; provide information showing significant problem(s) are or will be addressed in reasonable time frame.
Adjacent /immediately downstream of commercial non-dairy farm	
Livestock access to river, tributary, or slough	
Adjacent/immediately downstream of noncommercial farm or livestock for personal use	
Adjacent/downstream from area with evidence of inadequate septic system	
Riparian buffer <20 m wide	Review existing water quality data; determine need for additional data; provide information showing significant problem(s) are or will be addressed in reasonable time frame.
Riparian buffer 20-40 m wide	Assume limited impairment unless significant disturbance identified.
Riparian buffer > 40 m wide	Assume functioning, unless significant disturbance identified.

TABLE 5: Screen for Water Quality Impairment in Forested Areas of Basin based on Land Use
(sediment delivery, hydrology, riparian buffer screened in section 3.1.2)

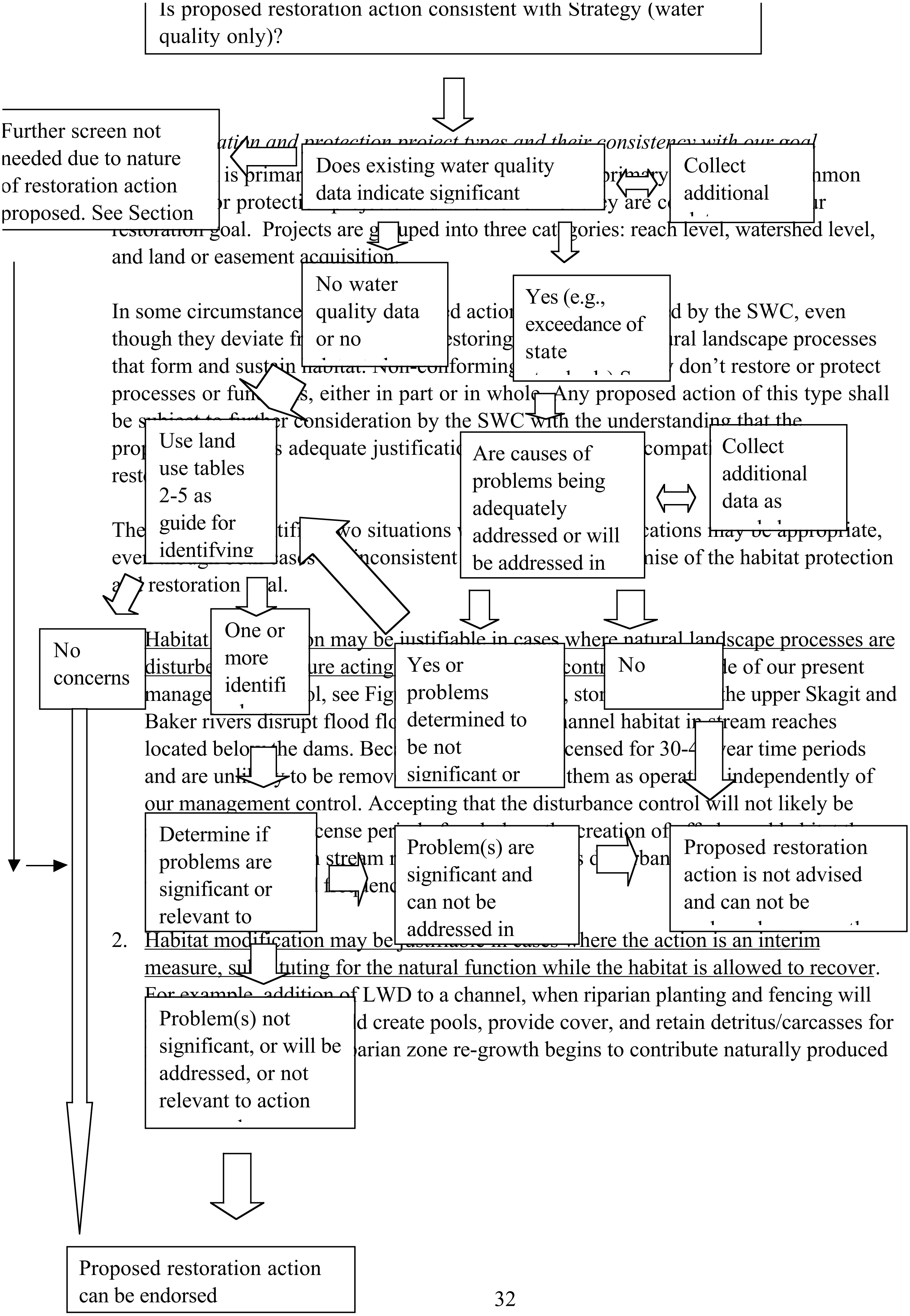
Screening Measure	Response Actions
Adjacent to paved or unpaved road	Check sediment/hydrology/riparian screens and existing water quality data; determine if problem may significantly limit salmon production; provide information showing significant problem(s) are or will be addressed in reasonable time frame. sampling for usual water quality parameters * may be advised to determine significance of problem.
Adjacent/downstream from recent timber harvest/thinning	
Adjacent/downstream from mining or sand/gravel operation (current and/or historic)	
Adjacent/downstream from area with history of intense or recent herbicide/pesticide application	
Adjacent/downstream from area with history of intense or recent fertilizer application	
Adjacent/downstream from area with recent history of prescribed burning or wildfire	
Adjacent/downstream from developed recreation area	
Adjacent/downstream from tributary	Identify land uses adjacent to tributary; determine need for additional data or potential impact based on land use information

* Usual water quality parameters include: dissolved oxygen, temperature, pH, turbidity, and fecal coliforms

Table 6: Washington State Freshwater Criteria for Selected Parameters, Dept. of Ecology

Water Quality Parameter	**Washington Surface Water Criteria: Freshwater**		**Effect on Salmon**
	Class AA	Class A	
Dissolved Oxygen	Shall exceed 9.5 mg/L	Shall exceed 8.0 mg/L	Salmon depend on DO to maintain the metabolic processes that produce energy for growth and reproduction. Salmon prefer waters with consistently high DO concentrations, greater than 7 mg/L.*
Temperature	Shall not exceed 16.0° C due to human activities. When natural conditions exceed 16.0°, no temp. increases will be allowed which will raise the receiving water temperature by greater than 0.3° C	Shall not exceed 18.0° C due to human activities. When natural conditions exceed 18.0°, no temp. increases will be allowed which will raise the receiving water temperature by greater than 0.3° C	Salmon are adapted to live within a specific temperature range. Excessive temperatures can cause a variety of ill effects such as decreased spawning success and death. Optimal range: 6-15 degrees Centigrade.*
PH	6.5-8.5	6.5-8.5	Most aquatic species such as salmon prefer a pH range from 6 to 9, with a narrower range for specific life cycle stages.* Various contaminants are more toxic to salmon at higher or lower pH levels.
Turbidity	Not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10% increase in turbidity when the background turbidity is more than 50 NTU	Not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10% increase in turbidity when the background turbidity is more than 50 NTU	High levels may be indicative of excessive sedimentation from a variety of sources, both natural and man-made. Excessive sediment can have a variety of negative effects including increased mortality of eggs and fry; reduced habitat; and altered food supply.
Fecal Coliform	Organism levels shall both not exceed a geometric mean value of 50 colonies/100 mL and not have more than 10% of all samples obtained for calculating the geometric mean value exceeding 100 colonies/100 mL	Organism levels shall both not exceed a geometric mean value of 100 colonies/100 mL and not have more than 10% of all samples obtained for calculating the geometric mean value exceeding 200 colonies/100 mL	High levels may be indicative of excessive nutrient loading, which can lead to low DO levels and ammonia toxicity.

* U.S. Army Corps of Engineers, 1991



...ation and protection project types and their consistency with our goal

... is primar... primary ... mmon ... r protecti... y are c... r restoration goal. Projects are g... uped into three cat... gories: reach level, watershed level, and land or easement acquisition.

In some circumstance... d action... d by the SWC, even though they deviate fr... estoring ... ral landscape processes that form and sustain habitat. Non-conforming... don't restore or protect processes or fun... s, either in part or in whole. Any proposed action of this type shall be s... r consideration by the SWC with the understanding that the prop... s adequate justificati... compat... rest...

The ... tif... wo situations ... cations may be appropriate, even ... as... inconsistent ... nise of the habitat protection and restoration ... al.

1. Habitat ... n may be justifiable in cases where natural landscape processes are disturbe... ure acting ... contr... le of our present manage... l, see Fig... , stor... he upper Skagit and Baker rivers disrupt flood fl... annel habitat in stream reaches located belo... the dams. Bec... censed for 30-4... year time periods and are unl... to be remov... them as operat... independently of our management control. Accepting that the disturbance control will not likely be ... cense per... creation of ... stream r... s c... ban... frequenc...

