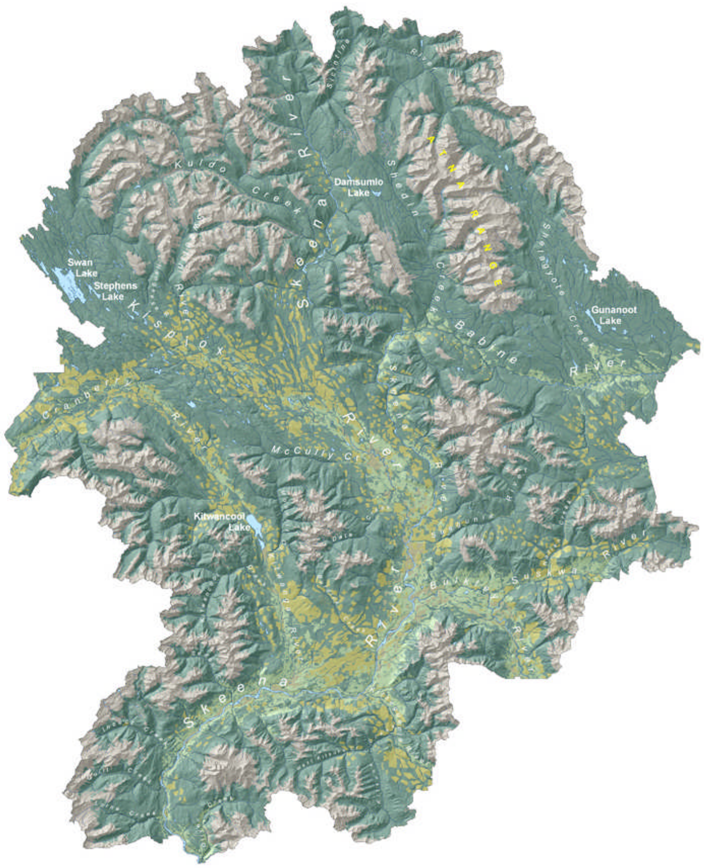
MID SKEENA WATERSHED RESTORATION EFFECTIVENESS MONITORING



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SUMMARY

The purpose of this report is to present background information and results from effectiveness evaluations conducted on instream structures, riparian, road deactivation, and stream crossing works that were installed between four and eight years ago by watershed restoration programs. In 2006, Gitksan Watershed Authorities was retained by the Pacific Salmon Commission to conduct a effectiveness monitoring in three Mid Skeena sub-basins: the Kispiox, Kitseguecla, and the Suskwa.

This watershed restoration effectiveness monitoring assessment is part of a larger regional effort to ensure treatment designs and their applications are effective, and if not, provide technical feedback to refine designs. As well, the evaluations will rate the extent of watershed recovery achieved and help to ensure funds are spent on the most cost-effective treatments.

Well-designed and properly implemented evaluations are a prerequisite to determining the success or failure of watershed restoration. The objectives of these evaluations are:

1. To document the configuration and condition of rehabilitation works;
2. Monitor the effectiveness of rehabilitation works in improving fish and fish habitat;
3. Determine if further rehabilitation or maintenance works are required, and if so, prioritize future works.

The Kispiox, Kitseguecla, and the Suskwa sub-basins had a number of roads deactivated, hillslope failures stabilized, instream structures established, and stream crossing sites rehabilitated. This project assessed these sites utilizing the provincial standard effectiveness evaluation protocol: *Framework for Conducting Effectiveness Evaluations of Watershed Restoration Projects* (Gaboury and Wong 1999). For this project, effectiveness evaluations were conducted at various levels of intensity, depending on restoration project complexity.

Within the Kispiox Watershed, the Murder Creek instream structure project conducted in 2001 is considered a success; however, the Murder Creek culvert at Kispiox Trail crossing needs to be replaced with a bridge or open bottom structure. The majority of instream structure instalments were poorly planned, not suitable for the sites, or poorly implemented. Deactivation works in the Kispiox are rated good with few sediment related problems.

