WATERSHED RESTORATION
PLANNING AND PRIORITY SETTING

An Emphasis on Fish Habitat

March 2003

This document is modified from 'Planning and Priority Setting for the Next Five Years, Phase 3 Watershed-Level Planning, Working Draft, May 15, 2000', prepared by the WRP Provincial Coordination Team.

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IDENTIFYING PRIORITY WORK WITHIN TARGET WATERSHEDS AND PREPARING A WATERSHED RESTORATION PLAN

INTRODUCTION

These guidelines describe a structured process for: *selecting* subbasins *within target watersheds* that have a high likelihood of restoration success; *identifying* those watershed components that are most critical to restore; and *establishing* a priority list of works within those components. The end product is a *Restoration Plan* (RP) which:

- identifies the critical fresh-water limiting factors affecting fish and/or domestic water supply
- identifies the components targeted for restoration
- describes the subbasin, component and site-level restoration objectives
- identifies the high-priority restoration activities and sites to meet these objectives
- establishes a baseline for completion
- provides a schedule of works and budget estimate, and
- describes an evaluation plan.

Creating a RP is a two-staged approach:

- Stage **A** identifies the high priority subbasins and components for restoration – those that are a high priority in relation to specified restoration goals for the watershed.
- Stage **B** develops watershed action strategies based on habitat limiting factors, cost and risk assessment for the high priority subbasins.

By targeting subbasins and priority components, there are opportunities to reduce detailed assessment work. For example, it is unlikely that detailed field assessments will be required for every subbasin or for all components within subbasins targeted for restoration.

This approach differs from previous versions of Integrated Watershed Restoration Plans (IWRPs) outlined in program materials and standards agreements as it is based on a progressively more targeted identification of:

- priority subbasins in relation to probable critical limiting factors and potential for success of restoration, and
- specific works required to address only the critical limiting factors for fish.

KEY PRINCIPLES

Watershed-level planning is guided by a number of key principles:

- *Stakeholder and partnership involvement*
  Numerous groups within a community may have an interest in a particular watershed. Such groups may include forest tenure holders, forest worker groups, permitted water users, First Nations, resource stewardship groups, recreational groups, licensed outfitters or guides, and various government agencies.
- *Integrated Restoration Plan*
  A planning procedure that integrates the assessment of watershed geomorphology, risk (hazard and consequences) and critical limiting factors into the selection and prioritization of cost-effective restoration works.
- *Preventative work is most cost-effective*
  Restoration work that targets sites with potentially high hazard and high consequences are usually the most cost-effective.
- *Restoration work not to impact non-target aquatic organisms*
  Decisions on restoration sites and activities to benefit the target species should not negatively impact or reduce historic habitat area for non-target aquatic organisms.
- *Implementation of restoration works to adhere to government regulations*
  Implementation of the program adheres to the various regulatory acts where required; i.e. Fisheries Act, Water Act, municipal bylaws, Navigable Waters Protection Act, Forest Practices Code and any other approvals that may be pertinent.
- *Feedback monitoring results to incrementally improve program design.*
  Restoration works are monitored and evaluated in the short and long term including both routine monitoring, and detailed monitoring for a subset of projects and operational trials. Results are used to evaluate the overall program design. For example, results may indicate improvements to existing techniques and activities or may suggest how new activities may be added to meet the full range of program objectives.
- *Maximize resource benefits in priority watersheds*
  Where feasible, planners and implementers work cooperatively with other stakeholder initiatives so that the full range of land use impacts within a watershed are addressed.

ASSOCIATED TERMS

Watershed units: major watershed boundaries identified on a base map for each region of BC (usually 3rd to 5th order streams averaging 30,000 ha, but ranging from 10,000 to 50,000 ha for the coast to 500,000 ha in the dry interior).

Subbasins: the watersheds of tributary streams within a watershed.

Components: groupings of watershed processes—hillslope, riparian, and channel components.

Watershed process types: a classification of B.C. watersheds / streams according to process types, based on *hillslope connectivity* or *coupling* (the degree to which the stream channel is coupled to the hillslopes) and *stream connectivity* (the capacity of the stream channel to transport sediment).

Target Watersheds: those watersheds that contain high to very high values of targeted fish species/stocks.

A ~ Selecting Subbasins and Identifying Watershed Components for Restoration

The initial task in this phase is to identify subbasins of the target watershed that are the best candidates for restoration works. A target watershed will likely range from a 3rd- to 5th-order stream comprised of a number of subbasins. Problems are often restricted to one or two subbasins in the entire watershed.

Existing overview assessment information can be used to:

- identify the important subbasins,
- estimate the impact on fish habitat and water quality by *watershed component* for each subbasin, and
- determine the potential for restoration success for each subbasin.

A six-step approach is recommended to complete the task. The steps are summarized below. Detailed procedures for each step follow the summary list.

Step 1	Identify the subbasins.
Step 2	Compile an overview information sheet for each subbasin.
Step 3	State goals for each target watershed.
Step 4	Assess the relative impact of components (i.e., landslides, gullies, roads, riparian, channel, and instream fish habitat) on critical limiting factors for fish habitat and/or water quality for each subbasin.
Step 5	Determine the potential for restoration success for each component in each subbasin.
Step 6	Identify the high priority subbasins for more detailed assessment, planning and restoration.

Step 1
Identify the subbasins

Subbasins are commonly one or two stream orders less than the key watershed stream order. Major subbasins of a watershed can be identified by reviewing an appropriate map. Residual areas should be grouped together. If an Interior Watershed Assessment Procedure (IWAP) or a Coastal Watershed Assessment Procedure (CWAP) has been carried out previously, then subbasin boundaries will have been identified already.

Step 2
Compile an overview information sheet for each subbasin

Overview information will need to be compiled for all subbasins. In some cases, this information may already be available from a previous Watershed Restoration Program (WRP) Overview Survey or a Watershed Assessment.

The information needed for each subbasin includes:

- land tenure
- approximate area logged (obtained from the MWLAP Watershed Condition Atlas)
- overview channel stability and channel type (using Re-Cap – the Reconnaissance-level Channel Assessment Procedure)
- riparian condition of the tributaries and mainstem (obtained from recent air photos, forest cover maps or aerial reconnaissance)
- overview fish habitat assessment (e.g., Overview Fish Habitat Assessment Procedures (FHAP) – Johnston and Slaney 1996) that identifies critical habitat reaches, estimates habitat condition, and designates areas of special concern
- overview hillslope condition that describes the extent of landslides and roads with potential of landslides (obtained from air photos, aerial reconnaissance, or terrain stability maps).