2. Habitat modification may be justifiable in cases where the action is an interim measure, substituting for the natural function while the habitat is allowed to recover. For example, addition of LWD to a channel, when riparian planting and fencing will ... d create pools, provide cover, and retain detritus/carcasses for ... arian zone re-growth begins to contribute naturally produced

Reach Level Actions

Reach level actions are those intended to protect or restore processes or function primarily benefiting the reach where work is completed (as opposed to downstream effects). Reach level actions include: floodplain, fish passage, in-channel, and riparian corridor projects.

Floodplain

Objective	Example of Specific Actions	Consistent with Goal?
restore floodplain functions	remove introduced floodplain fill, remove or set back dikes, modify or remove tidegates	yes
speed or aide recovery of habitat conditions prior to disturbance	re-establish channel meanders	need justification demonstrate natural processes will not: • re-establish meanders without help, or • prevent success of project

Fish passage

Objective	Example of Specific Actions	Consistent with Goal?
improve fish passage (develop appropriate depth, velocity, jumps target species and life stages)	• existing facility modification (e.g., culvert baffling, fish ladder, tide gate), • facility (culvert, bridge, tidegate) replacement, • removal of human caused barrier (culvert, dike, tidegate, etc.)	yes
improve fish passage (develop appropriate depth, velocity, jumps target species and life stages)	removal of natural barrier	need justification
improve fish survival by preventing stranding or other types of mortality	screening at diversions	yes (provided that removal of the diversion and withdrawal is not possible)

In-channel

Objective	Example of Specific Actions	Consistent with Goal?
create complex cover for winter rearing or holding adults	LWD introduction, debris bundle introduction, boulder introduction	need justification
create off-channel habitat	off channel development (e.g., excavation)	need justification
create or enlarge pools or mainstem edge habitat	introduce structures (e.g., LWD, boulder)	need justification
energy dissipation -- prevent downstream erosion, allow for riparian recovery	introduce structures (e.g., LWD, boulder)	need justification
increase spawning habitat area	gravel introduction, install sediment retention ponds	need justification
improve egg to fry survival in spawning habitat	gravel cleaning	need justification
bank stabilization (prevent channel migration or reduce bank erosion)	LWD introduction, bank contouring, bioengineering, rip rap or other structural method (e.g. sheet pile)	need justification
reduce sediment supplied to downstream areas	creation of sediment retention ponds	need justification

Riparian

Objective	Example of Specific Actions	Consistent with Goal?
exclude livestock (a human-caused disturbance) from riparian area	install/maintain fencing	yes
speed the recovery of riparian functions	interplanting appropriate conifer species	yes
speed the recovery of riparian functions	plant disturbed riparian areas (e.g., grazed areas, skid trails, landings, cable corridors, hot burned stream side areas)	yes
speed the recovery of riparian functions	planting on flood deposit (high bars) near channels	need justification Demonstrate: • the need to establish riparian forest at site and • that watershed level processes will not prevent success
speed the recovery of riparian functions	planting streamside landslides	need justification
speed the recovery of riparian functions	thin hardwoods to allow for conifer release	need justification

Watershed Level Actions:

Watershed level actions are those intended to protect or restore processes or function benefiting an entire watershed (as opposed to the reach where work is completed). Watershed level actions include those that address disturbed hydrology, sediment, and water quality.

Hydrology

Objective	Example of Specific Actions	Consistent with Goal?
restore natural hydrologic regime	remove impervious surface	yes
restore hydrology to downstream areas	build stormwater retention facility	yes

Sediment

Objective	Example of Specific Actions	Consistent with Goal?
create conditions which allow reveg to occur	decompact road surfaces (ripping)	yes
prevent failure via concentration of run-off	outsloping roads	yes
prevent failure via concentration of run-off	waterbarring roads	yes
removal of potential sources of failure	remove culverts	yes
removal of potential sources of failure	remove or reconfigure unstable fills	yes
speed recovery of normal surface erosion level for forested areas	seeding and planting native vegetation on disturbed areas	yes
armor against surface erosion and design drainage against traffic impacts	rocking road surface	yes
prevent failure via concentration of run-off	Reroute road drainage to stable receiving areas	yes
prevent failure via concentration of run-off	correct stream diversion potential at stream and road intersections	yes
prevent failure via concentration of run-off	correcting concentrated road drainage	yes
prevent failure via concentration of run-off	relieving inboard ditchlines more frequently	yes
removal of potential sources of failure	remove or reconfigure unstable fills	yes
removal of potential sources of failure	upgrade stream crossings to pass 100 yr streamflow and associated bed load and debris	yes
speed the recovery of erosion prone surfaces with the potential to deliver	revegetating bare road cuts and fills	yes
prevent logging or development of landslide-prone areas	map hazard areas, identify prescriptions needed to avoid increased mass wasting	yes
reduce sediment supply by speeding recovery of mass wasting site	plant streamside landslides	need justification,

Water quality

Objective	Example of Specific Actions	Consistent with Goal?
reduce dairy waste		yes
reduce septic tank waste		yes

Land acquisition and easements

Objective	Example of Specific Actions	Consistent with Goal?
prevent further human disturbance to existing habitat, allow passive recovery to occur	acquisition of fee simple lands	yes
prevent further human disturbance to existing habitat, allow passive recovery to occur	acquisition of less than fee simple interests in land (e.g., timber rights, conservation easements)	yes

3.2. PRIORITIZING APPROPRIATE ACTIONS

This section is intended to guide the SWC in prioritizing proposed actions that are determined to be "appropriate" in the previous screening step. Proposed restoration or protection actions needing prioritization include all projects enacted in the Skagit and Samish River basins, especially those projects seeking SWC funding. Projects seeking SWC funding are prioritized in order to rank projects by cost-effectiveness, which then determines which projects receive funds when the cost of proposed projects exceeds available funds. Other projects are ranked by cost-effectiveness simply to provide the SWC with information on types of projects most commonly enacted and their relative cost-effectiveness. This information will be used in monitoring the long-term progress of restoration efforts in the Skagit and Samish River basins.

3.2.1 Prioritization method

Cost effectiveness is the primary basis for prioritizing restoration and protection projects. The benefit unit used in our determination of cost effectiveness is the area of the generalized habitat types affected by the project, with relative value rankings based on the relative importance of each habitat type for salmonid production (Section 3.1.1, Table 1). Cost effectiveness is applied to three categories of projects: (1) reach level projects, (2) land and easement acquisition projects, and (3) watershed level projects. We propose evaluating three different categories separately because past efforts suggest that combining a wide range of project types may bias benefit estimates, thereby misrepresenting true priorities (e.g., Beamer et al. 1994).

(**Note:** This means the SWC will have to set priorities on how much to emphasize each category in their total budget or work load.)

Reach level projects

The basic cost-effectiveness equation for reach level projects is:

$$\text{cost-effectiveness} = BT/C,$$

where B is the benefit, T is the time over which the benefit is accrued, and C is the cost[8] of the project.

Benefit (B) calculations first require that we have a rating of the Value (V) of habitats in a reach. The tentative ratings by habitat type are: Isolated = 0, Secondary = 1, Degraded = 1, Important = 2, and Key = 3. Benefit (B) is calculated as a change in numeric habitat type rating (ΔV), multiplied by the area of the reach level habitat types (Table 1) affected by the project (A):

[8] It should include cost for the initial project, annual operation and maintenance, and monitoring.

$$B = \Delta V * A.$$

If a project will change a habitat from one type to another, it's ΔV is V_{future}-$V_{present}$. For example, a culvert replacement that reconnects an isolated important habitat has

$$\Delta V = 2 - 0 = 2.$$

Improvement of a degraded habitat to an important habitat would have

$$\Delta V = 2 - 1 = 1.$$

We tentatively propose that projects making some improvement in a habitat but not changing its type receive a ΔV of 0.5. This rating is used where a project affects an entire stream reach, but does not change a diagnostic rating from "impaired" to "moderately impaired." For example, fencing and planting a riparian buffer area out to 30 feet (about 10 m on Figure 4) will not change the riparian rating from impaired to moderately impaired, but the action restores some of the riparian functions.

Where a project only affects part of a reach, the area of a project is only that area of stream actually affected by a specific project. That is, if a project changes habitat in only 100 m^2 of stream, but is spread out over 1000 m^2 of stream, its value of A is 100 m^2, not 1000 m^2.

As described in section 3.1.2, each habitat-forming process has a set of criteria for determining whether habitats are classified as degraded, important, or key. These classifications help project proponents determine what level of degradation exists at a site, and what restoration efforts are necessary to restore disrupted processes and functions. For example, riparian restoration values for non migrating channels are based primarily on the ability of a buffer to supply conifer LWD over the long-term (Figure 4). As a baseline, we use recruitment from a 200 year old Douglas fir stand on ground of site class II. 100% of the recruitment is obtained at a buffer width of about 64 meters. We assume that recruitment of more than 80% of the potential LWD will eventually lead to channel recovery to the key classification. Thus, any buffer width over 40 meters will have a future value of 3 (i.e., riparian functions are defined as "functioning"). If the buffer recruits less than 50% of the potential LWD (< 20 meters wide), we presume the channel will eventually become degraded because depletion of in-channel LWD exceeds the rate of recruitment. The future value is therefore a 1 (impaired). Buffers between 20 meters and 40 meters get a future value of 2 (moderately impaired).