Instream structures installed in the Suskwa Watershed are rated fair for overall effectiveness. Road deactivation in the Suskwa is rated good, but routine maintenance appears to be lacking. The major hillslope stabilization project effectiveness located on the Suskwa FSR at 1.5 km is rated as fair to good; there are some reconstruction and maintenance issues to address.

In the Kitseguecla Watershed, the road deactivation works are considered good. The hillslope stabilization project located on the Kitseguecla FSR at 9.5 km is rated as fair to good with drainage works required on Slide 4 and 5. The hillslope stabilization projects in the West Kitsuns Creek area are rated fair; a strategic remedial plan never to be developed and implemented. The instream structure located on Trib 1 is rated as a success.

ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

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1.1 OBJECTIVES

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1. To document the configuration and condition of rehabilitation works;
2. Monitor the effectiveness of rehabilitation works in improving fish and fish habitat;
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This project assessed watershed restoration sites in the Kispiox, Kitseguecla, and the Suskwa sites utilizing the provincial standard effectiveness evaluation protocol, compiled the results, and prepared a text and tabular report with an appended map series documenting the findings and setting priorities for future restoration efforts.

1.2 WATERSHED RESTORATION PROGRAM BACKGROUND

Natural freshwater habitats of Pacific anadromous salmonids have undergone massive alterations in lower and middle Skeena Watershed since the early 1900s. These changes have been due primarily to forest harvesting activities and linear transportation development. Impacts from forest harvesting have generally resulted in habitat simplification and loss of water quality and quantity. Rail and road transportation development has impeded fish passage to fish species life history stages in varying degrees depending on the stream crossing particulars. Overall, past land management practices have lessened the productive capacity of forest lands, and particularly, fish producing waters.

In 1994, the B.C. Government introduced the *Forest Practices Code* and Forest Renewal BC (FRBC), an initiative aimed at rehabilitating B.C. watersheds. The Watershed Restoration Program (WRP) was an ambitious program under FRBC to restore the productive capacity of forest, fisheries, and aquatic resources that were adversely impacted by past forest harvesting practices. Within the Middle Skeena, the Kispiox, Suskwa, Kitseguecla, and Kitwanga watersheds received WRP funding from 1995 to 2001, when FRBC was discontinued due to changing government priorities.

The major goals of the Watershed Restoration Program were:

- to protect, restore and maintain fisheries, aquatic and forest resources that have been adversely impacted by past forest harvesting practices,
- to provide community-based employment, training and stewardship opportunities, and
- to provide a mechanism to bridge historical forest harvesting practices and the new standards established by the Forest Practices Code

Restoration activities funded under the Watershed Restoration Program adopted a process-oriented approach that:

- reduced the generation and delivery of sediments from hillslopes to stream channels,
- re-established natural drainage patterns and water quality,
- replaced lost channel-structuring elements within streams to increase the amount and quality of fish habitat, and
- restored habitat within selected terrestrial, riparian and stream ecosystems towards pre-logging conditions.

The intent of the restoration work was to return the processes that caused the adverse impacts to their natural levels rather than simply treating the symptoms of the impacts. By altering the rates of processes that controlled the physical and biological structure of watersheds, the program hoped to re-establish more productive, normally functioning ecosystems for the future.

WRP program goals, objectives, and intents were a significant move forward to improving salmonid habitat and the rate of habitat loss has declined. However, the science and how-to implementation of habitat restoration is not well-known in the Skeena Basin. Insufficient understanding and/or information of ecological processes and their context at the basin and sub-basin levels is still common. Developing baseline information on habitats and their use for salmonid species preferences by life stage, and gaining an understanding of factors that limit salmonid production requires multi-year pre-improvement inventories because of the natural variability in fish populations and the environment. Further complications arise when predicting the effects of habitat improvements without extensive experience.