This overview information is best summarized in a one-page format. An example summary – for the Rainy Creek subbasin in the Maple River target watershed – appears in Table 1 on the next page. In the example, the channel and riparian conditions of the subbasin are rated as poor; the hillslope and road conditions are fair.

A contractor could quickly gather the information by contacting key individuals and organizations in the region and by reviewing existing reports.

Table 1. Example summary overview information for the Rainy Creek subbasin/Maple River target watershed

Watershed:	Maple River
Subbasin:	Rainy Creek
Drainage Area (ha):	491 ha
Tenure:	100% TFL
Area Logged (%)	Approximately 50%, mostly recent
Equivalent Clearcut Area (ECA) (%)	Approximately 40-50%
Channel:	
Type (CAP):	Step-Pool
Width (m):	6-9 m
Gradient %):	3-6%
Watershed type	The stream channel is highly coupled to the hillslopes. Limited floodplain development.
Channel Conditions	Poor. The mainstem channel of Rainy Creek appears to have been substantially aggraded as a result of forestry-related landslides. There is evidence on the 1995 air photos of channel aggradation on the alluvial fan, upstream of the Bend River, and of avulsions on the fan. In addition, there is evidence that the Rainy Creek channel experienced a "debris torrent," with deposition of the sediment and debris in the channel adjacent to the B Main bridge. The air photos indicate that the sediment and debris was excavated from Rainy Creek upstream of B Main, resulting in channel straightening. The high ECA for this basin results in a high risk of increased peak discharge and accelerated bed material transport.
Riparian Condition	Good. All riparian forests are intact.
Road Condition	Fair. Approximately 1 km of the 12 km road system is high risk. Failures from this mid-slope road will impact the mainstem of the river. The rest of the road system is isolated from fish habitat but has not been deactivated. Road materials in general have a low soil erosion hazard.
Hillslope Conditions	Fair. A number of natural and forestry-related landslides have deposited coarse sediment into Rainy Creek, including 3 moderate sized slides about 500 m upstream of the alluvial fan apex. Two of these slides are still actively transporting sediment to the creek channel. It is expected that elevated bed load transport from the mid- and upper-reaches of the Rainy Creek basin will continue for a few year, with ongoing aggradation of the channel from the Bend River to the fan apex, above the B Main bridge.
Fish Target	Steelhead/Rainbow Trout
Habitat Conditions	Fair-poor. A debris torrent and aggradation of landslide coarse sediments have infilled pools and boulder dominated sections in the middle and upper reaches of the creek. This has impacted rearing habitat for trout. Ongoing aggradation will continue to limit the carrying capacity of rearing habitat.

Step 3

State objectives for each target watershed

This step involves developing objectives for entire target watersheds. These will be high-level objectives addressing the major problems or degraded resources in relation to the fish values. This will allow you to place the work on subbasins within the context of the whole watershed.

Step 4

Assess the relative impact of watershed components on critical limiting factors for fish habitat for each subbasin

Watershed processes are administratively organized into "component" groups – hillslope components, riparian components and channel components. (The hillslope component is further divided into road, gullies, and landslide-risk aspects.) Estimating the impact on fish habitat of each component requires an assessment of the relative importance of the components affecting the stream reaches containing the fish habitat. The relative importance of the components in affecting channel integrity varies by watershed type. This is discussed in Figure 1 and in more detail in Appendices 2 and 3.

Figure 1 Watershed Process Types

Watersheds have unique combinations of physiography, climate and geology which drive the geomorphic processes that determine the sediment supply, the stream discharge, the channel type and ultimately the fish habitat. Upstream of an identified reach, the main difference between watershed types is the degree to which the hillslopes are connected to the streams (its hillslope connectivity or coupling) and the capacity of the stream to transport sediment (its stream connectivity). Typically, as you move downstream from reach to reach in a watershed, the dominant watershed processes above the identified reach progress from one dominant type to another. For example, in small coastal watersheds the channel is often strongly coupled to the hillslopes and landslides dominate the stream channel morphology, but there are few alluvial reaches. Further downstream channels become partially coupled to hillslopes and landslides can trigger dramatic changes in alluvial reaches of the channel. As watershed area increases and hillslope and stream channel gradients become less, fluvial processes dominate channel morphology and the relative affect of hillslope processes is much less. Further downstream, the channel may become locally coupled to valley sides, where it is incised through thick glacial sediments.

Watersheds in different parts of the province have "typical" sequences of process types affecting the stream reach as one moves downstream (Appendix 1). Each of the types has a characteristic sediment budget, stream channel type, dominant processes affecting the stream reach, and appropriate restoration techniques (Figure 2).

A more complete description of each type, the dominant processes affecting the stream reaches and recommended priority restoration activities for that type are described in Appendix 1: Watershed Process Types and Associated Restoration Opportunities. A thorough description of watershed processes appears in Appendix 2: Watershed Dynamics, prepared by Dr. Michael Church (available on request from Heather.Deal@gems1.gov.bc.ca).

Use the compiled overview information for each subbasin (from Table 1) together with an appreciation of the dominant watershed components affecting the identified stream (as outlined in Figure 1 and Appendices 2 and 3) to estimate the impact on fish habitat of each component. The grid shown in the Table 2 example can be used to record this information.

Table 2. Impact by watershed component on fish habitat (Example: Rainy Creek)

Rainy Creek	Landslides	Gullies	Roads	Riparian	Channel
Habitat	M	M (old)	M	L	H

Step 5

Determine the potential for restoration success for each component in each subbasin

This step involves determining the potential for success in restoring each watershed component in each subbasin. The potential for success should be guided by the following principles:

- The main goal is to restore channel function so that the watershed will naturally recover critical habitat *at an accelerated rate*. Restoration work that addresses the component most strongly affecting the identified reach has the greatest potential for success.
- The most cost-effective works are those that address the *critical limiting* factors for the targeted fish species.
- Watersheds with a *single* impacted component generally have the *highest* potential for restoration success.
- Watersheds where *many* components are impacted (e.g., stream disturbance, landslide activity and hillslope erosion, and riparian disturbance have all contributed to habitat loss) have the *lowest* potential for restoration success.