The time (T) over which the benefit is accrued is an estimate of the duration of the benefit produced by a project. For example, a new culvert may have the life span of 50 years, so any benefits gained by a culvert replacement can be expected to end after 50 years. Projects that are slow in attaining full benefit (e.g., riparian planting), have T values that represents the time lag inherent in the recovery process. T values by project type are listed in Appendix 2.

Land acquisition and easement projects (reach level)

Land acquisition and easement projects are typically intended to (1) protect those areas where high quality habitat exists, (2) prevent further disruptions to habitat-forming processes, and/or (3) to allow for recovery of habitat-forming processes. The Council, as a matter of course, recognizes the importance of land protection and has adopted a "*protect the best first"* approach. This section deals only with reach level acquisition and easement projects. Non-reach level projects, that is, projects outside of the channel migration zone, will be treated in the Watershed Level Land Acquisition and Easement Projects section of the Watershed Level Projects chapter.

Screening

Projects that acquire land or easements where the only reach level habitat type present in the parcel is "isolated" would be inconsistent with the Strategy, if there are no immediate plan to reconnect the isolated habitat. Projects proposing to acquire isolated habitat for the purpose of reconnecting it will be consider restoration projects and will be prioritized within the restoration project section of the Strategy.)

Cost effectiveness

The cost-effectiveness equation for prioritizing reach level protection projects is:

$$\text{cost-effectiveness} = B/C,$$

where

$$B = (RH+FP)*CF*TF,$$

and

$$C = CM*P.$$

RH is the benefit estimated from the area of reach level habitat within the parcel and P is the purchase price of the parcel or easement. FP is the benefit of non-channel floodplain habitat within the parcel. CF is the "connectivity" factor for the parcel. TF is the "threat" factor. CM is the "cost" modifier. Results are presented in the unit "benefit acres" per $1000.

Reach Level Habitat Benefit (RH)

The reach level habitat benefit (RH) calculations first require that we have a rating of the Value (V) of habitats in a reach. The ratings by habitat type are: Isolated = 0, Secondary = 1, Degraded = 1, Important = 2, and Key = 3. RH is calculated as the numeric habitat type rating (V), multiplied by the area of the reach level habitat types (Table 1 in the Strategy) affected by the project (A):

$$RH = V*A$$

The rating results of habitat types within a parcel are a function of applying the screens for each landscape process considered in the Strategy (e.g., hydrology, sediment, water quality, etc.). Reach level habitat area (A) is calculated as the length of the habitat within the parcel (e.g., an off-channel segment) multiplied by the average width of the habitat for reach level habitat segments completely within the parcel. Only one half of the area is credited to reach level habitats where only on side of the reach level habitat is within the parcel. An example includes parcels adjacent to mainstem river segments.

Non-channel Floodplain Benefit (FP)

In areas where channels naturally migrate or avulse over two bank-full channel widths, we give the parcel added value for non-channel areas in the 100 year floodplain that are not isolated from mainstem river reaches or estuarine habitats. (Note: the floodplain areas, mainstem reaches, and estuary reaches are all SWC GIS products). No benefit is given to floodplain areas isolated through hydromodification. The reason for including this benefit is over the long-term, current non-channel floodplain areas could become one or more of the different reach level habitats. Obviously, isolated areas are precluded from this potential benefit.

Vegetation land cover is the factor considered when designating whether "connected" non-channel floodplain areas are impaired, moderately impaired, or functioning. Based on Pollock (1998), the non-channel floodplain area of the Stillaguamish River Basin before the majority of European settlement (circa 1873) was characterized by mixed hardwood and conifer forest stands. The stands were 36% coniferous (by stem frequency) with median dbh for conifers between 16 and 20 inches. The dominant conifer species within floodplain forests was hemlock (one half of the 36%) while Red Alder dominated the hardwoods (31% of all floodplain tree stems). The median dbh for hardwoods was between 8 and 12 inches. Nineteen percent (19%) of the floodplain conifers were large (>20 inches) while only 9% of the hardwoods were large. Because the Stillaguamish is adjacent to the Skagit, it is expected that its natural vegetative composition is similar. Pollock's research therefore provides a reference point in which we can compare existing floodplain areas to estimated historic conditions for the Skagit River Basin.

Pollock's research seems to indicate that relatively young (median age around 20 years) deciduous dominated forests were the norm in floodplain areas of the Stillaguamish River. Larger trees and a conifer component were certainly present in floodplain forest stands, but to a much lesser degree than the large sized conifer dominated stands of upland forests or along non-migrating channels. Floodplain forest stand characteristics are thought to be primarily shaped by relatively frequent disturbances by natural fluvial processes and beavers.

With this in mind, we consider non-channel floodplain areas of the Skagit and Samish River Basins upstream of the estuarine emergent marsh zone without forested land cover due to man's activities as "impaired". Areas of non-channel floodplain with forest stands where the median tree size is less than 12 inches dbh are considered "moderately impaired". Areas of floodplain with forest stands where the median tree size is greater than 12 inches dbh are considered "functioning". Areas of floodplain where the median tree size is less than 12 inches dbh due to the effects of natural landscape processes, such as fires and floods, are also considered "functioning". To calculate the floodplain benefit (FP) for a parcel, the acreage of non-channel floodplain are multiplied by the following ratings: isolated = 0, impaired = 1, moderately impaired = 2, and functioning = 3. The value is added to the reach level benefit (RH) of the parcel.

Connectivity Factor (CF)

Reach level processes function across areas larger than individual parcels. The protection of small, disconnected parcels amongst disturbed areas will not provide adequate conditions for the restoration and maintenance of healthy salmonid stocks. Therefore, in order to protect and/or restore natural processes, land acquisition and easement projects need to occur strategically, such that larger areas of riparian lands and reach level habitats are protected. Parcels in areas where habitat conditions will be maintained in natural conditions in perpetuity by landowners are considered to be "protected". The objective of the connectivity factor (CF) is to give preference to protection projects aimed at parcels adjacent to other protected parcels, or within a reach with a high percentage of its floodplain and reach level habitat area already under protected status.

The connectivity factor has the potential to inflate the current habitat benefit (RH + FP) by no more than 20%. Two threat factors are considered: "adjacency" and "percent of reach protected", where

$$\mathrm{CF} = a + p + 1.00$$

Adjacency (a) to other protected lands can inflate the benefit value of a potential acquisition or easement by 5%. If a parcel is adjacent to a protected parcel, then the benefit is inflated by 5% ($a = .05$). If the parcel is not adjacent to a protected parcel there is no change to the benefit value ($a = 0$).

Up to 15% inflation of the benefit value is possible when considering the percentage of the reach's floodplain area already in protected status (*p*). This factor is determined by multiplying the percentage of the reach's floodplain area in protected status by 15%. If the entire reach level floodplain was already protected, except the parcel being considered, the full 15% inflation to the parcel's benefit would be credited (*p* = 100% x 15% = .15). If no reach level floodplain was in protected status, then no credit would be given (*p* = 0% x 15% = 0).

<u>Threat Factor (TF)</u>

The threat of habitat degradation to a parcel is an important factor evaluating the value of acquiring land or easements within a river basin. A threat factor (TF) is incorporated by inflating the current reach level habitat benefit (RH + FP) by up to 20%. Two factors are considered: "potential" (up to 10% inflation of the benefit) and "known imminent" (up to 10% inflation of the benefit), where

$$\text{TF} = pt + ki + 1.00$$

The potential threat (*pt*) factor is meant to capture non-immediate threats posed to a parcel based on the parcel's zoning or land use designation. We are using the land use designation because of the known relationship between land uses and aquatic habitat degradation (see hydrology and water quality sections). The effective impervious surface percentages associated with various land uses are an accepted means of predicting instream habitat conditions from a variety of causes including: changed hydrologic functions, riparian clearing, bank stabilization, water and sediment quality (Booth and Jackson 1997). Also, the relationship between the amount of effective impervious surface per unit area by different zoning or land use designations has been established (e.g., Dinicola 1989). ***Table 1*** shows the percentage the benefit of a parcel is inflated by its land use/zoning category.