1.3 Effectiveness Monitoring

Since the WRP was initiated, restoration prescriptions and treatments have included conceptual designs and techniques known to work and others that are new methods, particularly in applications to hillslope stabilization and placement of in-stream structures. From a management perspective, evaluating projects to understand their benefits is just as important as planning and constructing the projects themselves. Because salmonid habitat improvement knowledge is limited, quantitative and qualitative evaluations of habitat improvement work can expand the knowledge base.

Mid Skeena effectiveness monitoring can be used to examine three aspects of restoration: physical changes in habitat resulting from design and rehabilitation work, biological production, and the cost effectiveness of the work. Evaluations that examine these three aspects are the most meaningful.

This evaluation project attempted to examine the physical changes in habitat resulting from design and rehabilitation work, biological production, and the cost effectiveness of the work; however, in most instances, records pertaining to individual projects were unavailable from the proponents or government ministries due to the Watershed Restoration Program being shelved and government agency reorganization.

Some fundamental restoration activities such as deactivating roads to reduce the supply and delivery of sediments from hillslopes and connecting high value fish habitats that have been isolated by culverts or artificial obstructions are easily evaluated and comprehensive research and monitoring is not needed. Other actions such as riparian restoration and slope stabilization of surficial slides may be largely effective in some sites and conversely, in-effective in others.

Instream structure placements have not been thoroughly evaluated in general and their effectiveness is commonly debated in the scientific community. Most instream structure evaluations have focused on the physical response with little attention to fish and biotic productivity. The response of fish and other biota are inherently more difficult to evaluate than are physical conditions, but the biological response to restoration activities is the ultimate measure of effectiveness. Of course, this is assuming that the restoration designers and technicians understand which types of restoration to conduct first, how site specific actions or techniques fit into the larger context of basin and sub-basin restoration, and how the actions will be effective.

Efforts to protect remaining habitats in the Skeena Watershed are extremely important and remain a higher priority than habitat restoration because protecting habitat costs substantially less from the short to the long term than rehabilitating it. Habitat protection also has predictable results. Many restoration projects in the mid Skeena have been experimental and unproven.

