ABSTRACT

The Fish Habitat Assessment Procedure (FHAP) is one component of an integrated watershed restoration project conducted for the B.C. Ministry of Environment, Lands and Parks (MoELP) by Dillon Consulting Limited (Dillon) in the Sage Creek watershed. Sage Creek is located in the extreme southeast corner of the province (East Kootenays) in both the Engleman-Spruce and Montane-Spruce Biogeoclimatic Zones. The objective of the FHAP was to identify areas of the Sage Creek watershed where salmonid habitat has been degraded by past forest harvesting or related activities. As well, rehabilitation procedures which are applicable to specific areas were developed to maintain and enhance the extent and quantity of critical fish habitats presently available within the watershed.

An impassable fish barrier (5 metre high waterfall) limits fish access to the lower seven reaches (approximately 23 km) of Sage Creek. The quantity and quality of fish habitat in these reaches has been impacted by various forestry-related activities conducted in the mid- and upper watershed. These activities (logging, resource development, insect damage and wildfires) have resulted in the removal of large areas of forest cover, particularly in the mid and upper reaches of the watershed. Poor forest harvesting practices, such as extensive harvesting of riparian areas and construction of access roads adjacent to and through streams has resulted in the destabilization and subsequent erosion of soils, extensive areas of soil compaction, changes to the historic hydrologic regime and the overall loss of riparian function. These impacts have cascaded through the ecosystem promoting the increased rate and quantity of sediments delivered to the Sage Creek channel, and the deterioration of fish habitat in the fish-bearing reaches of the watershed.

Fish habitat restoration will not take place until problems in the upslope, riparian, and channel morphology are addressed. Restoration activities proposed will address a lack of pool habitats in the fish bearing reaches. Specific techniques proposed include placement of large woody debris structures, selective thinning of a large log jam, as well as the monitoring and possible protection of several critical off-channel habitats which may be blocked by transported sediment prior to channel stabilization. These measures, combined with efforts at channel and riparian rehabilitation will result in an improvement to overall watershed health.

SAGE CREEK FISH HABITAT ASSESSMENT PROCEDURE (FHAP)

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APPENDICES

1.0   INTRODUCTION

1.1.   Background

The Fish Habitat Assessment Procedure (FHAP) is one component of the Sage Creek Integrated Watershed Restoration Project.   Other components are the Riparian Assessment and Prescription Procedure (RAPP), and the Channel Condition and Prescription Assessment (CCPA). These project components have been synthesized into an integrated watershed assessment and restoration document (*Sage Creek Integrated Watershed Restoration Project Report*) which is bound under separate cover.

Sage Creek is thought to have historically provided important spawning and rearing habitat for bull trout (*Salvelinus confluentus*) populations of the Flathead River system (Fraley and Shepard, 1989 and T. Weaver, *personal communication*), as well as mountain whitefish (*Prosopium williamsoni*), and westslope cutthroat trout (*Oncorhychus clarki lewisi*). Available information is limited but it is believed that there has been a decline in fish populations likely resulting from the degradation of the quality of these spawning and rearing habitats associated with past forest harvesting activities. Behnke (1972), for example, reported an estimated 99% decline in original populations of interior cutthroat trout over the past 100 years.

In response to these declines, some preliminary watershed assessment/inventory work was conducted in the Sage Creek watershed. According to a variety of sources described in Section 3.0, and confirmed by the results of an Interior Watershed Assessment Procedure (IWAP) conducted by Columbia Environmental Services (1996), the Sage Creek watershed has been severely degraded, at least in part, due to poor forest-harvest practices of the past. The problem has been compounded by insect infestation and wildfires.

In July 1997, Dillon Consulting Limited was retained by the Kootenay-Boundary Region of the B.C. Ministry of Environment, Lands and Parks (MoELP) to conduct a FHAP using standard Watershed Restoration Program (WRP) and Forest Renewal British Columbia (FRBC) protocols as part of an integrated watershed assessment and restoration project. This technical report presents and discusses the methods and results of the FHAP undertaken in the Sage Creek watershed by Dillon Consulting Limited in 1997.

1.2.   FHAP Objectives

The Sage Creek FHAP was conducted in two phases - the Overview Assessment Phase and the Level 1 Field Assessment Phase. Activities associated with each phase are described below.

1.2.1.   Overview Assessment

The Overview Assessment is intended to identify the general nature of impacts of forest-harvesting, to identify areas of potential concern, and to focus field activities on areas where restoration and rehabilitation measures can be implemented.

The specific objectives of the Overview Assessment of the Sage Creek FHAP were to:

? determine what fish species (and life stages) are at risk due to the impacts of poor forestry practices in the watershed;

? identify and prioritize sub-basins and reaches (if possible) requiring further quantitative detailed fish habitat surveys, prescriptions and rehabilitation;

? identify preliminary restoration opportunities and strategies; and

? propose a field program for Level 1 Assessments.

1.2.2. Level 1 Field Assessment

The Level 1 Field Assessment procedures represent assessment tools which were intended to confirm the nature and specific locations of impacts arising from forest-harvesting practices and to identify effective restoration prescriptions which will benefit impacted watersheds.

There were five specific objectives to the Level 1 Assessment of the Sage Creek FHAP. They were to:

? confirm or revise information from the Overview Assessment regarding the nature, location, extent and severity of forest harvest impacts on fish habitat;

? assist with locating important contemporary and historic habitats for salmonids, and prioritizing restoration work of these habitats based on their relative health;

? collect sufficient information to identify and prioritize restoration options, and to identify initial project objectives and scope;

? identify the need for any level 2 assessments; and

? prepare budgets and schedules for fish habitat restoration projects.

2.0   STUDY AREA

The Sage Creek watershed is located in the extreme southeast corner of the province, in the South Peak Ranges Hydrologic Zone, and within both the Engleman-Spruce and Montane-Spruce Biogeoclimatic Zones (Figure 1). Over 4,000 hectares of the watershed have been logged and harvestable timber has been impacted in other areas by pine and spruce beetle infestation and wildfires.

The watershed covers over 22,000 hectares and encompasses over 450 kilometres of waterways. The Sage Creek mainstem is approximately 42 kilometres in length and drains to the Flathead River system. The confluence of Sage Creek with the Flathead River is located just south of the Canada-U.S.A. border in Montana. Twenty sub-basins make up this fourth-order watershed. Major tributaries of the watershed include Ruby Creek, Langemark Brook, Sunkist Brook, Flanders Brook, Roche Creek, and Nettie Creek, as well as a number of smaller unnamed watercourses.

Significant fish species of the Sage Creek watershed include westslope cutthroat trout, mountain whitefish, and bull trout. Bull trout is a "blue-listed", or vulnerable, species in British Columbia indicating that this species' characteristics make them particularly sensitive to human activities or natural events. Bull trout and cutthroat trout represent the target species for restoration efforts in the Sage Creek watershed.

2.1.   Watershed Hydrology

The hydrologic response of interior watersheds to meteorological influences situated within the south-eastern areas of British Columbia is strongly influenced by the surrounding topographical relief of the local mountain ranges. It is this feature that dictates the local hydrologic conditions of the Sage Creek basin. Although there are no climate or streamflow monitoring gauges operating within the Sage Creek basin, data sources collected from stations located within nearby geographically and hydrologically similar basins were available for use in this investigation and enabled the approximation of runoff characteristics of the Sage Creek basin.

2.2.   Meteorology

Precipitation statistics were provided by Atmospheric Environment Service (A.E.S.) climatological monitoring stations operating at 4 sites in the vicinity the Sage Creek basin study area. Stations used in this review included AES operated stations at Fernie and Elko, B.C. and Beaver Mines, Alberta. In addition to the above Canadian-operated stations, selected statistics were also retrieved from the U.S. operated Kalispell monitoring station in Montana. The nearby Beaver Mines station is the geographically closest and highest elevation monitoring station in the region and presumably represents a reasonable estimate of the monthly distribution of precipitation for at least the lower reaches of the Sage Creek basin. Annual precipitation statistics for the Sage Creek basin were derived by prorating the statistics from the Beaver Mines station with the regional average total annual precipitation of 800 mm as shown in Table 1. Also included in the table are the average monthly temperature estimates for the Beaver Mines Station which are deemed to be reasonably similar to those conditions experienced in the Sage Creek basin.

Table 1   **Sage Creek basin Monthly Precipitation and Temperature Estimates**

Month	Rainfall (mm)	Snowfall (water equivalent)(mm)	Precipitation (mm)	Mean Monthly Temperature
January	3.8	70.7	74.4	-2.6^{o}C
February	2.6	55.0	57.5	0.7 ^{o}C
March	3.3	66.5	69.8	3.6 ^{o}C
April	15.0	76.3	91.3	9.5 ^{o}C
May	64.4	18.3	82.6	14.9 ^{o}C
June	81.2	0.5	81.7	19.2 ^{o}C
July	47.5	0.0	47.5	22.9 ^{o}C
August	50.6	0.0	50.6	22.4 ^{o}C
September	50.1	12.9	63.0	16.9 ^{o}C
October	16.8	29.1	45.8	11.8 ^{o}C
November	9.6	56.5	66.1	3.1 ^{o}C
December	5.2	64.5	69.6	-1.7 ^{o}C
Annual	**350.0**	**450.0**	**800.0**	**10.1 ^{o}C**

2.3.   Watershed Runoff (streamflows)

By utilizing precipitation trends and watershed physiographic features as screening tools, several streamflow monitoring stations operated in the region were noted to experience reasonably similar climatic conditions, and were therefore selected to assist in deriving runoff statistics for the Sage Creek basin. Four watersheds gauged by Water Survey of Canada (Environment Canada) were used for this analysis and presented in Table 2.

Table 2   Characteristics of Gauged Watersheds Used to Derive Runoff Statistics

Watershed	Wastershed Area	Period of Record
Couldry	118 km^2	1974 – 1992
Howell	145 km^2	1979 - 1994
Castle	376 km^2	1967 - 1994
Waterton	614 km^2	1949 – 1994

The above list of selected stations possess drainage areas (118 - 614 km^2) that encompass or bracket the 220 km^2 measured drainage area for the outlet of Sage Creek, and therefore enable a good estimate of the Sage Creek runoff characteristics.

Using streamflow statistics from the above-noted gauges, the average monthly flow for Sage Creek was estimated. The results are summarized in Table 3.

Table 3   Mean Monthly Flows for Sage Creek

Month	Mean Flow (m^3/s)	Month	Mean Flow (m^3/s)
January	0.9	July	7.7
February	0.7	August	3.0
March	1.1	September	2.1
April	4.3	October	2.0
May	16.2	November	1.5
June	18.5	December	1.0

Estimates of maximum instantaneous flow (*i.e.* peak flow) were also derived from information obtained from the four gauged watersheds discussed above. Extreme peak flows were determined using Environment Canada's Consolidated Flood Frequency Analysis Program (CFA) and the results are summarized in Table 4.