Table 1: Matrix to estimate potential threat (*pt*) factor

Land Use/Zoning Designation	Percent Effective Impervious Area (EIA) *	Inflation Factor (pt)
Wilderness Area/Protected Area	0% to 2%	0%
Forest/Agriculture/Recreation Area/Parks with developed areas (e.g., campgrounds, ball fields)/Low Density Residential	1% to 4%	4%
Medium-High Density Residential/Urban/Industrial	10% to 86%	10%

* Dinicola 1989; Beyerlein 1996

In addition to potential threats, we will capture known imminent (*ki*) or immediate threats posed to a parcel by certain planned activities. We believe it is critical to inflate benefits based on immediate threats because of the somewhat opportunistic nature of parcel availability and the fact that "imminent" threats are documented and could result in long-term negative impacts to aquatic habitats, if not prevented by the land protection action (e.g., purchase or conservation easement). ***Table 2*** summarizes the actions that we regard as imminent threats, the information that would be necessary to document these threats, and the inflation factor associated with these threats.

Table 2: Matrix to estimate known imminent (*ki*) threat factor

Planned Activity	**Documentation**	**Inflation Factor (ki)**
Timber harvest within CMZ or specified buffer width for adequate protection of stream type	Forest Practice Application	5%
Zoning change or conversion to a more intensive land use: no greater than low density residential	Rezone hearing	5%
Zoning change or conversion to a more intensive land use: equal to or greater than medium density residential	Rezone hearing	10%
Parcel for sale	Real estate listing	5%
Parcel for sale with additional buildable lots	Real estate listing	10%
Proposed rip-rapping, diking, or other hydromodification	Permit application	10%
Proposed dredging	Permit application	10%
Road building within floodplain or 200 feet of class 1-2 water	Permit application	10%

Cost Modifier

The intention of the cost modifier (CM) is simply to give credit to "good buys" and penalize "bad buys", relative to market value. As such, it will help to dissuade groups from pursuing above market value purchases that will drive prices up within the area as a whole. The cost modifier is calculated by dividing the sale price (P) by the appraised market value (AV) of the parcel:

$$CM = P / AV$$

The cost quotient (C) is then determined by multiplying the cost modifier by the purchase price:

$$C = CM * P.$$

(**Note**: Cost effectiveness for reach level projects and land acquisition and easement projects could potentially be combined if passive restoration was incorporated to account for ΔV and the agreement period was incorporated to account for T.)

Watershed level projects

Watershed level projects address disruptions to habitat-forming processes which are distributed across the landscape (similar to and including non-point source pollution problems). Examples of these types of issues include changes in sediment supply to stream channels, changes in magnitude and frequency of peak flows, and inputs of pollutants such as pesticides or herbicides. Causes of these changes are spread out over wide geographic areas and often encompass several landowners and legal jurisdictions. Methods for diagnosing disruptions to these processes vary by process (Section 3.1.2). Consequently, methods for identifying restoration tasks also vary by process.

For projects designed to reduce sediment supplied to channels in a watershed, Kennard (1994) presents an efficient and systematic field-based methodology for identifying road segments that present a high hazard to aquatic resources. The method first uses a series of office and field screens to rapidly identify low hazard road segments. Additional efforts are then focused on assessing the higher hazard areas, predicting landslide runouts, and ranking risks to aquatic resources. The output of this methodology is a list of road sites with a high or moderate probability of failure and damage to aquatic resources. These sites can then be prioritized for restoration based on cost-effectiveness. Restoration of sediment production rates from non-road sites typically follows a passive restoration approach. A watershed analysis or similar assessment is commonly used to identify areas prone to mass wasting (e.g., WDNR 1995). Delineation of landform units with higher mass wasting potential and greater land use sensitivity then become areas where logging or other land uses are restricted. This approach helps prevent future increases in sediment supply due to land use and allows for recovery of mass wasting in areas where natural forest vegetation can recover.

Similar approaches can be developed for hydrology and water quality projects. Each approach is expected to use a basin-wide assessment of locations and magnitudes of causes of degradation, which will allow for identification of those locations most responsible for the cumulative degradation.

Giving credit to protecting the best habitat

For project categories using ΔV, a project that reduces a threat to existing habitat would be prioritized using ΔV as: $V_{present} - V_{future\ (w/o\ project)}$. In these cases, a project would be preventing habitat from changing from one type to another. For example, if a forced pool riffle channel (key habitat) is at risk of converting to a plane bed channel (degraded habitat) because riparian conditions are inadequate, then the project's ΔV equals 2.

$$\Delta V = 3 - 1 = 2.$$

This occurs where inadequate buffers were left after logging or land clearing, but LWD in the channel has not yet been depleted.

3.2.2 Risk of failure

Risk is not used in our calculation of cost effectiveness, however, it is an important consideration for final project prioritization. It is a rank of the relative risk of a project failing to achieve the estimated benefits. Risk assessment should examine the potential for project failure from:

1. not properly identifying the problem and therefore designing an improper solution,
2. improper implementation,
3. disturbance events (e.g., floods, debris flows) from other sources masking or overriding the potential benefits of the project, and
4. failure of the project due to disturbance events that exceed the design specification.

The risk of failure due to #1, #2 and #3 should typically be low, because the screening process (Section 3.1) and implementation monitoring explicitly address some of these issues. Therefore, failure due to disturbance that exceeds the project's design specification is the main factor considered by the SWC.

3.3. PROJECT MONITORING AND MAINTENANCE

3.3.1 General Approach

The SWC will not support restoration or protection projects without a "reasonable" monitoring and maintenance plan. Each monitoring plan should be linked to the SWC's overall habitat protection and restoration strategy to ensure "feedback" for adaptive management. The SWC employs the three monitoring types: implementation, effectiveness, and validation.

<u>Implementation monitoring</u>

Implementation monitoring is the first monitoring phase and the SWC will generally require it for all projects. Implementation monitoring answers the question: Were the identified project activities correctly carried out on the ground?

<u>Effectiveness monitoring</u>

Effectiveness monitoring is used to determine if the project's objectives were achieved by what was done on the ground. Each table provides general guidelines and techniques to be used by the project proponent to develop an effectiveness monitoring plan. It is important that the proposed monitoring approach be testable and measurable.

<u>Validation monitoring</u>

Validation monitoring is the third and final monitoring phase. Validation monitoring evaluates if the hypothesized cause and effect relationship between the action and habitat conditions or ecosystem function were correct. For example, in a sediment reduction project, validation monitoring would determine whether reduced sediment supply actual restores channel morphology and pool depths as expected. Validation monitoring is not part of each project plan. Rather, the SWC will develop a validation monitoring plan as part of the proactive plan (Section 4).

3.3.2 Guidelines for monitoring and maintenance plans by project type

The following tables include a listing of general habitat protection or restoration project action categories. Each action category contains a list of typical objectives, statements of problems and solutions, implementation and effectiveness monitoring guidelines and techniques, and maintenance plan recommendations. The tables can be used by a project proponent to formulate a project specific monitoring and maintenance plan. Each table contains general monitoring guidelines for each project category. Some projects may require a more rigorous or comprehensive effectiveness monitoring program depending on the scale and complexity of the project. Over time, it is likely that additional tables will be added to accommodate projects that may not fit into the existing category types.

Fish Passage Project

Objective: Remove fish barriers that causes an excessive delay and /or abnormal expenditure of energy during the movement of fish in the basin.

Problem

Culverts : High velocity within culvert exceeds swimming ability of juvenile and or adult salmon. Excessive drop at culvert outlet limiting juvenile and or adult fish entry into the culvert. Inadequate depth within culvert (sheet flow) limiting adult and or juvenile fish passage through culvert. High velocity and or turbulence at culvert inlet and or outlet creating standing wave conditions which limit passage.
Dams and/ or spillway : Creates velocity, sheet flow or height barriers to free passage of juvenile and or adult fish into impoundment.
Off channel rearing habitat isolated due to fill, diking, channel change
Tide gates restrict free movement of juvenile and adult fish into estuary and slough habitats.

Examples of Specific Actions

Remove culvert or reduce height of jump by lowering culvert, installing downstream controls weirs. Remove culvert or replace with larger cross section culvert or span creek with bridge. Remove culvert or increase water depth in culvert by embedding in stream bed, reducing culvert slope, installing baffles, installing control weirs downstream of culvert. Remove culvert or change entry and exit conditions, increase culvert cross section. Remove dam or provide fish ladder which meets WDFW fish passage requirements. Remove or modify tide gates or dikes to reconnect isolated habitat.

Monitoring

Implementation: Verify that the project was built as designed.	Effectiveness: Is the project passing fish upstream
Complete an as built drawing of the project. Measure such physical parameters as stream flows, water depths, water velocity, and height of steps that fish must jump.	Are any of the measured as built physical parameters beyond the fish passage limitations of the target species and life stage.
Discuss any variation between as built and designed project.	Document adult fish or redds upstream of culvert in fall and winter. To document juvenile passage, observe juvenile fish moving upstream through the facility at likely migration periods.

Maintenance Plan

1. Describe the maintenance plan for the life of project.. What party will be responsible for routine inspection and or maintenance of structure. How often will the site be visited. Is there funding available to carry out the plan?