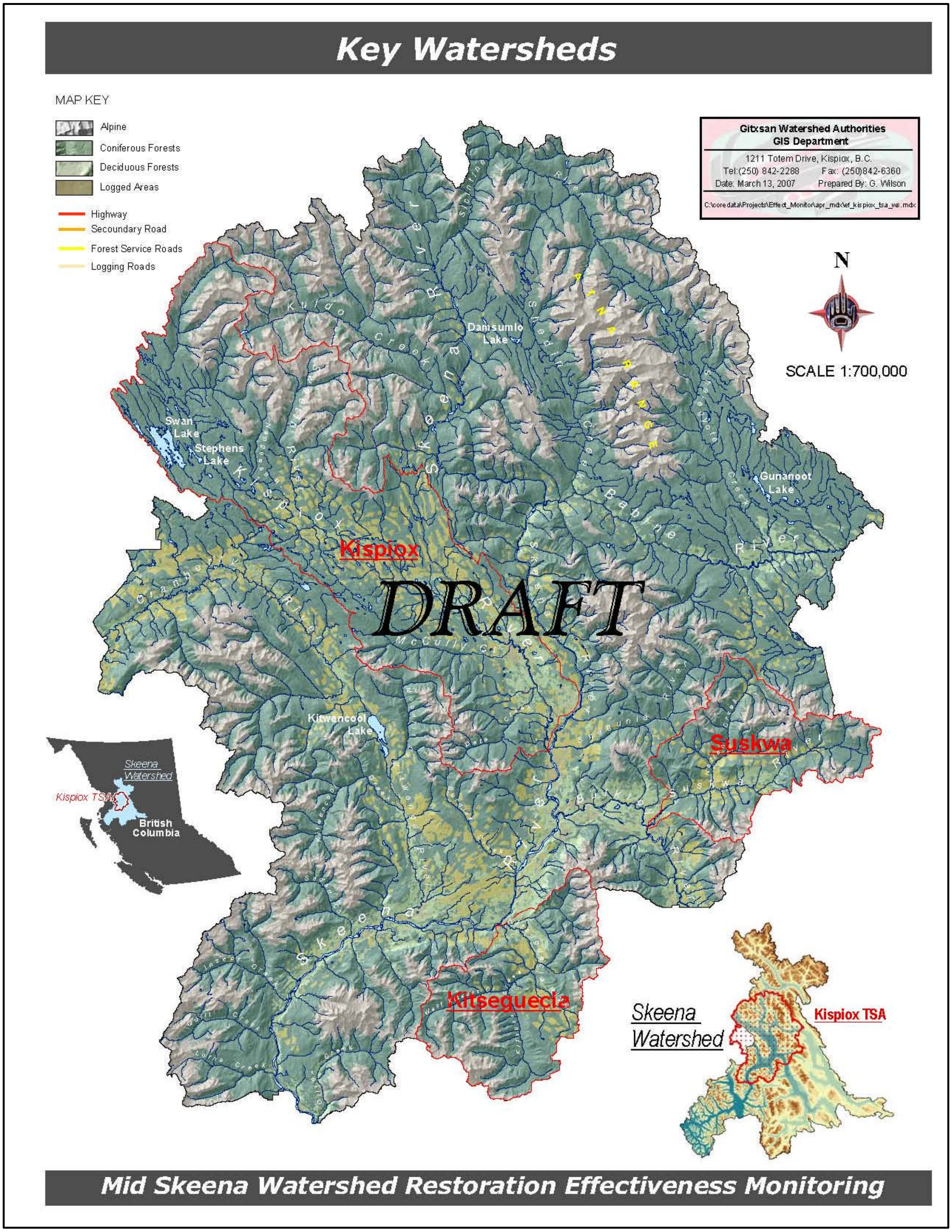

Figure 1. Mid Skeena Watershed Restoration Sub-basins

2.0 METHODS

2.1 PRE-FIELD PLANNING

An office-based planning and information compilation element was conducted to review background information that included previous assessments and restoration objectives, prescriptions, and site works. Significant amounts of information were compiled for past Suskwa, Kispiox, and Kitseguecla watershed restoration activities from both B.C. Ministry of Environment and B.C. Ministry of Forests and Range. This information was organized into watershed folders and where possible, further broken down into specific individual sites.

In reviewing specific site information, it was often difficult to figure out if rehabilitative prescriptions and treatments were applied, by whom, and if the activity was reported on. Frequently, information showing the exact location of restoration sites was unavailable and in some cases different reports showed conflicting locations. This situation was exacerbated by WRP files being moved to and archived in Victoria when the program was discontinued in 2002. Additionally, some BC ministry staff, forest licensee staff, and lead proponent staff involved in administrating the Suskwa, Kitseguecla, and Kispiox WRP relocated out of the area. In essence, the majority of available WRP information was not available in a state facilitating effectiveness monitoring.

All WRP sites were designated as to watershed and segregated into hillslope, riparian, and stream components in order to relate evaluation objectives to WRP objectives and activities. The sites were then further divided to the site level such as road segment or landslide segment. Further division to the site specific level described individual deactivation features such as a cross-ditch, water bar, or ditch block. On hillslope stabilization projects, site specific level could be represented by sections of brush layers or live stakes.

Sites with instream structure placements and hillslope stabilization components per respective watersheds were organized into routine, qualitative evaluations. Deactivated road systems and all sites were noted on field maps that were generated to facilitate access and positioning.

Evaluation plans were created that focused on hillslope and aquatic components; riparian restoration prescriptions for the three watersheds were established, but not implemented. Extensive deactivated road systems, particularly in the Kispiox, were relegated to a visual qualitative visual inspection from helicopter. Deactivated road systems in the Kispiox, Kitseguecla, and Suskwa watersheds were planned to be visited with vehicles or by foot. Major stream and hillslope restoration projects were screened to enable meaningful routine ground evaluations. Two hillslope stabilization projects were selected for operational techniques refinement evaluations. No restoration projects in the Mid Skeena were selected for intensive evaluations mostly due to the lack of pre-treatment surveys and information.