Table 4   Peak Flow Frequency Analysis - Sage Creek

Return Period	2-year	5-year	10-year	20-year	50-year	100-year
Flow (m^3/s)	36.90	49.30	62.50	80.50	114.00	151.00

Again using stream flow data for the four gauged watersheds the average annual daily low flow estimate for the 220 km^2 Sage Creek basin was estimated at approximately 0.6 m^3/sec. It should be noted that this estimate is just an average of annual low daily flowrates and that lower flows can occur. Prorating this strictly by drainage area to the Sage Creek basin translates to an extreme low flow estimate of approximately 0.27 m^3/sec.

Additional information regarding the determination of Sage Creek stream flow estimates is presented in the Channel Condition and Prescription Assessment Report.

3.0   METHODS

This section summarizes the methods used, and data sources compiled and reviewed, to complete the Overview and Level 1 Assessments of the FHAP.   Fisheries assessment work followed technical procedures described in WRP Technical Circular No. 8 (Johnston and Slaney, 1996).

3.1.   Information Sources

A variety of existing and easily obtained information was assembled and reviewed to assist in the characterization of fish distribution, abundance, habitat requirements, habitat use and habitat conditions in the Sage Creek watershed. A description of the range of background information sources utilized is presented below.

3.1.1. Maps

The following maps were compiled and reviewed in the Overview and Level 1 assessment phases of the FHAP project:

?   Terrain resources information management (TRIM) digital topographic maps;
?   National topographic series (NTS) maps;
?   1:20,000 scale Forest Cover maps;
?   Cranbrook Forest District recreation map; and
?   fish stream classification/fish distribution mapping.

The following cartographic information was compiled for the Sage Creek watershed:

>   Gazetted Name: Sage Creek
>   Watershed Code: 330-9566-776-778
>   NTS Map Sheet: 082G01 (1:50,000 scale)
>   BCGS Sheets: 082G008, 082G009, 082G018, 082G019, 082G020 (1:20,000 scale)
>   UTM at POI: 11.685900.5430600 (POI = Canada/USA border)
>   Stream Order: 4 (at POI)
>   Named Sub-Basins: Nettie Creek (330-9566-776-778-200)
>   Sunkist Brook (330-9566-776-778-600)
>   Ruby Creek (330-9566-776-778-616)
>   Flanders Brook (330-9566-776-778-693)
>   Roche Creek (330-9566-776-778-708)
>   Wise Creek (330-9566-776-778-815)
>   MoF Region/District: Kootenay/Cranbrook
>   Nearest Community: Elko (located 43 km north of Sage Creek watershed via forest service roads)
>   Licensee: Crestbrook Forest Industries - Elko Division

3.1.2. Aerial Photographs

Two sets of aerial photographs of the watershed were provided by the MoELP. These were colour photographs for August, 1994 (1:17,000 scale) and black and white photographs for 1972 (1:16,000 scale). An additional set of black and white photographs was obtained from the University of British Columbia's Geographic Information Centre for 1948 (1:32,000 scale). Aerial photos were used to review historic watershed characteristics such as channel pattern, fish habitat condition, riparian vegetation, and changes in land use related to forest harvesting.

3.1.3. Current and Previous Studies

Few research or assessment projects have been undertaken within the watershed. The following project reports were acquired and reviewed for site-specific information related to watershed condition and fish distribution:

?   *Sage Creek Interior Watershed Assessment Procedure (IWAP).* Prepared for the B.C. MoELP by Columbia Environmental Services 1996; and

?   *Sage Creek Fish Stream Identification project.* Prepared for the B.C. MoELP by Columbia Environmental Services 1996.

3.1.4. Inventory Summaries

Inventory summary data were compiled to assist in establishing background conditions in the watershed. The only available inventory data was obtained through the on-line Fisheries Information Summary System (FISS) database jointly managed by the BC MoELP and DFO which contains information on fish, fish habitat and fishing.

Sage Creek watershed were found through literature searches at university libraries and various Internet search engines. As well, a number of scientific papers, reports and technical guidebooks were used to assist in the identification and development of restoration opportunities. Of particular significance to the project were the following references:

?   *Flathead River International Study.* Prepared by the Biological Resource Committee of the Flathead River International Study Board, International Joint Commission, 1987;

?   *A Review of Bull Trout (Salvelinus confluentus) Life-history and Habitat Use in Relation to Compensation and Improvement Opportunities.* Prepared by J.D. McPhail and J.S. Baxter, 1996; and

?   *Life History, Ecology and Population Status of Migratory Bull trout (Salvelinus confluentus) in the Flathead Lake and River System, Montana.* Prepared by J.J. Fraley and B.B. Shepard, 1989.

Additional scientific literature referenced or consulted in this study are presented in Section 6.0.

3.2. Aerial Reconnaissance

Prior to the initiation of the Sage Creek FHAP, an oblique-angle, low level helicopter video was commissioned by the MoELP in Cranbrook and provided to the study team. This flight produced a spatially geo-referenced and differentially corrected (GPS) video of the mainstem and selected tributaries within the watershed and was used by the team during the Overview and Level 1 assessments to observe and confirm watershed characteristics including aspects of fish habitat condition.

On July 30, 1997 a helicopter reconnaissance of the Sage Creek watershed was completed to view the broad characteristics of the watershed from an overhead perspective. This flight afforded key team members an opportunity to confirm and/or collect more detailed information of relevance to the FHAP. A second helicopter overflight of the watershed was completed on October 16, 1997 to review a potential watershed restoration opportunities.

3.3. Reach Classifications

The Sage Creek mainstem and major tributary channels of the watershed were subdivided into twenty distinct reaches based on protocols in WRP Technical Circular No. 7 (Hogan *et. al,* 1996). The identification of reach breaks was undertaken within the CCPA with input from staff conducting the FHAP Overview Assessment. Reaches were defined through the use of aerial photographs, helicopter video, and 1:20,000 scale TRIM maps. A reach was considered to be an area of homogeneous stream channel characterized by uniform discharge, gradient, channel morphology, channel confinement, and channel materials. Reach boundaries were established at significant changes in gradient, confinement, and/or discharge.

3.4. Fish Distribution

The distribution of fish species known to inhabit Sage Creek and its lower tributaries was evaluated, by stream reach. Physical barriers to fish passage were noted and utilized in establishing fish distributions. Since aquatic biophysical maps were not available for Sage Creek, overview fish distributions were established by using historical inventory reports, and the FISS database which mapped distributions of the chosen target species by life stage. Distribution data were summarized alpha-numerically onto FHAP Form #1, Overview Fish Distribution Form, and plotted graphically onto a 1:20,000 topographic base map. Information was also entered into a georeferenced database using ArcInfo formats.

3.5. Habitat Conditions

An overview of fish habitat condition was undertaken using existing aerial photography, aerial videotape, and aerial reconnaissance of the study area. This step is intended to identify areas of concern, such as degraded habitats, barriers to fish passage, shifts in riparian structure, and changes in sediment transport patterns or shifts in LWD abundance which are related to forest harvest practices. The overview habitat

condition information was assembled on FHAP Form #2 which was used to identify preliminary rehabilitation strategies.

3.6. Preliminary Habitat Evaluation

The preliminary assessment and evaluation of fish habitat is based on qualitative, rather than quantitative, comparisons and indications of habitat degradation. It attempts to assign values to a select group of habitat variables leading to the identification of potential opportunities for fish habitat restoration, as well as specific areas that require assessment during the field survey component. A variety of disturbance indicators related to the Sage Creek channel and riparian areas were examined to identify the current fish habitat condition.

Habitat information collected in the preliminary assessment phase was recorded on FHAP Form #3 and was used to identify areas of concern to be examined during the Level 1 field assessment phase. A text summary was generated for each fish-bearing reach which outlined the present fisheries values as well as the probable habitat impacts that were occurring in the reach. These impacted areas were also transferred, onto the 1:20,000 scale topographic base map and were ranked by their priority class (*i.e.,* high, medium, low) for field investigation.

3.7. Habitat Survey

The Level 1 field assessment attempts to confirm or revise the identification of the nature, location, extent and severity of forest harvest impacts on fish habitat identified in the Overview Assessment. It also identifies and prioritizes restoration options and determines if further Level 2 assessments are warranted. The Level 1 field assessment is a purposive survey of selected reaches in the watershed. Only high priority, fish-bearing reaches were examined in an attempt to determine the degree of habitat impairment and quantify the steps needed to rehabilitate the impaired portion of the reach.

Field assessments were carried out in accordance with the applicable standards and specifications presented in Johnston and Slaney (1996). A systematic random sampling design was utilized in the field program. Habitat units (*i.e.,* pools, riffles, and glides) within each stratum were intensively assessed within each reach. The physical channel characteristics of each selected habitat unit were recorded along with a qualitative assessment of available in-stream habitat (*i.e.,* cover including large and small woody debris), riparian vegetation type, off-channel habitats, and the presence and severity of any disturbance indicators. Information was recorded on FHAP Form # 4; Level 1 Habitat Survey Data Form. Also, summaries of habitat conditions were generated for each reach surveyed.

In addition to the standard FHAP measurements, pebble counts were conducted at Reaches 1 through 5 in an attempt to better understand channel dynamics and stability, as well as the appropriateness of the channel substrate for spawning. Transects were sampled across the width of the creek at 6 random locations within the reach. Twenty substrate particles along the transect were measured along the median and transverse axes and an average diameter was calculated. Frequency distributions of measured particles were plotted and standardized indicators (*e.g.*, D_{24}, D_{50}, D_{90}) were determined.

3.8.　　Field Verified Fish Distribution

A low-intensity survey of fish distribution was conducted as part of the Level 1 FHAP. The survey was conducted within the lower five fish-bearing reaches of the creek, and was stratified according to habitat type. The survey primarily utilized electrofishing as a means of confirming fish use and relative abundance of fish species within the various habitat units present in Sage Creek. Baited gee-type minnow traps were also used to augment the electrofishing data. The low intensity survey was conducted under authority of a fish collection permit obtained from the MoELP (Kootenay-Boundary Region). Information was summarized onto FHAP Form # 5, Fish Distribution Summary Form according to habitat type, sampling method, as well as species and life stage captured.

3.8.1.　Electrofishing

A Smith-Root Model 10 Electrofisher was utilized to assess fish distribution within each reach. "Electroshocking" was conducted opportunistically along the reach within individual habitat types. Field crews targetted those habitat areas which are known to support the target species (bull trout [BT], and westslope cutthroat trout [WCT]). Output levels were adjusted according to reach conductivity and temperature in order to limit fish mortality. In accordance with standard inventory practice the field crews would stop shocking if they had sampled 30 fish at one particular site.