Table 3 shows a decision-making matrix for the Maple River Watershed example. This is not intended as a "yes or no" matrix, but rather as a guide – using low, moderate and high ratings – to assist regional groups in understanding the complexities and interactions of watershed processes, and to help identify the target subbasins for more detailed assessment as outlined in Step 6.

The table helps to guide (and record) a procedure that evaluates the likelihood of restoration activities benefiting the probable limiting habitat for the fish species of concern. It does this in a stepwise fashion:

- in the first line for each creek under consideration, the *level of existing or potential disturbance* for each watershed component is noted
- in the second line, the *impact or risk that is posed to the critical fish habitat* by the disturbance is recorded.
- in the third line, the *likelihood of benefit to critical limiting fish habitat* from works on that component is given a rating.

In the example shown, under Howler Creek, there is a *high* riparian disturbance, and because the critical fish habitat is rearing habitat for Steelhead and Rainbow, the risk to that habitat is also given a *high* rating. Again, using the Howler Creek case, there is a *high* expected benefit from restoring the riparian component of the watershed that would be realized in the long term (>75 yrs).

Table 3. Examples of a procedure to evaluate the likelihood of restoration activities benefiting fish habitat in the Maple River Watershed

				Watershed Components					
Subbasin Example	**Target Species**	**Limiting Fish Habitat**	**Watershed Condition and Restoration Benefits**	**Landslides**	**Gullies**	**Roads**	**Riparian**	**Channel**	**Instream Fish Habitat**
Rainy Creek	Steelhead/ Rainbow	Summer rearing	Level of Existing or Potential Disturbance	Moderate	Moderate	Moderate	Low	High	High
			Impact or Risk to Fish Habitat	Moderate	Moderate	Moderate	Low	High	N/A
			Likelihood of Benefits to Fish Habitat from Restoration of Component	Low	Low	Low	Low	Low	Low
Howler Creek	Steelhead/ Rainbow	Summer rearing	Level of Existing or Potential Disturbance	Low	Low	Low	High	Moderate	Moderate
			Impact or Risk to Fish Habitat	Low	Low	Low	High	Moderate	N/A
			Likelihood of Benefits to Fish Habitat from Restoration of Component	Low	Low	Low	High (Long Term)	Moderate	High
Punch Creek	Steelhead/ Rainbow	Summer rearing	Level of Existing or Potential Disturbance	High	Moderate	Low	High	Moderate	High
			Impact or Risk to Fish Habitat	Moderate	Moderate	Low	High	Moderate	N/A
			Likelihood of Benefits to Fish Habitat from Restoration of Component	Moderate	Moderate	Low	High (Long Term)	Low	Low

Step 6

Identify the target subbasins for more detailed assessment, planning and restoration.

The format shown in Table 4 can be used to tabulate the ratings for each subbasin, summarizing the information from Table 3. The subbasins receiving one or more *high* ratings go on the priority list for restoration works. These subbasins have the greatest potential for positive outcomes to help speed the natural recovery process.

Table 4. Likelihood of restoration success (Example: Maple River Target Watershed)

Watershed	Subbasin	Low	Moderate	High	Primary Component for Restoration	Secondary Component for Restoration
Maple	Rainy	*			None	
	Howler			*	Instream habitat	Riparian
	Punch			*	Riparian	

This concludes ***Stage A*** of the process. Building on the information gathered thus far, ***Stage B*** sets out a *plan of action* for restoration works for each high priority subbasin within a target watershed.

B ~ Developing a Plan for Implementing Restoration Works Within Each Target Watershed

Following the initial identification of subbasins that are the best candidates for restoration works (outlined in the previous section), the task now is to create a detailed plan for each high priority subbasin in the whole watershed.

The ***Restoration Plan*** (RP) will include a work plan for each priority subbasin identified. The plan should:

- define restoration objectives for the whole watershed based on fish goals
- identify priority subbasins and targeted components for restoration work
- establish subbasin, component, and site-level restoration objectives
- identify appropriate restoration activities by component and site
- create an implementation plan for activities, including access management, and
- develop an effectiveness evaluation plan, and identify benchmarks for determining completion of work within the watershed.

The RP should follow an integrated, holistic approach and be focused on speeding recovery of freshwater fish habitat but particularly the watershed processes that create and maintain fish habitats. For this reason, activities are integrated with watershed processes and targeted to critical limiting factors. Decisions on habitat restoration activities and sites are also guided by the principle that restoration for the target species should not negatively impact or reduce habitat of other endemic fish species.

It is recognized that other factors – such as exploitation pressure or ocean survival – may be limiting fish-stock productivity. However, the fish habitat goals of RPs are focused on speeding the recovery of freshwater habitats and increasing survival at each freshwater life stage through the restoration of watershed components and processes. Although restoration activities are sequenced to favor the recovery of targeted species, it is expected that the recovery of watershed processes will restore habitat for other endemic fish species over the long term.

An eight-step approach is recommended to complete the task. The steps are summarized below. Detailed procedures for each step follow the summary list.

Step 1 Complete required assessments and/or obtain existing ones.
Step 2 Identify critical limiting factors and confirm the watershed components affecting these factors.
Step 3 Determine priority components for restoration.
Step 4 Develop subbasin, component, and site-level restoration objectives.
Step 5 Identify priority restoration activities and field locations.
Step 6 Select restoration alternatives through analysis of cost-effectiveness and risk.

Step 7 Develop an implementation plan.
Step 8 Complete a RP document encompassing work plans for all high priority subbasins in the watershed.

The user will find many of the steps seemingly repetitive from the previous section. The difference is that overview information is required to select priority subbasins in Stage A; whereas, detailed assessment information is needed here in Stage B to guide the development of a *Restoration Plan*. When complete, the RP document will present a *recommended* plan for the watershed, including detailed restoration activities at a subbasin level.

Step 1
Complete required assessments and/or obtain existing ones

Detailed information about watershed condition and habitat limitations for the identified fish species are obtained from focused field-based assessments. To secure this information, first review any existing assessments. *In many watersheds, previously completed assessments will be adequate to determine priorities for restoration works*. If no information is available, the following assessment(s) can be done.