Riparian Restoration Project

Objective: Implement activities which will speed the recovery of riparian functions

Problem

Riparian corridors along many lowland and forest streams have been altered by land use practices (urbanization, farming, grazing, drainage district maintenance, logging) upsetting natural landscape processes which benefit fish populations. Stream side vegetation provides canopy shade to cool water, stream bank roughness to slow flows and disperse energy, root structure to strengthen stream banks, LWD for fish cover, detritus and carcass retention for nutrient sources.

Example of Specific Action

Install and maintain stream side fencing Interplant appropriate conifer species Plant disturbed riparian area(e.g. grazed area, skid trails, landings, hot burned stream side area Plant on flood deposits (high bars) near channels Thin hardwoods to allow for conifer release.

Monitoring

Implementation: Verify that the project was planted / fenced as designed.	Effectiveness: Are the plants growing and being maintained to insure establishment of an effective riparian corridor?
Briefly describe site conditions, dominant vegetation types prior to project, average width of riparian buffer, and any site preparation work performed. Estimate number of plants of each species and size planted, and any other treatments applied to improve survival.	What percent of the plant material survived the first summer; the second summer. Has the species mix significantly changed. What do you determine to be the major cause of plant mortality (rodent damage, reed grass competition, beaver, etc. Based on the observed plant growth how many years will be required for plants to reach 30% of mature stand height.
Briefly describe any fencing completed, land owner agreements, conditions, setbacks. Discuss any variation between as-built and designed project.	Is the fence effectively excluding livestock from the riparian corridor for the term of the agreement or life of the project. What happens at end of agreement or life of fence.

Maintenance Plan

Describe the maintenance plan for the first five years of the project. What party will be responsible for routine inspection and or maintenance of the site. How often will the site be visited. Is there funding available to carry out the plan. Is funding available to replace dead plant material.

Road Sediment Reduction Projects

Objective: Implement activities which reduce forest road related sediment from mass wasting and surface erosion sources to improve natural stream channel process and function.

Problem

Course sediment from mass wasting events (landslides) negatively impacts stream bed load and channel morphology. Effects are more apparent in lower gradient sections of the channel (response reaches). Large increases in course sediment supply tend to fill pools, widen and aggrade channels.
Large increases in total sediment supply to a channel also tend to increase the fine sediments in the bed which may impact the survival of incubating eggs.

Examples of Specific Action

Storm proof and upgrade forest roads : reroute road drainage to stable receiving area, correct concentrated road drainage, correct stream diversion potential at stream crossings, revegetate bare cuts and fills, remove or reconfigure unstable fills, upgrade stream crossing to pass 100 year flow events.
Decommission roads: De-compact road surfaces, seed, remove road culverts, out slope and water-bar road surfaces, remove unstable fill and side casting.

Monitoring

Implementation: Verify that the project was constructed as designed.	Effectiveness: Is the completed project accomplishing the desired reduction in sediment supply.
Briefly describe the project as built, miles of road de-commissioned, surfaces treated, culvert removed, etc. . How does the finished project differ from the design?	Aerial photo landslide inventories and field surveys in future years to determine if work reduced sediment supply. (See Beamer et al. 1998)

Maintenance Plan

Describe the maintenance plan for the first five years of the project. What party will be responsible for routine inspection and or maintenance of the site. How often will the site be visited. Is there funding available to carry out the plan.

In Channel Projects

Objective: Implement activities which improve natural stream channel process and function.

Problem

Stream channel has been realigned, simplified, ditched, diked, constricted. Channel has lost natural meander pattern, pool rifle complexity, ability to sort or transport gravel.
Bank protection projects using rock rip rap simplify channel complexity, reduce energy dissipation.

Examples of Specific Actions

Allow channel to return to natural meander, assist by selective excavation or placement of LWD or rock deflectors. Remove constrictions. Set dike back to allow for natural floodplain processes. Limit the use of rock to protect toes of banks, construction of deflectors. Use more creative bioengineering approaches to bank stabilization.

Monitoring

Implementation: Verify that the project was constructed as designed.	Effectiveness: Is the completed project accomplishing the objective.
Briefly describe the project as built. How does the finished project differ from the design. What factors help in project implementation, which factors hindered implementation. What would you do different.	Photo point documentation. Completed project, year 1,2,3.
Establish before and after photo points to document channel changes.	

Maintenance Plan

Describe the maintenance plan for the first five years of the project. What party will be responsible for routine inspection and or maintenance of the site. What party assumes responsibility for damage to property resulting from channel work. How often will the site be visited. Is there funding available to carry out the plan. Is funding available to replace failed structures, rock, LWD.

Floodplain Projects

To be completed

Objective:

Problem

Examples of Specific Actions

Monitoring

Implementation:	Effectiveness:

Maintenance Plan

Habitat Protection Projects

Objective: Protect important stream reaches, riparian areas, wetlands, and upland buffers from land clearing activities, development, livestock grazing and other potential encroachments through acquisition of fee-title or less-than fee interest.

Problem

High quality riparian and wetland habitat is threatened by modifications caused by land use activities including: clearing of vegetation buffers; livestock grazing; dredging, filling; diking and channelization; and development.
Degraded riparian and wetland habitat targeted for restoration often lack long-term protection from changes in landowner's objectives or management priorities for their property. This may threaten the viability of the restoration project.

Examples of Specific Actions

Acquire conservation easements or fee title on key riparian areas and wetlands: from willing sellers or donors, purchase or solicit donations of property rights necessary to ensure the long-term integrity of the natural processes. This may include acquisition of timber, farm/grazing, development rights, and/or restriction on hydrological modifications.

Monitoring

Implementation: Verify that necessary transactions have occurred, and legal documents are recorded.	Effectiveness: Will the actions taken provide for the long-term protection of the identified habitat conditions or natural landscape processes?
Are necessary easement and/or conveyance documents recorded with County Auditor? Is the landowner aware of the restrictions placed on the property and his or her management responsibility? Need for property survey????	Is easement or title held by a qualifying conservation organization or government entity? Are the land use restrictions adequate to protect habitat and natural landscape processes? Does the document conform to national standards for conservation easements? Does the entity holding fee or title have sufficient resources to maintain and/or monitor the property, and enforce compliance?

Stewardship/Compliance Monitoring

Describe the compliance monitoring plan for this property. What party will be responsible for routine inspection of the site? How often will the site be visited? Is there funding available to carry out the plan and enforce compliance if necessary?
For acquisition of land in fee, describe what resources the organization has available for stewardship planning and management activities.
Have any biological inventories or maps been prepared? Need for baseline inventory and

mapping for future monitoring purposes. Inventories and maps should focus on the resource values for which the property is being protected.

<u>Hydrology (and floodplain)</u>

Project Type	Secondary Obj.	Monitoring Questions and approaches	Maintenance planning	Sources
Tidal hydrology: Tide gate removal or alternative gate management	Restore original tidal flow patterns; restore tidal area vegetation	Monitor water flows at high and low tides along the entire affected area. Measure salinity. Monitor vegetation establishment within tidal area	If native vegetation do not establish; reintroduce tidal vegetation. Remove non-native plants	Mitsch & Gosselink 1993; Mitsch 1994
Tidal hydrology: Dike removal/set back/breaching	Restore original tidal flow patterns leading to flood plain dynamics; restore tidal area vegetation	Monitor water flows at high and low tides along the entire affected area. Measure salinity. Monitor vegetation establishment within tidal area	If native vegetation do not establish; reintroduce tidal vegetation. Remove non-native plants	Mitsch & Gosselink 1993; Mitsch 1994

Water Quality

Project Type	Secondary Obj.	Monitoring Questions and approaches	Maintenance planning	Sources
Water Quality Projects: Non-point source reduction projects	Reduce effects of eutrofication or sediments.	Bioassessment of nutrient reduction. Monitoring of total suspended sediment		Chapman 1996
Water Quality Projects: Composting Dairy Waste (reduction), and other nutrient loading reductions such as septic.	Reduce effects of eutrophication within stream reach. Reduce pollutant inputs to stream	Select appropriate bioassessment method to monitor changes over time. Preferably macroinvertebrates. Coliform counts reduced		Karr & Chu 1997; Chapman 1996
Water Quality Projects: Stormwater	Reduce pollutant inputs from storm water runoff. Restore hydrograph.	Monitor hydrograph. Non-urban areas: monitoring should include a bioassessment method. Urban areas: measure micropollutants in runoff water. Measure sediment reduction.		Azous & Horner 1997; EPA ; WADOE;

3.4. Procedures to implement

This section outlines the procedures for the Skagit Watershed Council to screen and prioritize projects. It identifies an administrative procedure for processing endorsement requests and identifies what information is needed for proposed projects.

3.4.1 Procedure for processing endorsement requests

Restoration and Protection Committee (RPC) recommendation to endorse proposed projects are presented to the full Council at the monthly Council meetings on the second Wednesday of every month. The applicant will be informed of the outcome in a letter from the Chair.