3.8.2.　Minnow Traps

Gee-type minnow traps were utilized in two locations adjacent to the base camp, and at one site on Roche Creek, in order to supplement the fisheries data collected by electrofishing. Baited traps were set in less than one metre of water and allowed to fish for a period of approximately twenty-four hours.

3.9.　　Water Quality

Water quality characterization was also conducted during the course of the field assessment between August 17 and 28, 1997. Water quality characteristics of the mainstem (first 5 reaches) and their accompanying five tributaries were examined. *In situ* water quality measurements were made in the field for the following parameters using the equipment identified below:

water temperature (in $^{\circ}$C)	Hand held glass stem thermometer
dissolved oxygen (in mg/l)	YSI Model 55 oxygen meter
conductivity (in uS/cm)	YSI Model 30 conductivity meter
pH	HANNA Instruments HI-9024 meter
turbidity (in NTU=s)	HF Instruments DRT 9141

All equipment was calibrated daily by the field crew according to the manufacturers specifications, except for the turbidity meter which was calibrated on July 23, 1997.

3.10. Fish Habitat Evaluation

During the Level 1 field activities, degraded habitats were identified by comparing the characteristics of the observed physical habitats against a set of conditions that would be expected in an undisturbed stream system. Since pre-logging data were, for the most part, very limited the study team inferred expected habitat condition using the diagnostic tables presented in the FHAP manual (*i.e.,* Table 5, Diagnostics of Salmonid Habitat Condition, Johnston and Slaney, 1996). This process provides a broad understanding of the degree of disturbance and enables a relative condition ranking to be applied to the reach as a whole. The objective of the evaluation process was to identify and interpret limiting factors to salmonid production through associations between habitat condition and fish presence. In addition, the channel assessment procedure and upslope hill impacts were examined for further indications of habitat degradation through altered geomorphologic processes and/or increased sediment inputs.

When field operations ended, all habitat data were compiled into a summary of habitat conditions within each reach (FHAP Form # 6: Level 1 Assessment - Habitat diagnosis summary form). These data were then used to identify and prioritize observed habitat disturbances and to recommend restoration methods and techniques to increase or rectify these limiting factors.

3.11. Fish Habitat Restoration Plan

Based on the results of the Overview and Level 1 Assessments, integrated opportunities for the restoration of fish habitat were identified and compiled into a restoration plan. The restoration plan presents the major elements of restoration including an initial description of project scope and objectives (*i.e.*, prescriptions) to address the impacts to the fishery resources identified in the assessment steps of the FHAP. In addition, the restoration plan identifies the need for Level 2 Assessments for several opportunities where further site-specific information is required to more fully understand the design and/or application of a restoration technique.

4.0   RESULTS

The assessment of fish habitat conducted in the Overview Assessment provides a broad understanding of target fish species and their historical distribution, abundance and utilization of existing habitats. The Overview Assessment also develops a preliminary evaluation of habitat conditions in the watershed. Detailed field assessment of habitat conditions and potential restoration opportunities are conducted in the Level 1 assessment phase.

The Sage Creek watershed covers 22,757 hectares, and is composed of twenty distinct sub-basins (size range 316 ha - 2,557 ha). Twenty distinct reaches on the mainstem were identified using the reach break analysis procedures outlined in Hogan *et al.* (1996) (Table 5 and Figure 2). These reaches are the basic river unit for all descriptions which follow. Individual reaches of the watershed's channels are identified on Map 1 (in pocket at back). Twenty nine tributaries to the mainstem were identified from mapping and aerial photographs along its 42 km length. Longitudinal profiles of the Sage Creek mainstem and selected tributaries are presented as an appendix to this report.

The results of the Overview and Level 1 assessments are presented below.

4.1.   Fish Distribution – Overview Assessment

Bull trout and westslope cutthroat trout have been identified as target species for the Sage Creek project, with bull trout being of highest importance. Both species are considered to be locally and regionally valuable as recreational sportfish, and both are considered to be sensitive to habitat impacts caused by land use changes (*e.g.*, forest harvesting). Other species known to occur within the watershed are mountain whitefish (*Prosopium williamsoni*), slimy sculpin (*Cottus cognatus*), and long-nose sucker (*Catostomus catostomus*) (Columbia Environmental Services, 1996).

Bull trout is an endemic western North American char. Due to declines in numbers the species was listed under the U.S. Endangered Species Act in 1994. Bull trout within the Flathead Lake and River drainage, to which Sage Creek drains, has been extensively studied by the Montana Department of Fish, Wildlife and Parks, and is recognized as the largest native fish species present in the system (Fraley and Sheppard, 1989). Bull trout are adfluvial, growing to maturity in Flathead Lake, and migrating to the Flathead River and its tributaries (including Sage Creek) to spawn in the fall.

Table 5   Physical characteristics of Sage Creek mainstem reaches, September 1997.

Reach	Length (m)	Gradient (%)	Width (m)	Morphology
1	4800	0.7	35	RPg-w
2	2300	1	25	RPg-w

Reach	Length (m)	Gradient (%)	Width (m)	Morphology
3	2000	1.3	24	RPg-w
4	6600	0.4	20	RPg-w
5	3500	0.4	25	RPg-w
6	4200	0.7	18	RPg-w
7	180	0	10	SPr
8	900	3.3	23	CPb
9	1500	3	16	SPr
10	3300	1.2	35	RPg-w
11	1400	1.1	18	RPc-w
12	700	0.7	25	RPg-w
13	900	1.7	15	CPc-w
14	800	0.6	14	RPg-w
15	1000	2.5	11	RPg-w
16	500	2	11	RPg-w
17	3300	2.7	8	CPc-w
18	2100	5.2	8	CP c-w
19	400	12.5	6	SPb
20	1700	12.4	6	SPb

Juveniles of the Flathead bull trout population typically rear in their natal stream for one to three years (BRC, 1987). Sage Creek is considered to be an important spawning tributary of the North Fork Flathead River.

Cutthroat trout are an important recreational sportfish throughout British Columbia. Populations of interior cutthroat trout, however, have declined significantly throughout their North American distribution, including the Westslope cutthroat subspecies (Liknes and Graham, 1988) which are found in Sage Creek. The Sage Creek watershed supports both resident and migratory populations of Westslope cutthroat trout (BRC, 1987). Migratory populations reside in the Flathead River, and enter tributary streams such as Sage Creek to spawn in spring.

Fish distribution in the Sage Creek watershed is limited to the lower 23.6 kilometres of the mainstem by a series of impassable falls of approximately 5 metres in height. Fish-bearing reaches of the mainstem are reach numbers 1 - 7. Within the fish-bearing reaches thirteen tributaries have the potential to allow fish access for portions of their length.

The most recent information available describing fish distribution in the Sage Creek watershed is the Fish-Stream Identification project conducted by Columbia Environmental Services (1996). Based on this and other information reviewed, both juvenile and adult life stages of bull trout and westslope cutthroat trout are distributed throughout the fish-bearing reaches of Sage Creek, as well as in a number of tributaries. Mountain whitefish have also been documented in all fish-bearing reaches of the Sage Creek mainstem. Fish distribution information is summarized, by reach and life history stage, on FHAP Form 1: Overview Assessment - Fish Distribution Summary Form (Appendix 1). Fish-bearing reaches of the Sage Creek watershed are identified on Map 1 (in pocket).

4.2. Habitat Condition – Overview Assessment

Using 1994 aerial photography and 1997 videography, as well as information collected during reconnaissance overflights of the watershed in 1997, areas of concern were identified in the overview habitat condition assessment. Historical aerial photographs (*i.e*., 1948 and 1972) assisted in further describing the origin of areas of concern. Table 6 provides a chronological assessment of activities in the Sage Creek watershed based on aerial photo and video review and interpretation. Figures 3 - 7 illustrate the extent of former impact areas.

Sage Creek Integrated Watershed Restoration Project
B.C. Ministry f Environment, Lands ad Parks - Kootenay-Boundary Region

Appendix C - FHAP

Table 6   Historical aerial photo and videography review.

YEAR / SCALE	LOWER WATERSHED	MIDDLE WATERSHED	UPPER WATERSHED
1948 / 1:32,000	? no evidence of human activity in the lower reaches ? road enters the watershed in Reach 4. ? channel is partially confined within terraces ? creek forms an irregular meander confined within floodplain	? access road extends as far as Reach 6 on Sage Creek and ends downstream of the canyon (Reach 7) ? some evidence of logging / clearing within sub-basin 6	? no roads or evidence of human activity ? evidence of a natural disturbance (*i.e.* beetle infestation or fire) in Sub-basin 12 (Roche Creek) and Sub-basin 13 ? channel appears stable and is attended by a well developed riparian zone
1972 / 1:16,000	? FSR bridge in Reach 4 under construction ? no roads have been constructed east of Sage Creek ? Nettie Creek watershed has not been impacted ? channel extensively aggraded, large amounts of recent sedimentation ? areas with exposed lateral and point bars	? Upper and lower Roche Creek and areas of Ruby Creek actively being clear-cut to waters edge ? road networks visible in association with clear-cuts ? beetle infestation near Flanders Brk ? airport runway constructed adjacent to Reach 5 of Sage Creek	? FSR constructed immediately adjacent to Sage Creek ? salvaging of beetle infestation area evident ? areas within Sub-basin 15 (Wise Creek) are in the process of being clear-cut
1994 / 1:17,000	? access roads constructed into Nettie Creek ? lateral bars and point bars observed to be unvegetated in 1972 have revegetated ? fewer barren channel bars observed	? riparian stands and valley areas have been clear-cut at numerous locations ? bridges removed from crossings in reaches 6 and 10 of Sage Creek ? extensive areas of channel have aggraded	? FSR constructed adjacent to the creek has been abandoned and a new FSR has been constructed approximately 150 metres upslope ? riparian stands and valley areas extensively logged
1997 Aerial Video/ variable altitudes	? channel condition appears similar to the 1972 aerial photos ? large amounts of recent sedimentation has occurred ? many unvegetated bars and points ? changes in channel planform have occurred (*i.e.* meanders cut off, new channels formed)	? aggraded channel at the confluence of Sage Creek and Roche Creek ? large amounts of sediment stored in lower Roche Creek and in Sage Creek mainstem ? extensive areas of unvegetated lateral bars and point bars	? observe many exposed bars ? similar to lower reaches, changes in channel planforms were observed.