Assessments in Target Watersheds

Here are the action steps when fish habitat is the issue:

- Determine the important reaches in each subbasin for the identified species.
- Complete a detailed fish habitat assessment on the critical reaches. If the critical limiting factors are known, the habitat assessment should assess only those habitat characteristics that relate directly to the critical limiting factors *within* the specific reach. A Channel Conditions and Prescriptions Assessment (CCPA) for specific reaches may be conducted as part of the habitat assessment where it is evident that stream channel instability is a concern. Also, a Fish Passage Culvert Inspection may be warranted if fish access is known or suspected within the subbasin.
- Complete a Riparian Assessment of only the identified, impacted reaches.
- Conduct either a Sediment Source Survey (SSS) – see WAP – or Erosion and Mass-Wasting Risk Assessment (EMRA) or equivalent on roads and hillslopes that could affect the identified reaches.

For the assessments in the final point above, the focus is on the following high-risk sources of sediment:

- roads with severe, active erosion from unconsolidated soils linked to a stream that is well above background rates of erosion (fill slopes into streams, high-raveling cutbanks, etc.)
- roads at risk of landsliding with linkage into a stream (e.g., midslope roads on steep slopes where a landslide will affect a stream)
- road crossings, particularly those on sensitive soils

- channel sediment sources where active streambank erosion is evident
- landslides, particularly those that are actively mass wasting
- eroding gullies tributary to a stream
- gullies at risk and tributary to a stream and
- livestock crossings.

Step 2

Identify critical limiting factors and confirm the watershed components affecting these factors

From the detailed fish habitat assessment, identify which element(s) of fish habitat are limiting the target fish's production. The elements of fish habitat include the nursery, rearing, food supply, and migration areas as well as the spawning grounds. For each stream reach, identify the factor(s) that are seen to be affecting specific elements of fish habitat or survival of particular life stages, and thus limiting production.

An increased sediment load, for example, is often a factor limiting for spawning (incubation survival) and rearing habitats. Freshwater fish survival may also be limited by a combination of factors, such as low nutrient concentrations, high temperatures and poor rearing habitat. Using a SSS, EMRA, CAP, Riparian Assessment or other appropriate procedures, identify the watershed components and processes that are causing or affecting the critical limiting factors.

Step 3

Determine priority components for restoration

Information to accurately identify important components for restoration can be summarized in a table or decision-making matrix. A completed example of this is shown in Table 5. This table is similar to Table 3, except that the table is now based on detailed assessment information. A greater understanding of the watershed occurs as new information becomes available. For example, the critical limiting habitat for Howler Creek in Table 3 was summer rearing habitat. After the detailed habitat assessments, the critical limiting habitat was identified as summer and winter rearing habitat in Table 5. The potential impacts of components and benefits of restoration on the critical limiting factors needs to be re-considered as new information becomes available.

Table 5 provides a mechanism to document watershed characteristics and condition, and to qualitatively assess the likelihood of significantly improving critical fish habitat for the species of concern by restoring specific watershed components. It includes a column for the dominant watershed process type for the identified reaches and rows organized in a progressive fashion:

- in the first line for each creek under consideration, the *level of existing or potential disturbance* for each watershed component is recorded based on information from the detailed assessments.

- in the second line, the *impact or risk that is posed to the critical fish habitat* by the disturbance is recorded.
- in the third line, the *likelihood of benefit to critical limiting fish habitat* from works on that component is estimated.

Each estimate in the third point above is conditioned by the watershed process type.

Step 4
Develop subbasin, component, and site-level restoration objectives

Subbasin, component, and site-level objectives provide the basis for all restoration and evaluation work conducted within a watershed. The objectives will direct the development of prescriptions and become a benchmark for future effectiveness monitoring. (For more information on developing restoration objectives, see the document: *A Framework for Effectiveness Evaluation of Watershed Restoration Projects 1999;* http://srmwww.gov.bc.ca/frco/bookshop/tech.html)

Where possible, restoration objectives should be phrased to address a particular watershed process (physical or biological) and *structured to address the critical limiting factors identified through the restoration planning process.* Component-level objectives include the road, gully, landslide, riparian, and stream components within a subbasin. Where appropriate, component-level objectives should specify the extent of risk reduction. For example, the objective may state that road deactivation works will reduce risk of road related slope failures from a high to a low risk level. Site-level objectives include distinct site features within each component (e.g., cutslope, fillslope, running surface, and ditches are sites that make up the road component).

All objectives should be:
- specific, measurable and attainable
- indicate a change in direction (increase or decrease) toward a more stable state or a future condition of reduced environmental risk, based on current conditions
- focused on manipulation of hillslope and stream processes in relation to Watershed Level objectives.

Table 5: Example of a decision-making matrix for identifying investment opportunities to address critical habitat limitations in a watershed based on targeting components with a high likelihood for success

Example for Maple River Watershed

Subbasin Example	Target Species	Watershed Process Type	Limiting Fish Habitat (from detailed habitat assessment)	Watershed Condition and Restoration Benefits	Landslides (from SSS)	Gullies (from SSS)	Roads (from SSS)	Riparian (from detailed habitat assessment)	Channel (from Re-CAP)	Instream Fish Habitat (from detailed habitat assessment)
Howler Creek	Steelhead/ Rainbow	High hillslope coupling	Summer and winter rearing	Level of Existing or Potential Disturbance	Low	Low	Low	High	Moderate	Moderate
				Impact or Risk to Fish Habitat	Low	Low	Low	High	Moderate	N/A
				Likelihood of Benefits to Fish Habitat from Restoration of Component	Low	Low	Low	High (Long Term)	Moderate	High
Punch Creek	Steelhead/ Rainbow	Partially coupled	Summer rearing	Level of Existing or Potential Disturbance	High	Moderate	Low	High	Moderate	High
				Impact or Risk to Fish Habitat	Moderate	Moderate	Low	High	Moderate	N/A
				Likelihood of Benefits to Fish Habitat from Restoration of Component	Moderate	Moderate	Low	High (Long Term)	Low	Low

Step 5

Identify priority restoration activities and field locations

This step identifies the general type of restoration activity proposed and the field locations where restoration prescriptions should be prepared. Watershed assessments completed in Step 1 will have identified reaches, segments, and sites that have experienced negative impacts of earlier forestry practices and would benefit from restoration. Step 3 identified components with a high likelihood of improving habitat. From this information, it is possible to identify the sites, segments or reaches for each high priority component where restoration prescriptions will be prepared. Restoration work in a subbasin can occur on multiple high priority components and at multiple sites for each high priority component. These locations should be illustrated on a map.