The RPC meets once a month, preferably in the week prior to the monthly Council meeting, to review projects and make endorsement recommendations.

In preparation for the monthly RPC meeting, the Technical Coordinator evaluates the proposals that have been submitted during the previous month in terms of their completeness and their conformance with the Strategy (Section 3.1 and 3.2).

If a submittal is incomplete, the Technical Coordinator contacts the project proponent and, where possible, works with the applicant to develop the required information.

If the proposed project does not meet the requirements of the Strategy, the Technical Coordinator contacts the proponent and together they discuss what changes could be made to bring about conformance.

RPC members are available for consultation with the Technical Coordinator and, in certain instances, with project proponents.

3.4.2 Information needs required for project submittals

The following information is required to screen and prioritize any proposed project[9].

Project location and contact person

I. What is the location of the project? (provided on map, USGS 7.5 minute quad. or better resolution)

II. What water bodies and sub-watersheds are affected?

III. Who is the project proponent? (contact person/phone/address)

Project Description - describe the objective of the project.

I. What are the habitat problems that are being addressed?

II. What landscape processes will be protected or restored?

III. Describe why you believe that current watershed conditions will allow for success of the project.

IV. Describe the project, i.e., the work that is proposed. Include design specifications, drawings, etc., if available.

V. What is the estimated project cost?

Generalized Habitat Types, from section 3.1.1:

I. What reach types will be affected by this project?

II. What are the generalized habitat types of these reaches?

III. What is the area of each reach that will be restored or protected as a result of the project?

Landscape processes (see Section 3.1.2)

I. Has a watershed analysis been conducted for this watershed?

II. Hydrology

In the sub-watershed affecting the project area,

A. For mountain basins, has the current 2 year peak flood magnitude increased to equal or exceed the 5 year flood magnitude under natural conditions? What is that evidence?

B. For lowland basins, what percentage of the watershed area is impervious?

[9] The type, form and management of information by the RPC is likely to change over time as the RPC gains experience screening and prioritizing projects.

C. Is there evidence of low flow impairment, based on changes in the 7-day minimum flow? Has there been a determination made that there are currently inadequate stream flows?

IV. Sediment

A. What is the sediment supply rate for the sub-watersheds affecting the project area? In mountain basins, is sediment supply less than 100 $m^3/km^2/yr$ within the sub-watershed, or can a determination be made that current sediment supply approximates natural conditions?

V. Riparian

A. For reaches affected by this project, what are the existing widths of forested buffers?

B. For reaches affected by this project, what is wood loading (LWD pieces per meter of channel length)?

VI. Floodplains-not completed

VII. Water Quality and Nutrient cycling- not completed

A. Are state water quality standards being met?

VIII. Monitoring

A. Describe the monitoring plan (implementation, effectiveness, and validation; use the tables in Section 3.3.2 as guidelines)

IX. Maintenance

A. Is a maintenance plan or agreement necessary to insure project success?

B. If so, how will it be implemented? Include what maintenance will be done, its frequency, and who will be responsible.

4. ACTION PLAN FOR PROTECTING AND RESTORING AQUATIC HABITATS IN THE SKAGIT AND SAMISH RIVER BASINS

To this point, the SWC habitat protection and restoration strategy provides criteria for screening and prioritizing projects brought to the SWC for review and potential endorsement. That is, it develops criteria that allow the SWC to react to proposed projects in a consistent and scientifically defensible manner. However, it is not proactive in that it does not develop an overall plan for protecting and restoring aquatic habitats in the Skagit and Samish River basins. This section is intended to describe some of the inventories and assessments (resulting in lists of actions) necessary to develop a long-range plan for restoration.

(Note: So far this section is just of list of tasks identified while writing other sections. It is not comprehensive or prioritized, and all components need recommended time lines.)

1. Identify priorities for doing watershed analysis (watershed analysis is required on federal lands before actions can be done).
2. Review "T" values for project types (update Appendix 2).
3. Complete a "Gap Analysis" and "Identify Refugia (Key) Habitat" within the river basin based on the Lunetta et al. (1997) data and Species / Habitat matrix criteria for the purpose of identifying strategically important and / or threatened areas to protect or restore.
4. Using results in #3, identify *key* or *important* habitats that are hypothesized to become *degraded* (i.e., protect the best first)
    - Identify forced pool riffle or pool riffle channels with less than 60 meter riparian buffers -- develop a plan to protect them.
    - Overlay key habitats (and other types) with land use zoning designations to predict watersheds that will likely become degraded through impervious area; develop a plan to protect these areas.
    - complete the partial sediment budget to identify sub-basins with disturbed sediment supply; develop a plan to protect and restore sub-basins as appropriate.
    - identify isolated (including estuarine habitats) to reconnect
5. Develop a validation monitoring program for each significant project type for "feedback" to in the overall SWC strategy.
6. Recommend charter changes reflecting adoption of concepts
7. Identify other "applied" research
8. how to manage data gathered in the screening and prioritizing process

DEFINITIONS

ecosystem
A unit comprising interacting organisms considered together with their environment.

ecosystem management
The management of human actions with a view toward preserving ecosystem integrity while maintaining sustainable benefit for human populations (adapted from Montgomery et al. 1995)

effectiveness monitoring
The evaluation of whether an action achieved the desired effect. For example, in a sediment reduction project, effectiveness monitoring would determine whether sediment supply was actually reduced.

impervious area
The Effective Impervious Area in a watershed, as defined in Booth and Jackson (1997)

implementation monitoring
The evaluation of whether an action was carried out as designed (an "as-built" evaluation).

native
Indigenous to the Skagit River Basin at the species level.

natural landscape processes / functions
Natural landscape processes / functions are those that existed prior to Euroamerican settlement. Processes and functions are typically measured as rates and characterize what ecosystems or components of ecosystems do. The processes and functions in forested mountain river basins of the temperate zone primarily center around vegetation, water, and sediment.
For example, in a riparian ecosystem, this might include large woody debris recruitment, stream temperature control through shading, detention of surface water, storage of subsurface water, carbon and nutrient cycling, and others.

restoration
The return of an ecosystem, or selected components of an ecosystem to its' original form through actions by man or allowing recovery to occur naturally.

protection
Preserving ecosystems with relatively natural aquatic habitat conditions by preventing future impacts from unnatural disturbance and maintaining natural landscape processes / functions.

salmonid
The members of the family Salmonidae (i.e., the trout, salmon, and whitefish) native to the Skagit River Basin including their various life history forms (e.g., resident, anadromous).

validation monitoring
The evaluation of hypotheses regarding the cause and effect relationship between the action and habitat conditions or ecosystem function were correct. For example, in a sediment reduction project, validation monitor would determine whether reduced sediment supply actually restores desired habitat condition or ecosystem function.

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APPENDIX 1. GENERALIZED HABITAT TYPES – CORRELATION BETWEEN HABITAT TYPES AND ANADROMOUS FISH SPECIES IN THE SKAGIT WATERSHED.

The importance of identifying generalized habitat types for watershed restoration is illustrated by Frissell (1993) and Doppelt et al. (1993), where examples of habitat types are listed along with their biotic objective and restoration tactics. To apply this concept in the Skagit and Samish River basins, we derived generalized habitat types based on simple correlations between our understanding of anadromous fish life history strategies and reach level habitat types (approximately 10^2 to 10^4 meters in linear scale). We assume that relationships between fish life stages and habitat for each indicator species analyzed adequately identifies the "habitats to which salmonid stocks are adapted" in an effort to be consistent with our goal stated in Section 2.

Our analysis used five species and four life stages to determine generalized habitat types. The life history stages examined were: spawning/egg to fry, summer rearing, winter rearing, and estuary rearing. Several salmonid species were excluded from the evaluation because they are not as widely distributed in the Skagit. Native Char were excluded because of their bias toward higher elevation headwater tributary basins. Recent literature suggests that cold water for incubation is a major life history control and therefore, preference or dependence on different geomorphic habitat types is a lesser control. Cutthroat trout were excluded because of their spatial bias towards the lower elevation rain-dominated sub-basins of the Skagit. Sockeye were excluded because most of the population is limited to the Baker River Basin. While resident rainbow are found throughout the entire river basin, they are expected to have the same habitat preferences as steelhead and are thus included.

Classification systems described in Hayman et al. (1996), Montgomery and Buffington et al. (1997), Peterson and Reid (1984), and Simenstad (1983) were used to define the different reach level habitat types.

Under pristine habitat conditions (i.e., natural disturbances only) we define reach-level habitat types for anadromous fish as either key or secondary (Table A1-1, last column). *Key* habitat is critical[10] for at least one life stage combination considered, or is a preferred type by the majority of life stages considered. *Secondary* habitat does not provide critical habitat for any life stage combination considered and is not a preferred type by the majority of life stages considered.