The overview assessment of habitat condition identified the following characteristics in the watershed:

?   above average peak flow events have occurred in the past thirty years (*i.e.*, 1970, 1975, 1995) and appears to have caused significant changes to the Sage Creek mainstem;
?   a 1995 peak flow event has left the mainstem in a condition similar to what existed in 1972;
?   dominance of Riffle-Pool channel type except for Step-Pool channel type in middle (reaches 7 & 8) and uppermost (reaches 18 - 20) reaches;
?   indicators of channel disturbance primarily unvegetated bars, large sediment wedges, and eroding banks;
?   potential barriers to fish movement located throughout the watershed and primarily comprised of falls and chutes, log jams, and sloughing banks;
?   long, straight sections of homogeneous riffle habitats;
?   low pool frequency, abundant but clumped LWD, and some accessible off-channel habitat in fish-bearing reaches; and
?   primarily mature coniferous forest in the lower reaches, young coniferous forest in the middle reaches, and young and initial stages of coniferous forest in the upper reaches.

Detailed overview habitat condition assessment data are provided on Form 2 in Appendix 2 of this report.

4.3.   Preliminary Habitat Evaluation – Overview Assessment

Using indicators included in Technical Circular No. 8 (Johnston and Slaney 1996), information presented on Forms 1 and 2, and other data generated by the CCPA, the following limitations to fish habitat were identified within the Sage Creek watershed from the overview assessment:

?   upstream movement of all life stages of all fish species is limited by a natural obstruction (waterfall) located on the Sage Creek mainstem approximately 24 km upstream of the Canada/USA border (POI);
?   the quantity and quality of summer and winter holding habitat (*i.e.,* deep pools) is inadequate in some of the fish-bearing reaches of the mainstem and may be the result of increased peak flows, sediment delivery and subsequent pool infilling;
?   backwater and off-channel habitats have been isolated from the Sage Creek mainstem by aggrading materials;
?   several upslope areas having high connectivity to stream channels in the upper watershed represent sediment sources which may be transported to depositional zones in fish-bearing reaches of Sage Creek; and
?   numerous areas of the watershed have been impacted by poor forest harvesting and related activities that generate significant impacts on fish habitat such as logging through tributaries, poorly located and/or maintained roads and skid trails, absence of road/trail/landing deactivation initiatives, etc.

Priority areas which were identified for examination during the Level 1 (field) surveys are presented on Map 2. Highest priority areas are those which represent impacted habitats that have also been identified as being used by target fish species. All high priority areas corresponded with fish-bearing Reaches 1 - 7. Moderate and low priority classes were also identified.

Preliminary habitat assessment results are presented on FHAP Form 3 in Appendix 3 of this report. Fish bearing reaches of the mainstem were generally characterized as having Riffle-Pool channels dominated by cobble and gravel substrates. All reaches below the natural barrier were considered to be aggrading. Upslope impacts ranged from Low to Moderate. Fish-bearing reaches of tributaries were considered to be more stable than the mainstem with Low impacts from upslope areas. Channel type was characterized primarily as Riffle-Pool, but some pond and lake habitats were also identified. A summary of results is presented for each fish-bearing reach of the Sage Creek mainstem in Table 7.

Initial restoration opportunities identified from the preliminary habitat assessment included the protection and restoration of off-channel habitats, riparian enhancement to restore function, site specific bank stabilization, and in-stream habitat enhancement to increase pool frequency.

4.4.   Habitat Survey

Based on background information and the results of the Overview Assessment it was concluded that past forest harvesting activities in the watershed were largely responsible for adverse changes to the physical characteristics of the fish-bearing reaches of Sage Creek. Impacts of forestry-related activities in the upper reaches of the watershed have expressed themselves downstream through changes in the rate and quantity of sediment delivery and storage.

The Level 1 Assessment of existing fish habitat condition and fish distribution was carried out between August 17 and 28, 1997, corresponding with the summer low flow. Weather conditions during the course of field investigations were sunny and warm for all but one day. Key habitat characteristics of particular importance to the target species were examined in the lower 5 reaches of the Sage Creek mainstem and 5 tributaries located below the barrier to fish movement.

Table 7   Preliminary habitat assessment summary of Sage Creek fish-bearing reaches

---

Reach 1 Length (m):   4800   Gradient (%):   0.7

$ fish populations present within reach: Bull Trout (BT), Westslope Cutthroat (WCT), Mountain Whitefish (MW), Largescale Sucker (CSU), Slimy Sculpin (CCG)

$ channel extensively aggraded, large amount of recent sedimentation

$ partially confined within terraces, creek forms an irregular meander on a floodplain which is approximately 500 m wide

$ numerous areas appear to provide off-channel habitat

$ number of debris piles and debris jams within the reach

$ most LWD is isolated from the channel and does not provide any habitat function

$ dynamic nature of Sage Creek in this mainstem reach limits restoration opportunities - focus on enhancing off-channel habitat

Level 1 Priority: HIGH

Reach 2   Length (m):   2300   Gradient (%):   1.0

$ fish populations present within reach: BT, WCT, MW, CSU, CCG

$ channel has sinuous pattern, primarily single channel

$ channel is entrenched and has higher gradient than the reach directly downstream

$ number of remnant channels that may provide off-channel habitat, some appear to have a groundwater origin

$ remnant channels could be rehabilitated to provide rearing and spawning habitat if they do not already do so

Level 1 Priority: HIGH

Reach 3   Length (m):   2000   Gradient (%):   1.3

$ fish populations present within reach: BT, WCT, MW, CSU, CCG

$ channel is extensively aggraded, multiple/braided channels

$ debris piles and debris jams occur frequently within this reach

$ dynamic nature of Sage Creek in this mainstem reach limits restoration opportunities - focus on enhancing off-channel habitat

$ numerous areas that appear to provide off-channel habitat that could be enhanced

Level 1 Priority: HIGH

Reach 4 Length (m):   6600   Gradient (%):   0.4

$ fish populations present within reach: BT, WCT, MW, CSU, CCG

$ channel has sinuous pattern, primarily single channel

$ reach is a zone of sediment transport

$ number of remnant channels present that may provide off-channel habitat, some appear to have a groundwater origin

$ remnant channels could be rehabilitated to provide rearing and spawning habitat if they don't already do so

Level 1 Priority: HIGH

Reach 5   Length (m):   3500   Gradient (%):   0.4
$ fish populations present within reach: BT, WCT, MW, CSU, CCG
?   channel extensively aggraded, multiple/braided channels and elevated bars
$ reach is a zone of active sedimentation, wide flood plain
$ debris piles and debris jams occur frequently within this reach
$ dynamic nature of Sage Creek in this mainstem reach limits restoration opportunities - focus on
        enhancing off-channel habitat
$ numerous areas that appear to provide off-channel habitat that could be enhanced
Level 1 Priority: HIGH

Reach 6   Length (m):   4200   Gradient (%):   0.7
$ fish populations present within reach: BT, WCT, MW, CSU, CCG
$ Sage Creek confined with steep valley
$ sediment transport zone
$ narrow flood plain with few areas of off-channel habitat
$ channel has a sinuous pattern with large riffles
$ some small holding pools along channel margins, usually associated with functional LWD
$ one location of obvious bank erosion
$ limited restoration opportunities due to the confined nature of the valley and the resulting high
        velocities received
Level 1 Priority: MODERATE

Reach 7   Length (m):   180   Gradient (%):   0.0
$ fish populations present within reach: BT, WCT, MW, CSU, CCG
$ reach is the upper limit of fish populations (except were stocking has occurred)
$ reach confined within a narrow canyon, channel incised in bedrock
$ canyon provides deep holding pools for fish (BT, WCT, MW)
$ holding pools within this reach are important fish habitat
?   virtually no opportunity for fish habitat restoration activities due to hydrologic and geologic
        characteristics of reach
Level 1 Priority: LOW

A systematic random sampling design was implemented with pools, riffles, glides and cascades representing the four strata.   Sampled length ranged from 7 - 20% for mainstem reaches, and 3 - 31% for tributary reaches.

Habitat characteristics of all fish bearing reaches and tributaries are summarized on FHAP Form 4 in Appendix 4 of this report. Representative photographs of each sampled reach are presented in Appendix 8. Summary statistics of each of the mainstem and tributary reaches evaluated are presented in Section 4.6 Habitat Evaluation.

4.5.   Fish Distribtion

Electrofishing results are summarized in Table 8. Target species were collected in all reaches and tributaries assessed with the exception of Tributaries 1 & 2 (Reach 1). No fish were observed in either of these reaches. Numerous observations of YOY and juvenile salmonids were made at most sites. These fish were able to either escape the area, were unaffected by the electric current, or were not targetted by the electrofishing program.

Minnow trapping sites on Reach 4 (see Table 9) were located adjacent to the base camp facilitating the setting and retrieval of the traps. Westslope cutthroat were captured in one of the four traps set at this location. One site on Nettie Creek was also sampled using this collection technique. Traps were placed above and below a culvert/road crossing to assess whether it constituted a barrier to fish passage. Cutthroat trout were captured above and below the culvert suggesting that this culvert does not present a barrier to the passage of juvenile salmonids. No bull trout were collected in any of the minnow traps.

A more extensive minnow trapping program was not undertaken due to the remoteness and difficulty of access to many areas of the watershed. Returning to a site to retrieve a trap set previously would have consumed too much field time.

A summary of fish distribution results are presented on FHAP Form 5 in Appendix 5.

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Appendix C - FHAP

Table 8   Electrofishing results, Sage Creek, August 1997.

Location	Habitat Type	Bull trout		Cutthroat		Electrofishing Effort (Seconds)	CUE (# /hr)	Comments regarding the entire reach or tributary
		YOY	Juv.	YOY	Juv			
Reach 1, Mainstem	Back Channel	0	0	3	3	536	40.3	yoy and juvenile salmonids
	Riffle	0	0	0	1		6.72	seen in the pool habitat.
	Glide	0	0	1	0		6.72	
	Pool	0	0	1	1		10.33	
Reach 1, Tributary 1	All	0	0	0	0	95	0	NO FISH CAPTURED OR
Reach 1, Tributary 2	All	0	0	0	0	148	0	NO FISH CAPTURED OR
Reach 2, Mainstem	Riffle	0	0	1	3	336	42.86	large WCT seen in u/s pool
Reach 2, Tributary 4	Riffle	0	0	1	4	168	107.1	numerous yoy observed
Reach 3, Mainstem	Glide	0	1	0	0	302	11.92	juvenile and one large WCT
	Pool	0	0	0	3		35.76	above the log jam
Reach 4, Mainstem	Braided	0	0	3	1	697	20.66	numerous BT & WCT fry seen
	Riffle	3	0	0	0		15.49	
	Pool	>30	0	0	3		170.4	
Reach 4, Side Channel	Glide	1	0	1	0	N/A	N/A	DIP NETTED
	Pool	1	0	0	0	N/A	N/A	DIP NETTED
	Glide	0	0	0	2	697	10.32	Salmonids seen in pool
	Pool	0	1	0	3		20.67	
Reach 4, Tributary 7	Riffle	1	0	2	1	205	70.24	yoy seen in tributary
Reach 5, Mainstem	Pool	1	0	0	2	345	31.3	few fish observed
Reach 5, Ab. Channel	Pool	2	0	1	1	121	119	yoy WCT observed
Reach 5, Tributary 11	Riffle	0	0	2	8	155	232.3	WCT above and below b.dam

Table 9   Results of minnow trapping, Sage Creek, August 1997.