The Table 5 matrix is used to identify which component(s) have the greatest potential to affect the critical limiting habitat of the identified fish species through restoration works. Within each component, a variety of activities are possible but each may be judged by the restoration professional to have a certain level of effectiveness. The following is provided as a set of restoration alternatives for each component that have been grouped into 'levels of effectiveness' based on the effectiveness of treatments observed in restoration projects to date. Treatment effectiveness was based on a general assessment of cost-effectiveness, risk, primary or persistent sediment sources, and whether benefits were expected in a long or short time period. Preventative work is seen as the most cost-effective. It is recognized that exceptions to these levels of effectiveness may exist or will occur with further experience in watershed restoration. The choice of treatment will depend ultimately on the assessment by and experience of the restoration professionals.

Hillslope Component

Highly Effective

- Drainage control and road deactivation on roads at high risk of landsliding into the stream.
- Drainage control and revegetation on roads on unconsolidated sediments (glaciolacustrine or glaciofluvial) with recurrent point soil erosion sources and high delivery to a stream.
- Recovering, unstable fills and old bridge abutments at stream crossings (all watersheds).
- Hand- and heli-seeding of exposed mineral soil sites.

Moderately Effective

- Gully restoration of high-risk gullies.
- Drainage control and road deactivation on moderate-risk sites.
- Road ripping and revegetation of roads (except as specified above).

Least to Moderately Effective

- Landslide stabilization using bio-engineering techniques. The appropriateness of landslide stabilization techniques is best determined at the site level on an individual cost- effectiveness analysis. In general, however, landslide scars are not significant parts of the watershed sediment budget and the cost of mechanical or bio-mechanical stabilization is high. Where sediment yield is high, with a high consequence, the priority will be greater.

Riparian Component

Highly Effective

- Riparian works immediately adjacent to instream or off-channel habitat rehabilitation to obtain both short- and long-term benefits.
- Riparian work that will provide shade in a few years.

Moderately Effective

- Riparian work upstream of but in the same reach as prescribed instream works. While downstream movement of large woody debris (LWD) occurs, the majority of the benefit of riparian re-growth for LWD recruitment is realized in the same reach.

Least Effective

- Restoration of riparian forest not associated with instream work.

Stream Channel Component

Highly Effective

- Bank stabilization structures, such as “debris groins” that also provide instream habitat.

Moderately Effective

- Streambank stabilization using vegetative revetments at key sites.
- Bar stabilization using planted willow and cottonwood.
- Bank stabilization using integrated structures at key sites.

Least Effective

- Bank stabilization using rock at key sites. This treatment is less beneficial as fish habitat then when rock is integrated with LWD. However, for certain high energy sites it may be the most appropriate technique.

Fish Habitat Component

Highly Effective

- Removal of fish migration barriers where roads cross streams.
- Restoration of floodplain habitat through removal of barriers to back channels and side-channels and other off-stream habitat.

Moderately to Highly Effective

- Restoration and construction of off-channel habitat. This includes restoration of access by fish to historic off-channel habitats.

- Instream structures. The feasibility, type and number of channel structures that are appropriate are determined through the use of diagnostics for the channel type.

Least to Moderately Effective

- Stream fertilization using slow release fertilizer on nutrient-poor streams. Fertilization is most effective when coupled with physical habitat restoration and conservative risk fisheries management.

Step 6

Select restoration alternatives through analysis of cost-effectiveness and risk

For each subbasin, start by tabulating the existing restoration work and the future priority opportunities associated with each component. For each opportunity, list the anticipated cost and the habitat benefit expected. Anticipated costs should encompass all costs needed to fully implement a treatment. For example, riparian treatments may require follow-up manual brushing treatments over several years or stream fertilization may occur annually over multiple years.

This summary of investment opportunities (by watershed) can be used to identify potential trade-offs between activities and allow resource managers to make informed choices. It may still be necessary to choose between worthwhile priorities, given a restricted budget. In such cases, watershed-specific information on resource benefits and priorities, anticipated costs, and residual risks can be used to compare benefit and costs, and make choices on allocating funds between areas and activities. Refer to 'Revisions to the Forest Road Engineering Guidebook' (FPC) for a detailed method of risk assessment.

To compare investment opportunities within a watershed, the following premises apply:

- Complete, balanced mixes of activities are usually needed to effectively rehabilitate areas affected by past forest practices. The optimum mix depends on site conditions and restoration objectives. Therefore, in allocating funds choices should be made regarding which watersheds to address, without compromising any of the recommended activities for a chosen watershed.
- Total funding needed to implement restoration activities at the specified risk-level should be calculated for each watershed. Also, restoration costs associated with a reduction in risk to a specified risk level (e.g., high to low) should be factored into the calculations. Estimated costs correspond to a defined scope of activities. These are fixed amounts for that watershed – *not* flexible to fit available budgets. It costs what it costs.
- The use of cost-effectiveness comparisons is encouraged to systematically rank a large array of restoration options. For example, the priority, costs and resource benefits of various culvert replacements to improve fish access could be compared to additional hillslope, riparian or instream treatments. This will allow the selection of activities offering greater returns earlier in the restoration sequence.

- Watershed restoration techniques must be done on the principle of adaptive management. Follow-up monitoring of effectiveness in achieving results is a necessary funding item.

In some cases, activities may simply cost too much for the benefit that accrues. The recommended approach is to set maximum amounts – specified on a $/km of road, $/landslide, or $/km of treated-stream basis. Activity costs that *exceed* these amounts should have an individual cost-effectiveness analysis completed. This approach has the administrative advantage of simplicity and repeatability.

Step 7

Develop an implementation plan

The *Implementation Plan* should provide details for all subbasins that will receive attention. Samples of a suitable format are included in the accompanying document, *Restoration Plan: An Example*. The following background may be helpful in preparing the plan.

Worksite Priorities and Prescriptions

A map will be prepared that shows the proposed sites, segments or reaches where prescriptions for each priority component are recommended. Prescriptions are prepared for all high-priority components and on those sites identified in Step 6. This activity can be undertaken concurrently for all components.

Access Management

An *Access Management Plan* should be prepared for the entire subbasin. The goal of the access management plan is to integrate the watershed restoration plan with the needs of the various users of the watershed. Access management planning identifies current and future access needs in the watershed so that roads which may be needed for access are not deactivated without due consideration. This will involve addressing known access management strategies and/or developing strategies to the satisfaction of the District Manager (where access strategies are not known or not available). The following references will be useful for preparing access management plans: Watershed Restoration Program Technical Circular No.3, page 14; Integrated Watershed Restoration Plan, Schedule A, Section 5; and Forest Road Regulation, part 5.