[10] That is, required for the persistence of a life history type (e.g., estuary rearing chinook).

Under disturbed habitat conditions (i.e., both human and natural disturbances) we designated reach-level habitat types as important, degraded, or isolated depending on the degree and type of disturbance (Table A1-2, columns 2 and 3). *Important* habitat is a disturbed key habitat that still provides significant amounts of production for most life stages considered. *Degraded* habitat is key habitat that is disturbed to such an extent that it does not have significant production or is not preferred by the majority of life stage combinations considered. *Isolated* habitat is not used by anadromous salmonids (no direct biological function) because it is disconnected through anthropogenic blockages such as dikes, tidegates, or impassable road crossings.

Data used to designate whether the specific reach level habitat types were “critical”, “key”, or “secondary” for a life history stage included: Hayman et al. (1996), Beechie et al. (1994), Phillips et al. (1980, 1981), unpublished spawner survey database, and unpublished data from Eric Beamer (Figures A1-1 through A1-3 shown later in this appendix). Data from the Queets River (Sedell et al. 1984) was also used to determine juvenile fish use differences between large main channels and off-channel habitats. Tables A1-3 through A1-7 show our designation for each of the species by reach level habitat and life stage.

Table A1-1. Designation of generalized habitat type as a function of five to ten lifestages of five different salmonid species.

Reach Level Habitat Type	Chum	Coho	Chinook	Steelhead	Pink	total number of life stages examined	percent of all life stages designated "key" or "critical"	Overall Designation for "pristine" habitat
Tributaries Reaches:								
pool riffle	key	key	key	key	key	10	90%	**key**
forced pool riffle	sec	key	key	key	key	10	85%	**key**
planebed	sec	sec	sec	sec	sec	10	0%	**secondary**
step-pool/cascade	sec	sec	sec	key	sec	10	15%	**secondary**
Main River Reaches:								
main channel	key	sec	key	key	key	10	80%	**key**
off-channel habitat	key	critical	key	sec	sec	10	60%	**key**
Estuary:								
estuarine emergent marsh	key	sec	critical	sec	sec	5	40%	**key**
blind channel	key	key	critical	sec	sec	5	60%	**key**
subsidiary channel	key	key	key	sec	key	5	80%	**key**
main channel	key	key	key	sec	key	5	80%	**key**

Table A1-2. Designation of generalized habitat types based on habitat/species matrix.

Reach Level Habitat Type	**if "disconnected" (human caused)**	**if "disturbed" (human caused)**	**if "relatively intact" (pristine)**
Tributaries Reaches (channels < 50 meters bankfull width):			
pool riffle	isolated	degraded - important	key
forced pool riffle	isolated	degraded - important	key
plane bed	isolated	degraded	secondary
step-pool/cascade	isolated	secondary	secondary
Main River Reaches (channels > 50 meters bankfull width):			
main channel	isolated	degraded - important	key
off-channel habitat (e.g., ponds, sloughs, side channels, oxbow lakes, etc.)	isolated	degraded - important	key
Estuary:			
estuarine emergent marsh	isolated	unknown[a]	key
blind channel	isolated	unknown[a]	key
subsidiary channel	isolated	unknown[a]	key
main channel	isolated	unknown[a]	key

[a] Our present knowledge does not detect a difference in fish use from estuarine habitats that are relatively undisturbed.

Table A1-3. Reach level habitat type preference by chum salmon.

Reach Level Habitat Type	Spawning egg to fry	estuary rearing	sum	count	score (sum/count)	designation
Tributaries Reaches:						
pool riffle	yes		1	1	100%	key
forced pool riffle	no		0	1	0%	sec
planebed	no		0	1	0%	sec
step-pool/cascade	no		0	1	0%	sec
Main River Reaches:						
main channel	yes		1	1	100%	key
off-channel habitat	yes		1	1	100%	key
Estuary:						
estuarine emergent marsh		yes	1	1	100%	key
blind channel		yes	1	1	100%	key
subsidiary channel		yes	1	1	100%	key
main channel		yes	1	1	100%	key

Table A1-4. Reach level habitat type preference by coho salmon.

Reach Level Habitat Type	Spawning egg to fry	summer rearing	winter rearing	estuary rearing	sum	count	score (sum/count)	designation
Tributaries Reaches:								
pool riffle	yes	yes	yes		3	3	100%	key
forced pool riffle	yes	yes	yes		3	3	100%	key
planebed	no	no	no		0	3	0%	sec
step-pool/cascade	no	no	no		0	3	0%	sec
Main River Reaches:								
main channel	no	yes	no		1	3	33%	sec
off-channel habitat	yes	yes	critical		3	3	100%	critical
Estuary:								
estuarine emergent marsh				no	0	1	0%	sec
blind channel				yes	1	1	100%	key
subsidiary channel				yes	1	1	100%	key
main channel				yes	1	1	100%	key

Table A1-5. Reach level habitat type preference by ocean type chinook

Reach Level Habitat Type	Spawning egg to fry	spring & summer rearing	estuary rearing	sum	count	score (sum/count)	designation
Tributaries Reaches:							
pool riffle	yes	yes		2	2	100%	key
forced pool riffle	yes	yes		2	2	100%	key
planebed	no	no		0	2	0%	sec
step-pool/cascade	no	no		0	2	0%	sec
Main River Reaches:							
main channel	yes	yes		2	2	100%	key
off-channel habitat	no	yes		1	2	50%	key
Estuary:							
estuarine emergent marsh			critical	1	1	100%	critical
blind channel			critical	1	1	100%	critical
subsidiary channel			yes	1	1	100%	key
main channel			yes	1	1	100%	key

Table A1-6. Reach level habitat type preference by steelhead

Reach Level Habitat Type	Spawning egg to fry	summer rearing (2 summers, age 0+ & age 1+)	winter rearing (2 winters, age 0+ & age 1+)	estuary rearing	sum	count	score (sum/count)	designation
<u>Tributaries Reaches:</u>								
pool riffle	yes	yes	no		2	3	67%	key
forced pool riffle	yes	yes, age 0+ no, age 1+	yes		2.5	3	83%	key
planebed	no	no	no		0	3	0%	sec
step-pool/cascade	no	no, age 0+ yes, age 1+	yes		1.5	3	50%	key
<u>Main River Reaches:</u>								
main channel	yes	yes	yes		3	3	100%	key
off-channel habitat	no	yes, age 0+ no, age 1+	yes, age 0+ no, age 1+		1	3	33%	sec
<u>Estuary</u>								
estuarine emergent marsh				no	0	1	0%	sec
blind channel				no	0	1	0%	sec
subsidiary channel				no	0	1	0%	sec
main channel				no	0	1	0%	sec

Table A1-7. Reach level habitat type preference by pink salmon.

Reach Level Habitat Type	Spawning egg to fry	estuary rearing	sum	count	score (sum/count)	designation
<u>Tributaries Reaches:</u>						
pool riffle	yes		1	1	100%	key
forced pool riffle	yes		1	1	100%	key
planebed	no		0	1	0%	sec
step-pool/cascade	no		0	1	0%	sec
<u>Main River Reaches:</u>						
main channel	yes		1	1	100%	key
off-channel habitat	no		0	1	0%	sec
<u>Estuary</u>						
estuarine emergent marsh		no	0	1	0%	sec
blind channel		no	0	1	0%	sec
subsidiary channel		yes	1	1	100%	key
main channel		yes	1	1	100%	key

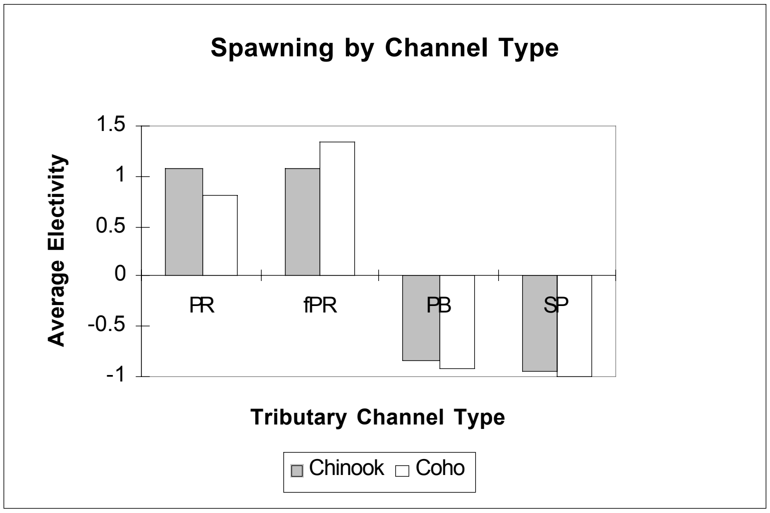

Figure A1-1. Electivity of spawning chinook and coho by tributary channel type (PR, fPR, PB, and SP refer to pool riffle, forced pool riffle, plane bed, and step pool channels respectively. Chinook data are from 38 different reaches in five streams of the Skagit River Basin. Coho data are from 26 different reaches in four streams of the Skagit River Basin. Data from Eric Beamer.