Location	Habitat Type	Water Level	BT	WCT	Capture effort (hrs)	CUE* (#/hr)
Reach 4:sec 2 site#1	pool, overhanging veg.	low	0	0	26	0
Reach 4:sec 2 site#2	pool, overhanging veg.	low	0	4 fry	26	0.153
Reach 4:sec 2 site#3	pool, boulder	low	0	0	26	0
Reach 4:sec 2 site#4	pool, overhanging veg.	low	0	0	26	0
Nettie Creek: site #1	pool, boulder	moderate	0	4 juv.	22	0.181
Nettie Creek: site #2	plunge pool CV	moderate	0	0	22	0
Nettie Creek: site #3	pool, boulder	moderate	0	0	22	0
Nettie Creek: site #4	pool, undercut bank	moderate	0	1	22	0.05

BT - Bull trout (*Salvelinus confluentus*)

WCT - Westslope cutthroat trout (*Salmo clarki lewisi*)

* CUE - Catch per unit of effort

***

10.4 - 15.2°C. Tributary water temperatures were somewhat cooler, ranging between 9.8 - 14.2°C suggesting an influence of groundwater contribution to some of the tributaries. Dissolved oxygen measurements ranged from 7.3 to 9.0 mg/l. Measurements of pH were all circumneutral. Water clarity was high at all locations, and measures of turbidity were well within the Ministry guideline of <5 NTU.

Overall, water quality measurements were typical to those expected from drainages of this geographic area of the province. All measurements were within the ranges developed for the protection of aquatic life by the Ministry of Environment, Lands and Parks and are considered to be suitable to sustain all life stages of salmonids at this time of year.

Table 10   Water quality measurements and corresponding government standards, Sage Creek, British Columbia. August 1997.

Location	Temp ($^{\circ}$C)[1]	Dissolved Oxygen (mg/l)[2]	Conductivity (uS/cm)	pH [3]	Turbidity (NTU)[4]
Reach 1, Mainstem	11.5	8.9	124.1	7.6	0.55

Reach 1, Tributary 1	10.1	9	207	8.2	0.33
Reach 1, Tributary 2	10	8.6	171.4	7.6	0.98
Reach 2, Mainstem	11.5	8.9	97.9	7.5	0.62
Reach 2, Tributary 4	11.3	8.7	113.6	7.6	1.45
Reach 3, Mainstem	10.4	8.8	112.8	7.5	0.22
Reach 4, Mainstem	15.2	8	109.8	7.5	0.11
Reach 4, Tributary 7	9.8	7.3	144.1	7.3	0.92
Reach 5, Mainstem	11	7.9	100.6	7.6	0.16
Reach 5 Tributary 11	14.2	7.9	58.4	7.8	0.43

Parameter	MOELP standards for aquatic life
1 Temperature (^{o}C)	22 - 24°C maximum for adults and juveniles 8 - 10°C maximum weekly average for spawning 13 - 15°C maximum for embryo survival
2 Dissolved Oxygen (mg/l)	Moderate level 6.5 mg/l for anadromous salmonids
3 pH	Below 6.5 aquatic function begins to be impaired
4 Turbidity (NTU)	Below 5 NTU is acceptable

4.6.　Reach Substrate Analysis

Table 11 presents the results of the pebble counts. The uniformity co-efficient which describes the range of the particle sizes is also presented for each reach. Frequency distributions and cumulative percentages of particle sizes are included in Appendix 10.

Table 11　Summary of particle size analysis (in cm) conducted on selected reaches of Sage Creek, August 1997.

Location	D_{24}*	D_{50}	D_{90}	Uniformity Coefficient
Reach 1	3.2	6.4	12.8	6
Reach 2	2.4	6.4	12.8	10
Reach 3	2.4	4.8	12.8	12

| Reach 4 | 1.6 | 2.4 | 6.4 | 4 |
| Reach 5 | 1.6 | 4.8 | 9.6 | 10 |

*Example : D_{24} = 24 % of particles are less than 3.2 cm in Reach 1

Particle size distributions were generally similar for all reaches, although mean particle sizes were slightly smaller, and less variable, in Reach 4. D_{24} values, for example, corresponded to coarse gravel for most reaches and medium gravel for Reach 4. Similarly, D_{90} size classes were representative of small cobbles in reaches 1, 2, 3, and 5 but only very coarse gravel in Reach 4.

4.7.   Habitat Evaluation

Form 6 (Appendix 6) of the FHAP Technical Circular presents the summarized diagnostics for mainstem and tributary fish habitat parameters in the Sage Creek watershed. Habitat ratings were assigned based on the measured frequency or measured area of specific habitat elements extrapolated over broader reaches of the system. The "generic" diagnostics table included in Technical Circular No. 8 was used to assign habitat rating since pre-logging data or regional standards were not available. Summary statistics of each of the mainstem and tributary reaches evaluated are presented in Table 12.

Several habitat parameters consistently received ratings of "Poor" in most reaches examined. These included all pool-related variables (*e.g.*, pool area, pool frequency), and parameters related to LWD, boulder cover, and overhead cover. While some of these ratings truly reflect habitat degradation resulting from past logging activities, others are more a function of the regional characteristics of watercourses of the East Kootenays (*e.g.*, boulders are uncommon throughout East Kootenay streams).

Table 12   Sage Creek Reach Summary Statistics

Reach 1		SD	Reach 2		SD	Reach 3		SD
Total reach length (m)	4800.00		Total reach length (m)	2300.00		Total reach length (m)	2000.00	
Sampled length	366.00		Sampled length	453.00		Sampled length	402.00	
Mean Wb (m)	33.62	18.50	Mean Wb (m)	21.00	3.24	Mean Wb (m)	26.88	8.94
Wb's in reach	10.89		Wb's in reach	21.57		Wb's in reach	14.96	
Mean Ww (m)	9.67	3.83	Mean Ww (m)	12.96	1.43	Mean Ww (m)	10.09	3.78
Mean Depth (m)	0.40	0.19	Mean Depth (m)	0.24	0.09	Mean Depth (m)	0.53	0.19
Mean Bankfull Depth (m)	2.68	1.41	Mean Bankfull Depth (m)	1.26	0.18	Mean Bankfull Depth (m)	2.08	1.07
Wb:Depth ratio	12:1		Wb:Depth ratio	16:1		Wb:Depth ratio	13:1	
Mean Grade (%)	1.50	0.79	Mean Grade (%)	0.78	0.55	Mean Grade (%)	1.63	0.74
Max. Grade (%)	3.00		Max. Grade (%)	2.00		Max. Grade (%)	3.00	
Min. Grade (%)	1.00		Min. Grade (%)	1.00		Min. Grade (%)	1.00	
		%			%			%
Total riffle (m)	112.00	47%	Total riffle (m)	71.00	22%	Total riffle (m)	75.00	35%
Total glide (m)	72.00	30%	Total glide (m)	246.00	78%	Total glide (m)	83.00	39%
Total pool (m)	56.00	23%	Total pool (m)	0.00	0%	Total pool (m)	54.00	25%
Total cascade (m)	0.00	0%	Total cascade (m)	0.00	0%	Total cascade (m)	0.00	0%
		Rating			Rating			Rating
Percent pool by area	15.30	P	Percent pool by area	0.00	P	Percent pool by area	13.43	P
Pool frequency	10.26	P	Pool frequency	0.00	P	Pool frequency	8.82	P
LWD/Wb	0.73	P	LWD/Wb	0.70	P	LWD/Wb	2.41	G
% wood cover in pools	2.00	P	% wood cover in pools	0.00	P	% wood cover in pools	22.67	G
Boulder cover in riffles	0.00	P	Boulder cover in riffles	1.50	P	Boulder cover in riffles	0.00	P

Over head cover	3.67	P	Over head cover	2.33	P	Over head cover	1.00	P
Off-channel habitat	2 SC	G	Off-channel habitat	1 SC	G	Off-channel habitat	2 PD	F
Holding pools (#/km)	2.73	P	Holding pools (#/km)	0.00	P	Holding pools (#/km)	4.98	G
Spawning area access	No blocks	G	Spawning area access	No blocks	G	Spawning area access	No blocks	G
Gravel quantity	8.00	G	Gravel quantity	4.00	G	Gravel quantity	6.00	G
Gravel quality		G	Gravel quality		G	Gravel quality		G

Reach 4		SD	**Reach 5**		SD	**Tributary 1**	
Total Reach length (m)	6600.00		Total Reach length (m)	3500.00		Total Reach length (m)	3600.00
Sampled length	670.00		Sampled length	458.00		Sampled length	160.00
Mean Wb (m)	18.72	10.61	Mean Wb (m)	17.71	6.21	Mean Wb (m)	1.53
Wb's in reach	35.80		Wb's in reach	25.86		Wb's in reach	104.49
Mean Ww (m)	9.86	5.00	Mean Ww (m)	10.27	3.41	Mean Ww (m)	1.35
Mean Depth (m)	0.31	0.30	Mean Depth (m)	0.23	0.34	Mean Depth (m)	0.29
Mean Bankfull depth (m)	1.85	0.84	Mean Bankfull depth (m)	1.31	0.66	Mean Bankfull depth (m)	0.60
Wb:Depth ratio	10:1		Wb:Depth ratio	14:1		Wb:Depth ratio	2:1
Mean Grade (%)	1.46	0.78	Mean Grade (%)	1.67	1.00	Mean Grade (%)	1.75
Max. Grade (%)	3.00		Max. Grade (%)	3.00		Max. Grade (%)	3.00
Min. Grade (%)	1.00		Min. Grade (%)	1.00		Min. Grade (%)	1.00
		%			%		
Total riffle (m)	56.00	11%	Total riffle (m)	118.00	33%	Total riffle (m)	124.00
Total glide (m)	297.00	60%	Total glide (m)	152.00	43%	Total glide (m)	21.00
Total pool (m)	144.00	29%	Total pool (m)	85.00	24%	Total pool (m)	15.00
		Rating			Rating		
Percent pool by area	21.49	P	Percent pool by area	18.56	P	Percent pool by area	9.38