Time Frame of Works

Works are generally completed from the top down. That is, work progresses from the hillslopes, to the gullies, to the riparian, and finally to the stream channel (Johnston and Moore 1995 in WRP Tech Circ. 1). However, depending on the watershed type, some of these steps can be omitted or works can be completed in parallel (as shown in Figure 2 on the next page). Some flexibility or discretion is needed for these decisions owing to site-specific conditions. For example, restoring fish access at culvert crossings may take precedence over all restoration works and be implemented first. Alternatively, hillslope works may occur concurrently with construction of an off-channel habitat that is isolated from potential sediment impacts.

Figure 2. Typical Restoration Activities and Sequencing by Watershed Process Type

Activities in the same column can be undertaken concurrently. See Appendix 2 for further clarification of watershed process types.

Time →

Implemented First	Implemented After or Concurrently With Activities in Left Column[1]
Hillslopes Coupled and High Channel Connectivity (Step-Pool Morphology)	
Stabilize Roads	
Stabilize Gullies	
Restore Fish Access	
Partially Coupled and High Channel Connectivity (Cascade-Pool/Riffle-Pool Morphology)	
Stabilize Roads	Restore/Construct Off-Channel Habitat
Stabilize Gullies	Floodplain Restoration
Erosion / Drainage Control	Riparian Restoration
Restore Fish Access	Bank Stabilization
	Construct Instream Structures
Uncoupled Hillslopes and Low to Moderate Channel Connectivity (Riffle-Pool Morphology)	
Fine Sediment Source Control	Restore/Construct Off-Channel Habitat
Bank Stabilization	Floodplain Restoration
Restore Fish Access	Riparian Restoration
	Construct Instream Structures

[1] Implemented after activities in left column have stabilized conditions, or can be done concurrently with left column activities if existing watershed component conditions and processes (eg., sediment delivery, flow regime) do not negatively impact restoration works.

All high-priority work should be completed in each of the priority subbasins of the target watershed before moving on to another watershed. This is important because:

- a significant amount of work must be done in a watershed before *any* measurable benefit can be obtained
- access may be cut off by road deactivation, and
- the interactive nature of the projects means the benefits of the restoration activity accrue synergistically.

There may be economies of scale that make a combination of projects less expensive to complete together rather than in isolation. Non-completion of an integrated, or multi-project, watershed restoration program may simply postpone the resource benefits to be derived from the whole program.

Milestone/Restoration Completion Benchmarks & Evaluation

For accountability and reporting purposes, the RP must address the issue of *completion* for each target watershed. To this end, the RP should describe benchmark(s) for determining when project expenditures can be concluded.

Expenditures in aquatic restoration projects will fall into three distinct phases: planning/assessment, major works, and evaluation/maintenance. The *planning and assessment* phase includes overview and detailed assessments as well as the preparation of restoration designs. In the *major works* phase, restoration treatments on all high-priority works are implemented. The third phase – *evaluation and maintenance* – continues beyond the major works phase. It encompasses the implementation of routine effectiveness evaluations as well as maintenance and additional treatments, if appropriate.

Three to five years after completion of all high-priority works, a brief status report on watershed recovery will be provided by qualified professionals doing the routine evaluations. The report will provide an interdisciplinary evaluation on the state of recovery of the subbasin and on the effectiveness of restoration treatments at meeting the stated restoration objectives. Specifically, this report will:

- summarize routine evaluation findings
- describe the present status and extent of recovery of the watershed components (e.g., sediment sources; levels of risk on roads, landslides and gullies; hillslope, riparian, channel and habitat condition)
- describe the state of recovery of watershed processes
- provide the rationale if further restoration work on recently identified high-priority sites or moderate-priority sites is required, and
- identify the specific sites requiring maintenance or treatment.

Helpful background information is included in the document: *A Framework for Effectiveness Evaluation of Watershed Restoration Projects*. Samples of the practical application of this appear in *Restoration Plan: An Example.*

Budget

Estimate costs for the restoration prescriptions, implementation of restoration works and the routine effectiveness evaluations. Ensure that the costs reflect the implementation of all evaluations and restoration work for each treatment, even if the work occurs over multiple years (e.g. follow-up manual brushing in a riparian treatment or multiple stream fertilization treatments).

Step 8
Complete a RP document for the target watershed

The RP document should be prepared for the target watershed and include the following:

- A summary on the rationale for investment and a brief introduction.
- The rationale for selection as a target watershed.
- Description of the watershed – location, boundaries, category, and dominant processes affecting the watershed.
- A map of the targeted watershed with all subbasins identified and their priority shown (~1:50,000).
- Specification of priority subbasins.
- Subbasin maps, showing detailed assessment highlights, and targeted restoration sites.
- Restoration priorities for subbasins, with information on basin condition, limiting fish habitat, and access management.
- Statement of specific restoration objectives (at the subbasin, component, and site levels) with activities for each components ranked in priority order.
- An implementation plan, including information on work-site priorities, time frame of works, and milestone and restoration completion benchmarks, an effectiveness evaluation plan, an access management plan and a budget.

Assessments do not need to be included in the plan, but should be referenced and available.

The accompanying documents*, Restoration Plan: A Coastal Example* and *Restoration Plan: An Interior Example,* can serve as guides in preparing similar documents in the regions. Following the format and style of these documents will ensure consistency and allow for easy reference to new plans as they become available.

Applying the Guidelines Where a Restoration Plan Exists and/or Where Considerable Work Has Been Completed

Previously completed *Restoration Plans* for target watersheds should be revised to reflect the new emphasis on targeted resource values. The key is to tie ongoing and planned works to the new goals. In some cases, decisions will have to be made using best judgment where dated assessments are less than perfect for the new goals. The revised RP should outline the watershed processes, critical limiting factors, restoration objectives, results of the assessments, high-priority components, and the schedule of works required to complete restoration in each subbasin. A checklist is provided to help determine possible shortfalls in an existing RP. Steps in the RP planning process that have been missed or that need to be revisited will be identified by the checklist.

The checklist can also be used if restoration in a watershed has progressed to the implementation phase and prescriptions or restoration works have been undertaken. Again, it is important that the restoration objectives be described relative to the revised goals of the RP, and that future restoration work relate to the revised site-level objectives.

Figure 3: Checklist for Determining Possible Shortfalls in a Completed RP

If the answer is 'No' to a specific question, refer to the specified sections (Stage A or B) of this planning guide (Stage:Step).