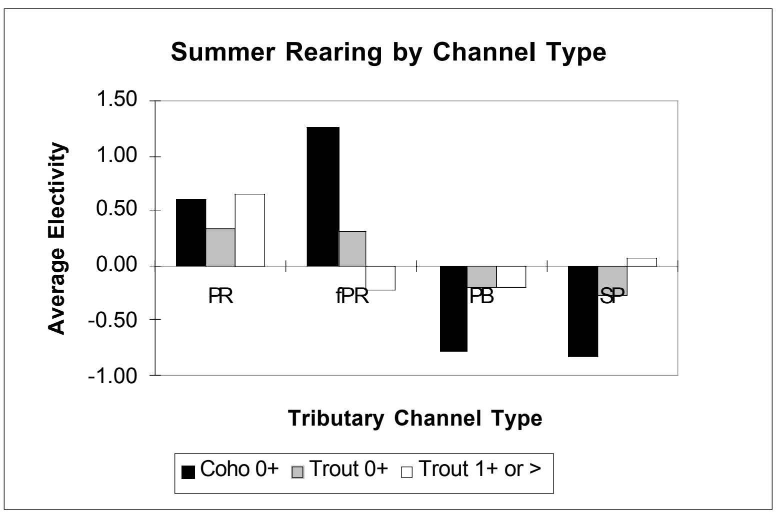

Figure A1-2. Electivity of juvenile salmonids at the end of summer by tributary channel type (PR, fPR, PB, and SP refer to pool riffle, forced pool riffle, plane bed, and step pool channels respectively). Trout are rainbow and cutthroat only. Data are from 21 different reaches in six streams of the Skagit River Basin. Data from Eric Beamer.

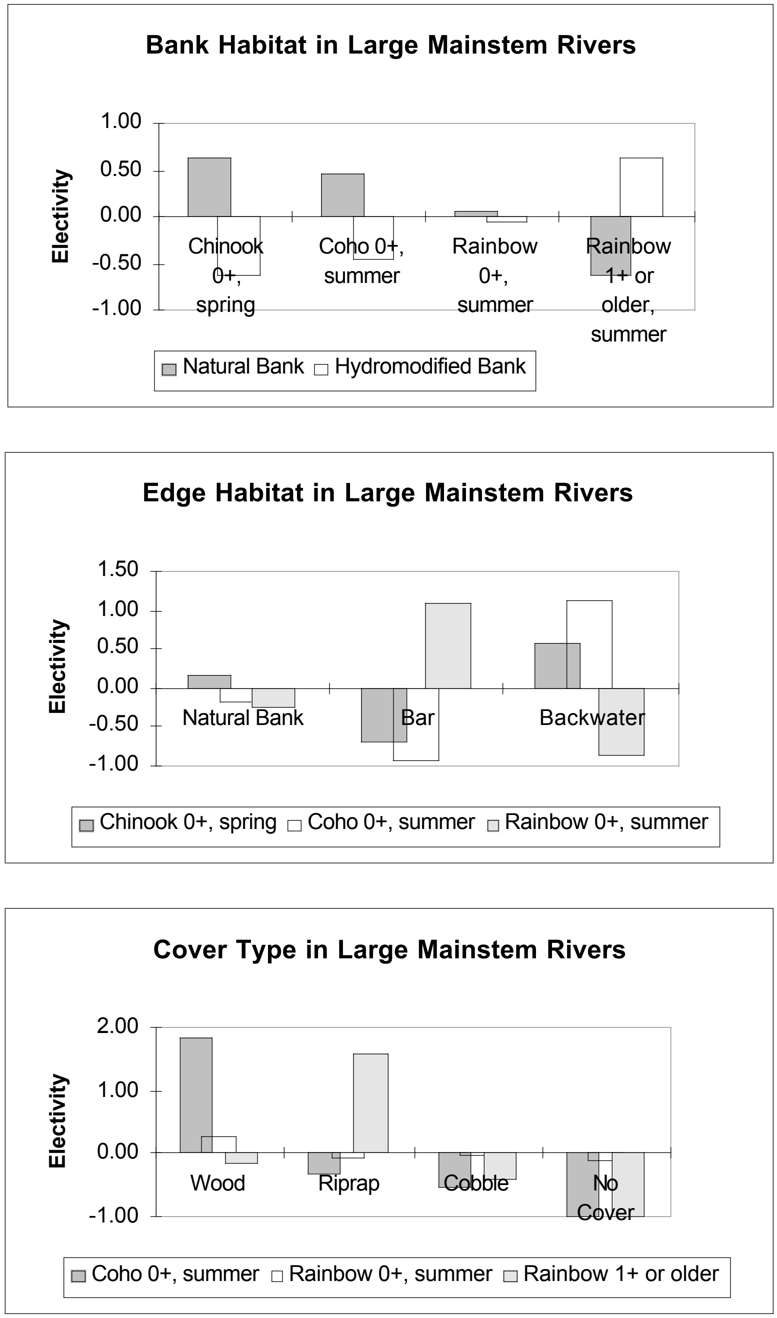

Figure A1-3. Electivity of juvenile salmonids in edge habitat of the Skagit River. Data from Eric Beamer.

APPENDIX 2. ESTIMATION OF PROJECT BENEFIT PERSISTENCE (TIME VALUES) BY TYPE.

Floodplain Projects

Example of Specific Actions	Time (T) in years
remove introduced floodplain fill	40-200[a]
remove or set back dikes	40-200[a]
modify tidegate	structure life
re-establish channel meanders	40-200[a]

[a] Benefits should begin immediately while the ending point is based fluvial disturbance. In locations not prone to avulsion, we use an assumed median return interval of 200 years based on long term channel migration rates. For locations prone to avulsion, we use 40 years.

Fish Passage Projects (reconnect isolated habitat)

Example of Specific Actions	Time (T) in years
existing facility modification (e.g., culvert baffling, fish ladder, tide gate)	facility life
facility (culvert, bridge, tidegate) replacement	facility life
removal of human caused barrier (culvert, dike, tidegate, etc.)	40-200[a]

[a] Benefits should begin immediately while the ending point is based fluvial disturbance. In locations not prone to avulsion, we use an assumed median return interval of 200 years based on long term channel migration rates. For locations prone to avulsion, we use 40 years.

In-channel Projects

Example of Specific Actions	Time (T) in years
introduce structures (e.g., debris bundles, LWD, boulders)	<1-50[b]
gravel cleaning	<1
gravel introduction	<10
install gravel catchments	structure life
streambank protection: • contouring, • bioengineering, • rip rap or other structural method (e.g. sheet pile)	structure life

b

Riparian Projects

Example of Specific Actions	Time (T) in years
fencing to exclude livestock	fencing life
• interplanting appropriate conifer species, • plant disturbed riparian areas (e.g., grazed areas, skid trails, landings, cable corridors, hot burned stream side areas, flood deposit (high bars) near channels), • thin hardwoods to allow for conifer release	40-200[c], with lag in starting time

[c] Benefits should begin immediately while the ending point is based fluvial disturbance for migrating channels (see endnote "a") and stand replacing wildfire for non migrating channels (see endnote "d"). The lag time can be estimated using established relationships between channel characteristics (bankfull width for small channels, bankfull depth for large channels) and average diameter of LWD in the channel (Bilby and Ward 1991 for small channels, Abbe et al. 1997 for large channels) and average stand dbh by age curves (e.g., McArdle et al. 1961).

Forest Road Decommissioning

Example of Specific Actions	Time (T) in years
Projects generally consist of a combination of the following: • decompact road surfaces (ripping), outsloping, waterbarring, remove culverts, • removing unstable fills, • seeding and planting native vegetation on disturbed areas	200[d]

[d] Benefits should begin immediately while the ending point is based on a median return interval for natural stand replacing wild fire disturbance in the Hemlock zone of about 200 years. Most anadromous salmonid production occurs in this zone.

Forest Road Upgrading or Stormproofing

Example of Specific Actions	Time (T) in years
Projects generally consist of a combination of the following: • Reroute road drainage to stable receiving areas, • correct stream diversion potential at stream crossings, • correcting concentrated road drainage, • relieving inboard ditchlines, • reconfigure unstable fills, • upgrade stream crossings to pass 100 yr streamflow and associated bed load and debris, • revegetating bare cuts and fills	structure life

Hydrology Projects

Example of Specific Actions	Time (T) in years
remove impervious surface	200[e]
build stormwater retention facility	facility life

[d] Benefits should begin immediately while the ending point is based on a median return interval for natural stand replacing wild fire disturbance in the Hemlock zone of about 200 years. Most anadromous salmonid production occurs in this zone.