Pool frequency	8.00	P	Pool frequency	7.25	P	Pool frequency	18.74	
LWD/Wb	1.68	F	LWD/Wb	2.98	G	LWD/Wb	0.08	
% wood cover in pools	30.00	G	% wood cover in pools	15.00	F	% wood cover in pools	3.50	
Boulder cover in riffles	1.00	P	Boulder cover in riffles	7.00	P	Boulder cover in riffles	0.00	
Overhead cover	7.50	P	Overhead cover	1.00	P	Overhead cover	68.57	
Off-channel habitat	2 SC	G	Off-channel habitat	1 SC	F	Off-channel habitat	0.00	
Holding pools (#/km)	5.97	G	Holding pools (#/km)	6.55	G	Holding pools (#/km)	0.00	
Spawning area access	No blocks	G	Spawning area access	No blocks	G	Spawning area access	No blocks	
Gravel quantity	13.00	G	Gravel quantity	5.00	F	Gravel quantity	7.00	
Gravel quality		G	Gravel quality		P	Gravel quality		

Tributary 4		SD	Tributary 2		SD	Tributary 7		SD
Total Reach length (m)	4352.00		Total Reach length (m)	1439.00		Total Reach length (m)	1831.00	
Sampled length	154.00		Sampled length	447.00		Sampled length	230.00	
Mean Wb (m)	4.20	0.71	Mean Wb (m)	12.00	6.24	Mean Wb (m)	9.30	11.64
Wb's in reach	36.67		Wb's in reach	37.25		Wb's in reach	24.73	
Mean Ww (m)	0.86	0.24	Mean Ww (m)	7.84	3.03	Mean Ww (m)	4.69	5.92
Mean Depth (m)	0.22	0.11	Mean Depth (m)	0.24	0.15	Mean Depth (m)	0.34	0.25
Mean Bankfull depth (m)	0.53	0.08	Mean Bankfull depth (m)	0.59	0.11	Mean Bankfull depth (m)	0.86	0.50
Wb:Depth ratio	8:1		Wb:Depth ratio	20:1		Wb:Depth ratio	11:1	
Mean Grade (%)	1.90	1.29	Mean Grade (%)	1.07	0.67	Mean Grade (%)	0.40	0.55
Max. Grade (%)	4.00		Max. Grade (%)	2.00		Max. Grade (%)	1.00	
Min. Grade (%)	1.00		Min. Grade (%)	0.50		Min. Grade (%)	0.00	
		%			%			%
Total riffle (m)	89.00	58%	Total riffle (m)	54.00	38%	Total riffle (m)	0.00	0%
Total glide (m)	61.00	40%	Total glide (m)	72.00	50%	Total glide (m)	114.00	54%
Total pool (m)	4.00	3%	Total pool (m)	17.00	12%	Total pool (m)	96.00	46%

| Total cascade (m) | 0.00 | 0% | Total cascade (m) | 0.00 | 0% | Total cascade (m) | 0.00 | 0% |

		Rating			**Rating**			**Rating**
Percent pool by area	2.60	P	Percent pool by area	3.80	P	Percent pool by area	41.74	G
Pool frequency	13.57	P	Pool frequency	37.25	P	Pool frequency	6.13	P
LWD/Wb	0.57	P	LWD/Wb	2.79	G	LWD/Wb	0.97	P
% wood cover in pools	0.00	P	% wood cover in pools	0.00	P	% wood cover in pools	0.00	P
Boulder cover in riffles	2.00	P	Boulder cover in riffles	3.00	P	Boulder cover in riffles	0.00	P
Overhead cover	11.25	F	Overhead cover	0.00	P	Overhead cover	16.25	F
Off-channel habitat	0.00	P	Off-channel habitat	1 SC	P	Off-channel habitat	0.00	P
Holding pools (#/km)	0.00	P	Holding pools (#/km)	2.24	G	Holding pools (#/km)	4.35	G
Spawning area access	No blocks	G	Spawning area access	No blocks	G	Spawning area access	No blocks	G
Gravel quantity	9.00	F	Gravel quantity	1.00	P	Gravel quantity	0.00	P
Gravel quality		P	Gravel quality		P	Gravel quality		P

Tributary 11   SD

Total Reach length (m)	1070.00	
Sampled length	233.00	
Mean Wb (m)	7.86	5.40
Wb's in reach	29.65	
Mean Ww (m)	4.26	6.95
Mean Depth (m)	0.30	0.19
Mean Bankfull depth (m)	0.64	0.14
Wb:Depth ratio	12:1	
Mean Grade (%)	1.14	0.38
Max. Grade (%)	2.00	

Min. Grade (%)	1.00	
		%
Total riffle (m)	21.00	9%
Total glide (m)	8.00	3%
Total pool (m)	14.00	6%
Total other (m)	200.00	82%

		Rating
Percent pool by area	6.01	P
Pool frequency	9.04	P
LWD/Wb	4.01	G
% wood cover in pools	25.00	G
Boulder cover in riffles	10.00	F
Overhead cover	0.00	P
Off-channel habitat	0.00	P
Holding pools (#/km)	4.29	P
Spawning area access	No blocks	P
Gravel quantity	6.00	G
Gravel quality		P

Indicators of fish habitat impairment are summarized for each reach/tributary evaluated in Table 13. Fisheries values and probable symptoms of impairment within each reach are also included in this table. As confirmed by the diagnostics table, ample spawning and rearing habitats are provided under existing conditions based on the microhabitat requirements identified by Keeley and Slaney (1996). The major fish habitat limitations are identified as low frequency of pools, the low abundance of LWD, and the combination of these habitat elements (*i.e.*, low abundance of pools with wood cover).

Forest harvesting activities, as well as other natural perturbations in the watershed (*i.e.*, beetle infestations, and wildfires) have caused significant changes to the physical characteristics of the Sage Creek mainstem. Changes to the hydrologic regime have accompanied reductions in forest cover and, combined with increased availability of erodible soils, have resulted in significant changes to the sediment storage and transport patterns, as well as the availability of functional woody debris. These geomorphological changes have caused the alteration of historic, stable fish habitats. These changes have been further compounded by flood events which have occurred in the watershed, the most recent of which occurred in 1995.

One of the most significant impacts of forest cover removal in the upper watershed appears to be the delivery of large quantities of material to the depositional reaches of the mainstem (*i.e.*, Reaches 3 and 5). The aggradation of bedload in these low-gradient reaches has resulted in the severing of connections between the mainstem and off-channel habitats such as high flow channels, side channels, and tributaries. In several locations within reaches 2 and 5, potentially valuable off-channel habitats are not accessible during low-flow periods. Most notably, fish collection activities conducted in August yielded YOY and juveniles of both bull trout and westslope cutthroat trout in isolated pools of abandoned side channels, as well as in reaches of off-channel habitat and tributaries that were isolated from the mainstem by aggraded materials.

Table 14 presents a description of off-channel habitats which were observed to support, or suspected of providing, habitat for early life stages of both target species. These habitats represent locations of restoration opportunity.

Table 13   Summary of impaired habitat indicators and fisheries values, Sage Creek watershed.

Reach/ Tributary	Impaired Habitat Indicators	Salmonid Fisheries Values	Probable Symptoms
REACH 1	low pool frequency, low pool extent	spawning - high juvenile rearing - high adult rearing - low	- altered pattern of discharge - increased sediment loads - loss of woody debris - infilling of pool habitat
REACH 2	no pools, limited woody debris, and poor cover	spawning - moderate juvenile rearing - low	-altered pattern of discharge
REACH 3	low pool frequency and extent limited woody debris	YOY and juvenile rearing - moderate	-altered pattern of discharge
REACH 4 (Section #1)	low pool frequency, low pool extent	YOY and juvenile rearing - low	-removal of riparian vegetation -road construction
REACH 4 (Section #2)	low pool extent	YOY and juvenile rearing - high	-increased sediment loads -altered pattern of discharge
REACH 5	low pool frequency	spawning - low YOY rearing - low	- altered pattern of discharge
Tributary 1	low pool frequency	spawning - low YOY and juvenile rearing - low	- road construction
Tributary 2	no pools low cover and limited LWD	fisheries value - low	- road construction
Tributary 4	low pool frequency and extent	YOY rearing - high juvenile rearing - low	- no obvious impacts
Tributary 7	low pool frequency	spawning - low YOY rearing - low	- no obvious impacts
Tributary 11	low LWD cover low pool frequency and extent	juvenile rearing - moderate	- removal of riparian vegetation

Table 14   Important habitats observed in Reaches 1 through 5.

Reach	Description	Habitat Characteristics	Target Species Observed	Restoration Opportunity
1	beaver pond / groundwater discharge	good rearing habitat, abundant invertebrates	Trout (fry / juvenile) observed	habitat protection / scour technique
2	marsh/abandoned channel / seasonally flooded / confluence Tributary 4	good rearing habitat within marsh, main channel provides good pool habitat, Tributary 4 - good rearing habitat and possibly spawning habitat for WCT	Adult WCT observed in the main channel, BT(fry) and WCT(juv) electrofished in the marsh and Tributary 4	habitat protection / scour technique
3	sidechannel / groundwater discharge	good rearing habitat, abundant invertebrates, good cover in large pool	Trout (fry / juvenile) observed	habitat protection / scour technique
3	marsh / confluence with Nettie Creek	rearing habitat / abundant cover within marsh	Unable to complete ground assessment.	habitat protection / scour technique
4	sidechannel / abandoned channel	seasonally flooded sidechannel, good rearing habitat, numerous pools with good LWD cover	BT (fry) and WCT (juv) electrofished	habitat protection / scour technique
4	marsh downstream of FSR Bridge / groundwater fed	shallow riffles feeding marsh provide good rearing habitat for juvenile BT, good rearing habitat within marsh	BT (fry) and WCT (juv) electrofished	habitat protection / scour technique
5	sidechannel / marsh / abandoned channel	channel provides rearing habitat, appears to be a remnant channel which is groundwater fed	no fish observed	habitat protection / scour technique
5	side channel / seasonally flooded / isolated tributary	good rearing habitat for BT and WCT, abandoned channel has a groundwater source, Tributary 11 is isolated (seasonally) from main channel	BT (fry) and WCT (juv) electrofished in side channel and Tributary 11	habitat protection / scour technique

5.0   DISCUSSION

Bull trout and westslope cutthroat trout represent significant fish stocks which have been negatively affected by poor logging practices in the Sage Creek watershed. Both species are known to be desirable species for recreational anglers in Sage Creek (Collins, 1981 reported in BRC, 1987) and the broader Flathead River drainage. Abundance of both species has declined over the past several decades (BRC, 1987; Liknes and Graham, 1988; several papers in MacDonald, 1985). In addition, bull trout are a species of special concern throughout their range in western North America. For these reasons, bull trout and westslope cutthroat trout represent target species for habitat restoration efforts in the Sage Creek watershed.

Field investigations of fish distribution undertaken in the watershed in August 1997 confirmed the use of mainstem and off-channel habitats by various life stages of bull and cutthroat trout, and several other species. The assessment and evaluation of available fish habitats identified habitat components which are degraded and potentially limiting to the production of these target species, as well as important habitats which require protection and/or enhancement.