Yes	No	Product
	A:1-6	Are there maps and a general description of the target watershed that include its location, boundaries, and geomorphological type?
	A:1-6	Are there maps of the targeted watershed with all subbasins identified and their priority shown?
	A:4-6	Is there a rationale for the selection and prioritization of the watershed and subbasin(s) for restoration?
	B:1	Are there subbasin maps, showing Level 1 and Stage 1 Assessment highlights, and targeted restoration sites?
	B:2-3	Has the interpretation of watershed conditions and habitat limitations been done in relation to the revised RP goals?
	B:2	Have the critical limiting factors been identified for the subbasin?
	B:3	Have the components been ranked in priority order of restoration at the subbasin level?
	B:4	Have subbasin-, component- and site-level restoration objectives been stated?
	B:5-6	Do proposed prescriptions or restoration works meet the revised objectives of the RP?
	B:5-6	Have anticipated restoration works been identified that address the priority components (i.e., site, anticipated type of work)?
	B:5-7	Is there a description of the critical work?
	B:6	Have the proposed restoration works been assessed for the acceptable level of risk?
	B:7	Have milestone/completion benchmarks been described and scheduled?
	B:7	Is there a project Implementation Plan?
	B:7	Is there a schedule of works?
	B:7	Is there an Access Management Plan?
	B:7	Is there a projected budget with estimated costs for each component?
	B:7	Is there an evaluation plan for assessing performance of restoration works, achievement of goals and objectives, a measure of the state of recovery of the watershed, cost-effectiveness of restoration work, etc.?

Assessments Commonly Applied in Watershed Restoration Projects

Overview and Stage 1 Levels

Hillslopes: Erosion and Mass-Wasting Risk Assessment (EMRA)
Sediment Source Survey (SSS) now used primarily for Forest Practices Code
Access Management
Gully Assessment Procedure

Riparian: Overview Assessment

Channel: Channel Assessment Procedure (CAP)

Stream Habitat: Overview Fish Habitat Assessment Procedure (FHAP)

Detailed Assessments (Level 1)

Riparian: Level 1 Riparian Assessment

Channel: Channel Conditions and Prescriptions Assessment (CCPA)

Stream Habitat: FHAP Level 1 Field Assessment

Restoration Designs or Prescriptions (Level 2)

Hillslopes: Prescriptions for Road Deactivation, Road Modifications, Landslide and Gully Rehabilitation

Riparian: Level 2 Riparian Assessment

Stream Habitat: FHAP Level 2 Field Assessment

List of Abbreviations

CAP	Channel Assessment Procedure
CCPA	Channel Conditions and Prescriptions Assessment
CWAP	Coastal Watershed Assessment Procedure
ECA	Equivalent Clearcut Area
EMRA	Erosion and Mass-Wasting Risk Assessment
FHAP	Fish Habitat Assessment Procedure
IWAP	Interior Watershed Assessment Procedure
IWRP	Integrated Watershed Restoration Plan
LRMP	Land and Resource Management Plan
LWD	Large Woody Debris
MWLAP	Ministry of Water, Land and Air Protection
MoF	Ministry of Forests
Re-CAP	Reconnaissance-level Channel Assessment Procedure
RP	Restoration Plan
SSS	Sediment Source Survey

Appendix 1
Watershed Process Types and Associated Restoration Opportunities

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WATERSHED PROCESS TYPES AND ASSOCIATED RESTORATION OPPORTUNITIES

The following discussion outlines a simple classification system for B.C. watershed process types based on the degree to which the stream channel is coupled to the hillslopes and the connectivity of the stream channel reaches. Watersheds have unique combinations of physiography, climate and geology which drive the geomorphic processes that determine the sediment supply, the stream discharge, the channel type and ultimately the fish habitat. The main difference between watershed types is the degree to which the hillslopes are connected to the streams (its hillslope connectivity or coupling) and the capacity of the stream to transport sediment (its stream connectivity). Typically, as you move from reach to reach, downstream through a watershed, the dominant watershed processes above the identified reach progress from one dominant type to another. Certain watershed restoration techniques will be more effective than others depending on the watershed process type. However, exceptions to the following discussion will occur. For example, lake-headed watersheds may reduce potential peak flow and sediment impacts downstream and thereby reduce the risk to instream structure works in otherwise unstable channels.

High hillslope coupling and high channel connectivity - small channels (<10 km^2) in mountainous areas

Small streams in the Coast mountains and wet Interior mountains are directly "coupled" to the hillslopes; that is landslides from the hillslopes directly enter the stream channels. Small streams also experience floods infrequently but with much greater extremes than larger watersheds, resulting in the main sediment transport mechanism being debris flows. Post logging acceleration of these sediment input rates can be 2-10x natural rates. Sediment moves through the reach mainly through debris flow events on a time scale of 20 - 100 years. Small steep gradient streams typically have a robust boulder step-pool structure which is not easily destabilized and recovers quickly once destabilized.

Preventative works
Maintain hillslope, road and gully stability.

Remedial works
Re-establish natural drainage of roads, pullback of sidecast material at potentially unstable sites and remove unstable slash from gullies.

Coupled hillslopes and high channel connectivity - Coastal and wet Interior mountain channels of order 10 to 30 km^2

On the Coast and wetter Interior mountains, stream channels in watersheds of 10 to 30 km^2 area are typically coupled to the hillslope, but in the zone immediately below headwater slopes the channel can become partially decoupled across floodplains. The greatest source of sediment is landslides and debris flows. These sources are 10-100 times as significant as any other sediment source.

Channels in this type of watershed exhibit the greatest structural complexity of any. They are subject to large sediment inputs from landslides and banks and strongly influenced by woody debris in diverting flow and storing sediment. Storage of bed material can increase rapidly. Dramatic channel aggradation is possible, because fluvial transport out of the reach can be much less than sediment input rates.

Preventative works

Maintain hillslope stability.
Maintain riparian forests.

Remedial works

The emphasis should be on maintaining slope stability of roads and gullies as even at this scale mass wasting is the primary sediment source. Riparian and channel stabilization work in wet mountainous areas may be futile unless it can first be established that sediment from the hillslopes has declined. The time for the sediment to work its way from the gullies into and through the critical reaches can be on the order of 50 to 100 years. A single large flood can destroy the effect of channel or riparian work. In watersheds with unstable slopes, the most effective management procedure is light engineering work on the floodplain to assure the maintenance of secondary and back channels.