2.2 FIELDWORK

Field evaluations reflected the original site restoration objectives and applied activities, which differed from watershed to watershed and from site to site. Variables were selected for the routine effectiveness evaluations that were practical, easily observed, and measurable. Qualitative assessments of structures or treatment was rated using an ordinal scale: good, fair, and poor.

Our field data collection included: administrative categories such as stream or site name, location coordinates, and watershed code; noting the fish presence, fish habitat quality, channel type, noting stream characteristics such as wetted width and depth, bankfull width and depth, stream gradient, substrate, stream velocity, barriers, and taking upstream and downstream photographs from the work if instream. Observations were focused on indicators related to restoration objectives. For example, if a log weir was placed to increase pool presence and scour gravel downstream of the weir, was the log weir functional, was pool presence maintained, and was gravel being scoured. Structures on each site were assessed both individually and a group as to design, placement, construction, structural integrity, and current function. Fieldwork was conducted from mid-May to late October.

The following procedures and field gear were used to collect effectiveness evaluation data:

- Bushnell Yardage Pro laser range finder.
- Meter stick, hip chain, or tape.
- Swoffer 2100 Current Meter.
- Suunto clinometer.
- Garmin eTrex Summit.
- Olympus Stylus 730, Olympus SP-500UZ, and a HP Photosmart R707 digital cameras.
- Oxyguard Handy Mk III dissolved oxygen meter.

3.0 KISPIOX WATERSHED EFFECTIVENESS EVALUATIONS

3.1 ENVIRONMENTAL SETTING

The Kispiox River is a large tributary of the Skeena River. It flows 140 km southeast from its headwaters to the confluence with the Skeena River (right bank) at Kispiox Village, approximately 12 km north of Hazelton. The watershed is bounded in the north and the east by the Southern Skeena Mountains, to the south predominantly by the Kispiox Range, and to the west by the low relief Nass Basin.

The Kispiox is a fifth order stream with a catchment area of 2,088 km^2. Elevation ranges from approximately 200 m at the mouth to 2090 m on Kispiox Mountain and 1850 m in the Skeena Mountains. This major tributary contributes about 9% of the Skeena River flows (Remington 1996). Kispiox River peak discharges occur typically in May and June due to spring snowmelt, then decrease through July and August. In September, fall rains and runoff from early snow melt increases stream flows once again through to October. Stream flows decrease through November and December when precipitation falls as snow, with low discharges recorded January through March.

Climatic information from the Murder Creek weather station (AES 1993), located in the lower Kispiox, shows mean annual precipitation of 631 mm over a twenty-year period, of which rainfall accounts for 71% (Environment Canada 2005). Total annual precipitation (TAP) is much greater in the upper watershed, particularly at higher elevations; Stockner and Shortreed (1979) reported 1500 mm TAP at Swan Lake. The Skeena Mountains to the north, and the Nass Basin, which broaches the northwest and western perimeter of the watershed, exert the major hydrological influences. The low elevation watershed divide to the Nass drainage in the west allows coastal weather systems to enter the watershed, leading to heavy snow packs in the mountains and the upper half of the drainage.

Three physiographic units are present in the Kispiox Watershed: the Nass Basin, the Kispiox Range, and the Skeena Mountains to the north and northeast. The Nass Basin is an area of low relief, which generally falls below 700 m and forms the valley floor. The Kispiox Range, which bounds the watershed to the southwest, is largely drained by Date and McCully Creeks. The southern Skeena Mountains form the headwaters of the Kispiox River and its major tributaries, the Sweetin and East Kispiox Rivers.

The broad northwest-southeast trending Kispiox Valley, approximately 100 km long and averaging 20 km wide, resulted from a block fault zone associated with plate tectonics and accreted terranes on the west coast of North America. The down-faulted block fault lines control the break between the valley and the mountains. This form of basin and range topography has resulted in the broad, linear down-faulted Kispiox Valley being separated by the uplifted mountain blocks, which are the southern Skeena Mountains, the Kispiox Range, and the Babine Range that lies east of the Skeena River.