Using this information, opportunities for the effective restoration of logging-impaired fish habitat have been identified and are discussed below. These opportunities are considered to be "preliminary" and "conceptual" and will require further development prior to their implementation in the watershed. Restoration opportunities identified in the following section are founded on the need to protect existing habitats of significance until historic fish production levels can be re-established in the watershed, as well as to restore habitats degraded by forest harvest practices.

It should be noted that the complete range of restoration opportunities are not described within this FHAP document. As channel and riparian condition assessments have also been completed simultaneously, some restoration opportunities which are applicable to the FHAP are addressed in these documents. Examples are the stabilization of sediment sources and aggraded mid-channel and lateral bars. While the stabilization of these areas is of utmost importance to the restoration of fish habitat, specific restoration measures and techniques are addressed in the CCPA document and not within the FHAP.

5.1.   Reach Specific Evaluations and Prescriptions

In the following sections, evaluations and prescriptions for each of the seven fish-bearing reaches of Sage Creek are presented. Channel and habitat characteristics are summarized, existing impacts discussed, and the requirements and justification for restoration measures are described. Preliminary restoration prescriptions and costs estimates have been developed for reaches considered to be of moderate and high priority, only. Where applicable, conceptual drawings of proposed restoration prescriptions are provided and the risks and timing of implementation are discussed.

5.1.1.   Reach 1

Existing Channel Characteristics and Suitability as Fish Habitat
Reach 1 of the Sage Creek mainstem is nearly 40 m wide and 3 m deep (bankfull) and extends
approximately 4800 metres upstream from the Canada/USA border. The channel is generally contained
within a relatively wide floodplain, with terraces rising about 40 metres beyond the channel margin. One
large eroding slope is located in this reach. The channel is moderately aggraded with gravel being the
dominant substrate. A large amount of sediment is stored within the channel in lateral and mid-channel bars.
Two tributaries join the Sage Creek mainstem within Reach 1 but are of minimal value due to their low flow
and undefined character. Other areas of off-channel habitat occur, some of which have been isolated by
aggrading bed materials.

Instream habitat of Reach 1 was characterized as poor due to the relative paucity of pools and functional
LWD throughout. LWD was unevenly distributed in debris/log jams throughout the reach. Areas of gravel
suitable for spawning by target species were scattered in a number of areas throughout the reach and were
rated as "high" in quantity and of "moderate" quality. Few areas of instream rearing habitat were
documented, although a variety of off-channel habitats are found in this reach. Riparian areas were
characterized as young forest comprised of mixed species.

Juvenile and YOY cutthroat trout and slimy sculpin were collected in this reach during the August 1997 field
investigations.

A comprehensive summary of Reach 1 channel conditions, fish use, habitat characteristics are presented on
the following pages. Representative photographs of Reach 1 are presented in Appendix 8 (Photos 1 & 2).

Watershed Impacts and Requirements/Justification for Restoration
Forest harvest activities in the mid- and upper basins of the Sage Creek watershed have resulted in changes
to discharge patterns, and increases in the rate of sediment generation and delivery to this reach. Reach 1 is
considered to be moderately aggraded with sediment wedges, elevated mid-channel bars, and multiple
channels found. Mean bankfull width in Reach 1 was over 33 m and mean width to depth ratio for the
reach was 12:1. Substrates of this reach were characterized as cobble-dominated, although the quantitative
pebble count procedure showed a distribution range between coarse gravels and small to medium cobbles.
Deposited sediments have impacted fish habitat quality in this reach through the infilling of pools and the
severing of connections between the mainstem and off-channel habitats. Increased runoff from the
watershed has resulted in higher peak flows and velocities which have limited the quantity of effective LWD,
and thus limited important and complex fish habitat elements. The 1995 flood event contributed to the
current channel condition.

Preliminary Restoration Prescription, Priority and Risk
Proposed restoration activities in Reach 1 are primarily related to addressing the large quantities of sediment
stored in this reach as mid-channel and lateral bars. Other restoration activities considered in Reach 1 were

the stabilization of a large eroding slope, and the protection of access to off-channel habitats from isolation by aggrading materials. These other activities were not developed further due to the large size of the unstable slope, and the limited value of the tributaries as fish habitat.

The objective of this restoration technique is to improve fish habitat through the alteration of channel morphology. Bar stabilization will promote channel downcutting and narrowing and specifically, the creation of deep pool and riffle habitats which are generally lacking in the fish-bearing reaches of the Sage Creek mainstem. The proposed bar stabilization activities can be achieved through the mechanical "scalping" back of aggraded materials and the placement of woody debris and plantings on the bars (Soto *et al.,* 1997). A typical drawing of the bar stabilization technique is provided in Figure 8. Further description of this restoration technique is provided within the CCPA document, as well as in the Integrated Restoration Report.

Bar stabilization is considered to be of "Low" priority for a number of reasons which includes evidence of the slow, but natural recovery of the channel (*e.g*., presence of some functional LWD), the instability of aggraded sediments in this reach, and the inaccessibility of the reach from the existing road network which would necessitate the extensive use of helicopter support for any
bar stabilizing typical here restoration works. In addition, instream works in the lower reaches have been given an overall low priority and the hierarchy of restoration works will focus on the stabilization of sediment sources in the upper reaches and basins of the watershed.

Depending on the timing of implementation, restoration activities in Reach 1 would be considered to be of moderate risk due to the high peak flows which will remain until revegetation of hillslopes and restoration of riparian zones in upstream reaches of the Sage Creek watershed occurs. The specific locations where this technique could be applied have not been identified at this time since the exact locations of sediment bars are expected to change between the time of field assessment (*i.e.*, 1997) and the expected time when instream stabilization will occur (*i.e*., 2000 or later).

5.1.2. Reach 2

Existing Channel Characteristics and Suitability as Fish Habitat
Reach 2 is generally contained by the terraces which attend Sage Creek in this area. Bankfull width and mean bankfull depth were approximately 21 and 1.3 m, respectively. Bankfull width-to-depth ratio was 16:1. At several locations within this reach, the channel intersects the attending terraces resulting in large eroding slopes. The channel is somewhat aggraded with bedload storage in only a few lateral bars. Channel morphology is characterized by long units of riffles and runs, with cobble substrates dominant. Two tributaries join the mainstem near the upstream end of the reach providing important off-channel habitat.

Pool habitats are limited in Reach 2 and are almost always associated with debris/log jams. These debris/log jams represent the majority of functional LWD in this reach, and typically are comprised of 10-

15 pieces of smaller wood, with 1 - 2 pieces of larger wood. Debris/log jams were most commonly found on the outside meanders of this reach.

Electrofishing effort in Reach 2 resulted in the capture of juvenile cutthroat trout and slimy sculpin during the 1997 field activities. All cutthroat were captured in riffle habitats. Juvenile cutthroat were collected in off-channel habitats near the upstream end of this reach.

A comprehensive summary of channel conditions, fish use, and fish habitat characteristics of Reach 2 are presented on the following pages. Representative photographs of Reach 2 are presented in Appendix 8 (Photos 3 & 4).

Watershed Impacts and Requirements/Justification for Restoration
No active forest harvest activities are occurring adjacent to this reach although the effects of past logging activities in areas upstream are evident. Channel disturbance indicators observed in this reach included some mid-channel and lateral bar formation, extensive sections of riffles, and the erosion of large terrace walls. Fish habitat limitations noted for this reach were the absence of pools and the low abundance of functional LWD.

Preliminary Restoration Prescription, Priority and Risk
Similar to the objectives of habitat restoration in Reach 1, Reach 2 restoration efforts should also focus on stabilizing instream sediments to address current fish habitat limitations in this reach. As described previously, bar stabilization will promote the formation of pool and deep glide habitats available for adult and juvenile bull and cutthroat trout, encourage the establishment of woody vegetation on presently exposed areas, and accelerate the natural recruitment of effective LWD.

Restoration of the large eroding slopes in this reach is not proposed due to the size, grade and instability of these slopes. Protection of important off-channel rearing habitats is also not proposed since they were located a considerable distance from the mainstem and therefore subject to a range of variables outside the control of the restoration efforts (*i.e.*, high potential for failure).

As described previously, the objective of the bar stabilization technique is to improve fish habitat through the alteration of channel morphology. This restoration technique promotes channel downcutting and narrowing and specifically, the creation of deep pool and riffle habitats which are generally lacking in the fish-bearing reaches of the Sage Creek mainstem.

Restoration in Reach 2 is considered to be of "Low" priority as some functional LWD (i.e., debris/log jams) is presently found, and potential areas of restoration are generally inaccessible from the existing road network. The cost/benefit of restoration would therefore be expected to be high as a result. In addition, instream works in the lower reaches have been given an overall low priority and the hierarchy of restoration works will focus on the stabilization of sediment sources in the upper reaches and basins of the watershed first.

If restoration activities were to be implemented in Reach 2 prior to the reestablishment of the historic hydrologic regime, these activities would be considered to be of moderate risk due to the high peak flows which presently characterize the watershed. The specific locations where this technique could be applied have not been identified at this time since the exact locations of sediment bars are expected to change between the time of field assessment (*i.e.*, 1997) and the expected time when instream stabilization will occur (*i.e.,* 2000 and later).

5.1.3.   Reach 3

Existing Channel Characteristics and Suitability as Fish Habitat
Reach 3 is approximately 2000 m long with a mean channel width and depth of 45 and 3 m, respectively. Terraces, which somewhat confined the channel downstream, are set well back from the channel in Reach 3. Channel morphology is classified as riffle-pool with a reach gradient estimated at 1.3%. Aggrading sediments which characterize sections of this reach, are dominated by cobbles, and are stored in large lateral and mid-channel bars. Pools are infrequent and shallow. A large log jam has promoted the development of side channel habitat, but has also enhanced erosion of the existing and new channels.

Pool habitats are fairly numerous in Reach 3 but are considered to be of poor quality due to their limited depth. Characteristic of the lower Sage Creek system, functional LWD is generally lacking although a large log jam of approximately 115 m in length is present within the reach. The availability of spawning gravel is extensive but is considered of moderate quality.

During the 1997 field investigations, juvenile cutthroat and bull trout were captured in pool and run habitats, respectively. Slimy sculpin were also collected in this reach in 1997.

Channel conditions, fish use, and fish habitat characteristics of Reach 3 are summarized on the following pages. Representative photographs of Reach 3 are presented in Appendix 8 of this report (Photos 5 & 6).

Watershed Impacts and Requirements/Justification for Restoration
Active forest harvesting is not occurring adjacent to this reach. Impacts of historic logging activities in upstream areas of the watershed, however, are evident in the form of aggrading bars and the reduction of functional LWD resulting from increases in available sediments and their delivery, as well as changes to the drainage pattern upstream. The main log jam found in this reach has prompted the creation of a new channel. Due to the volume and density of material in the log jam, even low flows are restricted from passing. Considerable streambank erosion has occurred upstream of the log jam.