In stream channels, structures in this type of watershed with a high hillslope sediment load are very risky. Structures should be placed in channels that are stable, or only modestly unstable, and replicating natural circumstances as far as possible. Habitat restoration may be limited in the short term to small tributaries and off-channel wetlands situated adjacent to the valley walls. Once the hillslopes have stabilized, riparian re-vegetation of bartops and riparian re-generation of stream banks is warranted.

Partially coupled hillslopes and high channel connectivity - Coastal and Interior mountain channels of order 100 km^2

Larger streams on the Coast and Interior mountains exhibit valley flats, floodplains and uncoupled stream channels in their downstream portions. They experience significant floods relatively more frequently, but they become relatively less extreme. Flows are less variable than further upstream.

The greatest source of sediment to coastal mid-sized streams is progressive channel bank erosion, with the initial disturbance often triggered by landslide inputs. The fluvial sediments are highly mobile and floods move the bed materials annually. Significant volumes of material are stored in the floodplain. Mid-sized streams are typically pool-riffle streams in which most of the channel bed is wetted at moderate flow indicating a channel that is capable of transporting the sediment supplied to the channel. Large woody debris forms an important element of the channel and log jams can dominate the storage and transport of gravel as well as channel avulsion onto the floodplain. If increased bed material is delivered, then much of it is stored in the channel, diverting flow to the banks and further increasing sediment load in the channel. The channels are sensitive to a change of sediment regime because gravel mobilized upstream move into bars and progress further downstream only slowly, on average a few meters a year. Hence a sharp increase in gravel supply creates aggradation in the reach. The stream is diverted around the deposits growing in the channel, attacks the banks, and recruits more gravel sediment and woody debris. Because the total volume of sediment stored in the reach may be greatly increased in a relatively short period of time, it is possible for these channels to become dramatically unstable. A disturbance created by natural or induced slope instability in the headwaters may take decades to a century or more to work its way through the reach. Such channels are very sensitive to loss of riparian forest. Historical studies have shown dramatic channel widening following riparian forest harvesting. This process is eventually attenuated downstream when the bed material is incorporated into the reconstructed floodplain.

Preventative works
Maintenance of hillslope stability.
Maintenance of riparian forest.

Remedial works
Restoration of hillslope stability to cut off “triggering” bedload.
Restoration of riparian forest is essential.
If these stream channels are already unstable, it will be a long time before the benefits of hillslope restoration will become apparent. After sediment delivery from the hillslopes has been stabilized, instream works can be considered.

Uncoupled hillslopes and moderate channel connectivity - Interior plateau channels of order 100 km^2

Interior plateau streams at this scale can be coupled or uncoupled from the hillslopes. Regardless, the natural landslide sediment supply is generally quite low. The greatest source of sediment to these streams is where they are incised through stored glacial sediments and through mass wasting the sand and silts from these deposits are entering the stream. Floodplains and streambanks are easily destabilized by loss of vegetation; cattle can be a major factor in destabilizing streambanks and channels. Where stream channels are steeper gradient boulder controlled cascades have the capacity to transport the sediment out of the watershed and into the larger river system below, where it can accumulate in fans or floodplain deposits. Channels are typically less affected by LWD input.

Preventative works
Maintenance of streambank vegetation.
Avoidance of direct damage to streambanks.

Reduce fine sediment sources, particularly where roads are designed across glaciofluvial or glaciolacustrine deposits.

Remedial works

Reduction of fine sediment sources at road crossings and on roads crossing glaciofluvial or glaciolacustrine soils.
Restoration of streambank vegetation.
Off- and in-channel restoration works.

Uncoupled hillslopes and low channel connectivity - small channels on lowlands or in the Interior plateau of order 1 to 10 km^2

Small streams flowing through low relief areas are much less flashy and channels are incised or meandering. Without hillslope sediment sources, sediment loads are minimal. These streams are decoupled from the hillslopes and have low stream connectivity.

Preventative works
Prevent destruction by traffic entering the riparian zone, avoiding slash accumulations in the channel and prevent the introduction of fine sediment from roads.

Remedial works
Restoration opportunities are to reduce fine sediment input from road related sources, particularly at stream crossings and to re-open fish migration barriers.

Low hillslope coupling and moderate channel connectivity - Coastal and southern Interior channels of order 1000 km^2

The downstream reaches in coastal watersheds at this scale are typically decoupled from the hillslopes. The greatest source of sediment to large streams is river bank erosion of stored alluvium. Channel gradients are low and bed materials are medium to fine gravel or sand. Gravel movement is on an annual basis. LWD does not play a major channel structural role, but may block side-channel entrances. Purely fluvial processes dominate the channel morphology. Channel instability is caused by fluvial erosion of stream banks and progressive lateral shifting, punctuated by avulsions where secondary channels are re-occupied. The effects of headwater disturbance reach these channels only after some years and are considerably attenuated. Induced sediment mobilization affects these channels only moderately. If a major disturbance were to occur it would take centuries to pass the sediment pulse through the system. Because of the long time scale, it becomes difficult to impossible to separate the effects of land use or restoration from changes created by natural changes in the environment. Monitoring programs at this scale of watershed would not be able to detect any impact that watershed restoration was having.
The exception to this is situations where there is a chronic supply of fine sediment from upstream sources. In the larger channels, deposited wash material can become a persistent problem with veneers of sediment or interstitial fills.

Remedial works
Restoration should focus on opening fish migration barriers on floodplains and on attempting to reduce the stream entry of fine sediment from the largest point sources. Rates of channel migration may be controlled by riparian vegetation reestablishment, however the efficacy of this unanswered. Off-channel habitats may be created on the floodplain, but instream habitat works would be limited in the larger channels.

Coupled valley sides - northern Interior channels of order 1000 km^2

Large northern Interior rivers are often incised through very thick glaciolacustrine sediments and the channel is strongly coupled to the near hillslopes. Undermining of toe slopes and slow creep in the glaciolacustrine sediments ensure a continual supply of fine sediment to the channel. Mobilization of fines from widespread glaciolacustrine silts is a major problem in some areas. Land use activity on valley terraces and lower slopes frequently rearranges drainage, resulting in gullying or slope failure along the terrace edge. Large woody debris generally plays only a minor role in channel stability.

Preventative works
Hillslope soil erosion control and drainage control is the main preventative measures.

Remedial works
Fixing point sources of fine sediment is probably inconsequential. The sediment budget is dominated by natural slumping of streamside glacial sediments.