Folded and faulted Bowser Basin marine sediments characterize the underlying bedrock in the Kispiox Watershed; minor amounts of an intrusive granitic stock appear in the Kispiox Range. The ice that covered and flowed down the Kispiox Valley during the last glacial period strongly glaciated the mountain slopes and the basin, leaving a legacy of drumlin fields, hundreds of small lakes, and a generally linear drainage pattern. Thick blankets of glacial till cover the main valley and mountain valleys and extend up the valley sidewalls.

The coastal/interior transition climate is reflected in the major ecological zones. Vegetation in the wide, gently sloping valley below approximately 750 m is represented by the Interior Cedar Hemlock (ICH) biogeoclimatic zone, dominated by forest stands of hemlock, spruce, subalpine fir, and in the southern half, red cedar. Before industrial logging, the majority of forest stands were mature hemlock and fir. These stands have been replaced with plantations of spruce and pine, while a major portion of the valley bottom has been replaced by deciduous forests. With increasing elevation, the ICH zone passes into a forest dominated by mature and overmature subalpine fir, representing the Engelmann spruce–subalpine fir (ESSF) biogeoclimatic zone (Pojar *et al.* 1988).

3.1.1 Stream Channels

Kispiox River is divided into three distinct reaches from the Skeena River upstream to Sweetin River. These lower three reaches are composed of a mix of pools, riffles and runs, which offer holding, rearing, and spawning habitat. The mainstem channel presents a regular profile with a gradient of 0.3% slope or less (MoE 1979). Bedrock outcrops are infrequent and bank erosion is common. Minor amounts of sediment are received from most tributaries other than Date Creek and McCully Creek, which contribute comparatively large amounts of natural sediment. Low summer flows may compromise off-channel habitat rearing capacity.

Figure 2. Upper Kispiox River.

Reach Four, from Sweetin River upstream to Gitangwalk Canyon is frequently confined by bedrock, which becomes more evident in reach five starting at the bottom end of Gitangwalk Canyon. Gitangwalk Canyon, defined as Reach Five, is approximately 1 km in length with an average gradient of 0.6%. The lower end of the canyon presents a 200+ m long cascade with two 1-2 meter drops that restrict pink and chum salmon access to the upper reaches of the river. Reach 7 and 8 both have average gradients of 0.4%. Another falls, about three meters in height, is found past the confluence of the East Kispiox River.

Weiland (2000b) noted that several tributaries in their lower reaches have very low gradient channels with very low sediment transport capability. Overall, most Kispiox River tributary channels downstream of Hodder Creek have received a degree of impacts ranging from low to high when compared to ambient, natural conditions prior to large-scale industrial logging. Triton (2001) stated that forestry impacts to fish habitat are extensive through the low-gradient reaches of most tributaries due to obstructions to fish passage, logged riparian zones, surface erosion, reduced instream habitat complexity, sub-surface flows, and degraded habitat quality.

Murder and McCully Creeks have avulsions in their lower reaches due to the combined effects of agricultural clearing of the floodplain and riparian zones, followed by high stream flows, and resultant downstream sediment deposition.

Low-gradient reaches of many tributaries in the watershed contain relatively large numbers of beavers. Nortec (1997) described twelve creeks where channel changes, bank erosion, and decreases in riparian suitability for conifers were due to beavers and their dams. Riley and Lemieux (1998) found that beaver activity on Kispiox River tributaries created large areas of habitat that supported high densities of coho fry. They recommended no removal of beaver dams unless it could be demonstrated that beaver activity had resulted in negative effects on coho populations. They suggested that beaver dam removal contravened the DFO's No Net Loss policy.

Figure 3. Beaver impoundment on Ironside Creek tributary crossed by Bridge Mainline.