Preliminary Restoration Prescription, Priority and Risk
Proposed fish habitat restoration opportunities in Reach 3 are related to the "thinning" of the large log jam located approximately 2500 m downstream of the Forest Service Road bridge. The log jam has resulted in the deposition of a large amount of fine sediment at the upstream end of the structure, and the development

of braided channels around it which are eroding riparian habitats. It is expected that fish habitat value within the structure is limited due to reduced flows, local areas of dewatering, and infilling of pools.

Details of the proposed restoration location, objectives, prescription, benefits and risk are presented on the following sheets.

5.1.4. Reach 4

Existing Channel Characteristics and Suitability as Fish Habitat
This low-gradient reach extends over more than 6000 m of the Sage Creek mainstem. Average channel dimensions are 20 m wide and 2 m deep (bankfull). Width-to-depth ratio is 10:1. Three tributaries join the mainstem within this reach. The reach is characterized as riffle-pool, moderately aggrading, and dominated by gravel substrates. Pools are infrequent and LWD is widely scattered occurring as debris piles. Large lateral and mid-channel bars occur at a number of locations. In the lower section of this reach a number of meanders have been cut-off creating side channels.

In the upper sections of Reach 4, fish habitat quality of the mainstem is limited by the low quantity of functional LWD and pools. Spawning gravels were identified in numerous locations but were considered to be of moderate quality. In the lower section of this reach, new channels have been established through the forested floodplain and are characterized by abundant LWD which provides excellent cover and complex fish habitat.

Electrofishing undertaken in Reach 4 yielded juvenile and YOY cutthroat trout from pools and backwater areas, respectively. Numerous YOY bull trout were also collected from shallow riffle habitats. Several sucker and slimy sculpin were also collected in this reach during the August 1997 field investigations. Slimy sculpin and largescale sucker have been collected in this reach prior to the 1997 field work (Columbia Environmental Services, 1996).
A summary of channel conditions, fish use, and fish habitat characteristics are presented on the following pages. Representative photographs of Reach 4 are presented in Appendix 8 of this report (Photos 7 & 8).

Watershed Impacts and Requirements/Justification for Restoration
Similar to the other fish-bearing reaches of the Sage Creek mainstem, forest harvesting activities in the upper basins of the watershed have increased the quantity of bedload delivered to the system, as well as increased peak flows. As a result, large lateral and mid-channel bars have formed in a number of locations in Reach 4, pool habitats have been filled, and functional LWD transported downstream. While similar characteristics occur in other reaches of Sage Creek, the availability of road access to this reach provides increased justification for habitat restoration.

Preliminary Restoration Prescription, Priority and Risk
Several fish habitat restoration opportunities occur in Reach 4 and are intended to address fish habitat limitations in this reach. The construction of LWD structures (debris catchers) at five locations is proposed

and intended to increase the quantity of functional LWD and thus, increase the quantity of pool habitat available to the early life stages of both target species of trout. Several areas of eroding bank immediately adjacent to the Sage Creek Forest Service Road are proposed for stabilization through the application of toe protection, LWD placement, and wattling. Finally, the protection of off-channel habitat from isolation by aggrading materials is proposed using LWD to promote scour at the channel outlet.

Preliminary prescriptions, costs, priorities and risks of the proposed restoration activities in Reach 4 are provided on the following summary sheets. Typical drawings of the triangular log jam and LWD structure techniques are provided in Figures 9 and 10, respectively.

5.1.5. Reach 5

Existing Channel Characteristics and Suitability as Fish Habitat
Reach 5 is approximately 3500 m in length and has a mean bankfull width of about 18 m and a mean bankfull depth of 1.3 m. The channel is somewhat confined by terraces and is of low gradient (~0.4%). Sediments are aggraded in a number of locations within this riffle-pool reach, particularly at the downstream end. Cobble dominates the substrate composition. Four tributaries join the Sage Creek mainstem within Reach 5 (Tributaries 10 - 13).

As is the case for most reaches of the Sage Creek mainstem, pools are infrequent and shallow in Reach 5. Functional LWD is also of limited abundance and distributed unevenly throughout the reach. The quality and quantity of gravels suitable for spawning were both evaluated as moderate. Riparian areas were characterized as young forest comprised of mixed species.

Juvenile cutthroat trout and YOY bull trout were collected from pool habitats in this reach. Slimy sculpin and longnose sucker were also collected during the 1997 field surveys. Juvenile and YOY cutthroat trout were also collected from riffle habitat of Tributary 11. Westslope cutthroat were the only species collected from this reach previously (Columbia Environmental Services, 1996).

A summary of Reach 5 channel conditions, fish use, and habitat characteristics are presented on the following pages. Representative photographs of Reach 5 are presented in Appendix 8 of this report (Photos 9 & 10).

Watershed Impacts and Requirements/Justification for Restoration
Similar to the other fish-bearing reaches of the Sage Creek mainstem, past forest harvest activities have resulted in impacts in Reach 5 and are related to altered discharge patterns as well as the rate of sediment delivery and storage. Disturbance indicators observed in this reach included sediment wedges, elevated bars and multiple channels. Deposited sediments have impacted fish habitat quality in this reach through the infilling of deep pool and glide habitats. Increased runoff from the watershed has resulted in higher peak flows and velocities which have limited the quantity of effective LWD, and thus limited important and complex fish habitat elements.

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Appendix C - FHAP

Preliminary Restoration Prescription, Priority and Risk

Proposed restoration activities in Reach 5 are primarily related to addressing the large quantities of sediment stored in this reach as mid-channel and lateral bars. Bar stabilization is proposed in Reach 5 to improve fish habitat, achieved through the deepening and narrowing of the channel. Deep pool and riffle habitats are generally lacking in this, and other, fish-bearing reaches of the Sage Creek mainstem. The bar stabilization technique was described previously.

Bar stabilization in Reach 5 is considered to be of "Low" priority as restoration works in upslope areas are required prior to instream works. Some natural stabilization is occurring in the reach, however restoration using this technique would significantly accelerate the stabilization of stored sediments, and thus, the value of fish habitat characteristics.

Depending on the timing of implementation, restoration activities in Reach 1 would be considered to be of moderate risk due to the high peak flows which will remain until revegetation of hillslopes and restoration of riparian zones in upstream reaches of the Sage Creek watershed occurs. The specific locations where this technique could be applied have not been identified at this time since the exact locations of sediment bars are expected to change between the time of field assessment (*i.e.*, 1997) and the expected time when instream stabilization will occur (*i.e.*, 1999, 2000).

5.1.6. Reach 6

While considered a fish-bearing reach, fish habitat, fish distribution and habitat restoration opportunities were not examined in Reach 6 as it is a canyonized reach.

5.1.7. Reach 7

Similar to Reach 6, Reach 7 is also a canyon. Fish habitat, fish distribution and habitat restoration opportunities were therefore not examined.

5.2. Level 2 Assessments

Prior to the implementation of any of the restoration activities described above, site-specific field assessments (Level 2) will be required. The objective of these assessments will be to collect detailed measurements required for the development of detailed habitat restoration plans at each location which reflect more current and site-specific biophysical conditions than those provided by the Level 1 assessment in 1997. For the proposed fish habitat restoration sites proposed at Sage Creek, the types of information to be collected during the Level 2 assessment include the following:

► the exact location of each restoration site;
► the proposed working area limits of each site;

► further definition of the restoration objective and recommended prescription at each site;
► projected sequencing of work activities to maximize efficiencies of equipment use and labour resources given the remoteness of the area;
► information leading to the development of construction supervision and environmental monitoring plans;
► identification of special concerns which may be related to crew safety, scheduling of activities, etc.;
► refinement of labour and material requirements and estimated project costs for each site; and
► expected benefits of the proposed restoration works.

As Level 2 assessments focus on the collection of detailed physical, biological and hydraulic information it is important that they are based on technical manuals such as the WRP's Technical Circular #8 (Johnston and Slaney, 1996) and Stream Analysis and Fish Habitat Design Field Manual (Newbury and Gaboury, 1993), as well as accepted engineering standards. Level 2 assessment teams should include Project and Field Co-ordinators, biologists and engineers, where appropriate.

Objectives of Level 2 assessments for each type of restoration opportunity proposed for the sage Creek watershed are identified in Table 15. A proposed schedule of when the proposed works could be undertaken and first-order cost estimates for conducting the Level 2 work are also provided in Table 15. These estimated costs are presented independently of one another and do not include costs of implementing the restoration activities.

Table 15.   Level 2 assessment requirements for proposed Sage Creek restoration activities.

Restoration Opportunity	Restoration Prescription	Priority	Objective(s) of Level 2 Assessment	Timing of Implementation	Estimated Cost of Level 2 Assessment
Lateral Bar Stabilization	Stabalize mid-channel and lateral bars using woody debris and native vegetation to promote downcutting and narrowing of Sage Creek channel.	Low	Survey of bar location, dimensions and elevation required to determine extent of materials to be "scalped", and quantity of woody debris and live plantings required for effective stabilization. Access planning.	Level 2 Field Work - June >98 Implementation of Restoration Work - August 1999?, 2000?	Labour - $5500 (10 pd=s) Expenses - $3000 Total - $8,500
Protection of Access to Off-Channel Habitat	Construct instream structures that will promote scour of outlet of off-channel habitat used by YOY and juvenile salmonids	Low	Detailed survey and hydraulic assessment required at potential sites to verify structure type and placement.	Level 2 Field Work - June >98 Implementation of Restoration Work - August >98	Labour - $5000 (8 pd=s) Expenses - $3500 Total - $8,500 Note: costs assume detailed assessment of four locations.
Log Jam "Thinning"	Selectively remove woody debris from log jam to enhance water flow while maximizing log jam function	Low	Identification of individual logs within log jam to remove. Identification of site specific characteristics such as access, staging area, stockpiling area, etc. Development of detailed restoration plan.	Level 2 Field Work - June >98 Implementation of Restoration Work - July/August >98	Labour -$4400 (8 pd=s) Expenses - $2500 Total - $6,900
Experimental LWD Placement	Construct debris catchers and LWD structures to increase cover and promote the scouring of pool habitats	Moderate	Identification of specific sites for LWD placement. Identification of access and staging locations. Development of detailed restoration plan.	Level 2 Field Work - June=98 Implementation of Restoration Work - August >98	Labour - $3400 (6 pd=s) Expenses - $2500 Total - $5,900

6.0   REFERENCES AND PERSONAL COMMUNICATION

6.1.   References

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6.2.   Personal Communications

The following individual provided additional anecdotal information about Sage Creek and its surrounding watershed:

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