3.2 KISPIOX WATERSHED RESTORATION PROGRAM

The Kispiox Watershed Restoration Program was initiated in 1995 and continued until 2001 when FRBC was repealed. From 1995 to 2001, approximately $1.1 million was invested in assessments, treatments and monitoring of upslope, road, riparian, and instream components to reduce forestry impacts and future risks. In 2001, Triton (2001) prepared a Watershed Restoration Plan for the Kispiox that summarized the WRP investment and work to date and outlined the watershed goals and a plan to rehabilitate instream and riparian components through the 16 sub-basins.

The proposed five year investment was budgeted at $1.28 million for 2002-06, which never occurred due to government changing priorities. The breakout of the proposed $1.280,000 was: planning 4%, riparian assessment and treatments 12%, road deactivation and fish passage work 22%, instream assessment and treatments 60%, and monitoring and evaluation 4%.

3.2.1 EFFECTIVENESS MONITORING RESULTS

This watershed restoration effectiveness monitoring project screened all restoration projects completed since 1995. The majority of completed work consists of road deactivation; assisting fish passage with culvert baffles and outlet pool weirs, debris jam removal, beaver dam breaching; excavation of off channel habitat as well as instream structural placements such as log and rock weirs, and deflector logs.

3.2.2 DEACTIVATION AND HILLSLOPE STABILIZATION WORKS

Deactivated road systems and all sites were assessed for field indicators that are commonly associated with slope instability and erosion. Sites were also evaluated for overall effectiveness. The residual risk at the sites was also assessed with respect to fish habitat and water quality. The majority of deactivation works consist of waterbars, cross ditches, deactivated stream crossings, and pullback of debris encroaching on streambanks.

Across hundreds of sites, deactivation work was consistently good with the results showing minimized erosion, good effectiveness of grass seeding, and deactivated stream crossings showing good work and streams running clear. Very few sediment related problems were observed at stream crossings. Maintenance of deactivated works is lacking and causing sediment delivery problems; a road inspection schedule and reporting system needs to established and implemented. Field indicators show that beaver dam failures can and do generate and deliver significant amounts of sediment and debris. A minor amount of the proposed deactivation includes culverted stream crossings that exhibited signs of being plugged by debris or the crossing was overtopped by upstream beaver dam failure outburst flows.

There is small quantity of road deactivation needed that would be beneficial to water quality; it is spatially sporadic and spread throughout developed areas of the watershed.

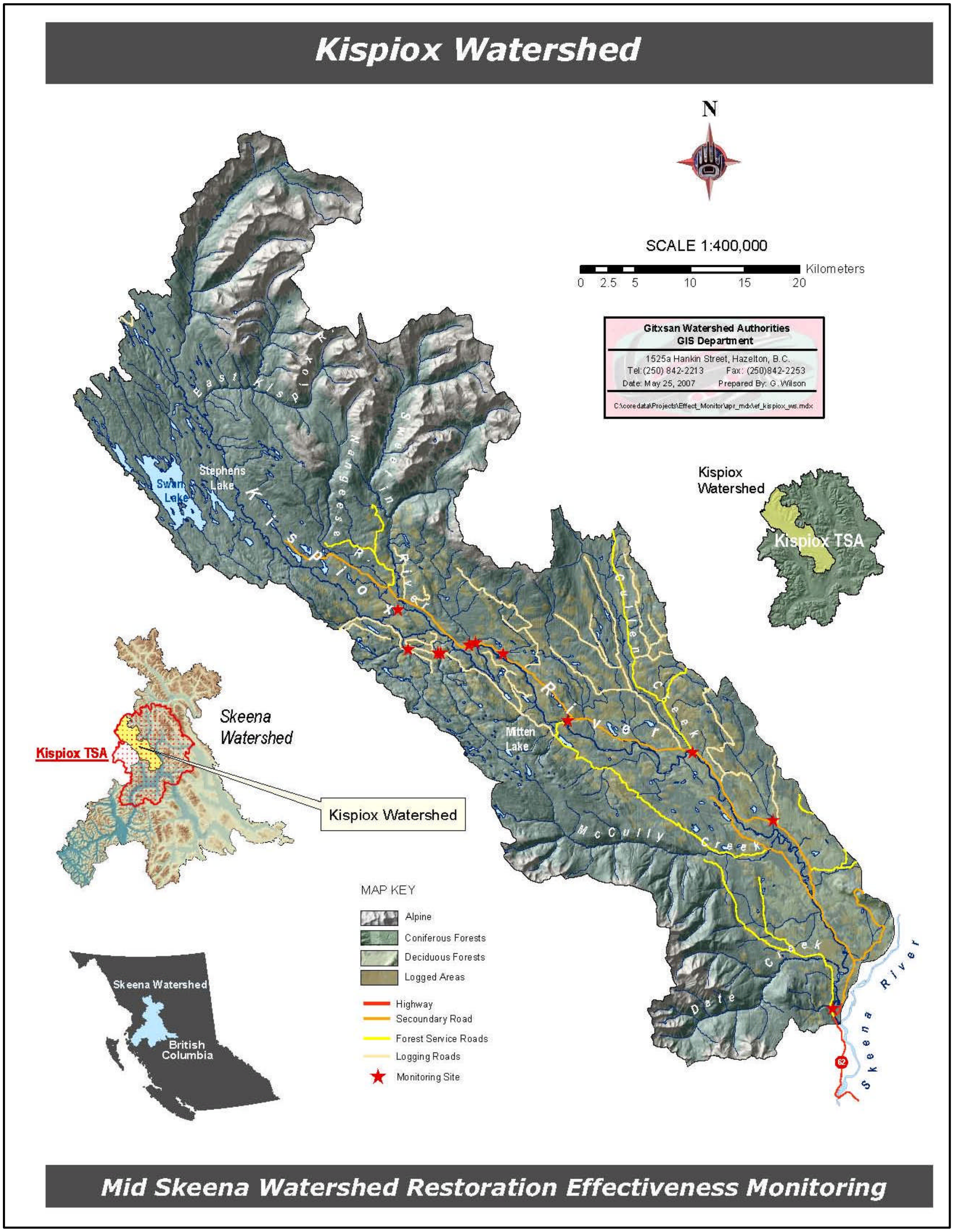

Figure 4. Kispiox Watershed Restoration Effectiveness Monitoring Sites map

3.2.3 RIPARIAN RESTORATION WORKS

Since 1995, an Overview, a Level 1, a detailed Level 2, a Fish and Fish Habitat assessment, and two detailed riparian prescription development surveys have been completed in the Kispiox Watershed. Recommendations for riparian rehabilitation were made in those studies. The final prescription for Kispiox included only the one site located at Murder Creek. This prescription was never implemented.

3.2.4 INSTREAM STRUCTURE WORKS

Eleven sites with multiple site specific activities were chosen for restoration effectiveness evaluations. Most sites involve instream structures other Sites 9 and 10, which are excavated groundwater channels. All restoration works were completed in 1997, other than the Murder Creek rehabilitation, which was redone in 2001.

Generally, all instream work completed in 1997 was sub-standard with under-sized wood or rock utilized and anchoring components that were undersized and improperly installed.

SITE I.D.	EAST	NORTH	WATERSHED	SUB-BASIN
1	576807	6152169	Kispiox	Murder Creek
2	582189	6135019	Kispiox	Dale Creek Culvert #1
3	552059	6167438	Kispiox	Corral Creek
4	548943	6168230	Kispiox	Clifford Creek
5	549534	6168485	Kispiox	Skunsnat Creek
6	557937	6161341	Kispiox	Twin Creek
7	546112	6167489	Kispiox	Steep Canyon Creek
8	543337	6167850	Kispiox	Beaverlodge Creek
9	542445	6171521	Kispiox	Nangeese River
10	569407	6158429	Kispiox	Cullon Creek
11	546325	6167526	Kispiox	Tributary to Steep Canyon Creek

Table 1. Kispiox Watershed instream structure works sites.

3.2.4.1 Murder Creek

Murder Creek is a moderate sized third order watershed draining into Kispiox River. The drainage is approximately 39.2 km^2 with a low gradient mainstem. Fish are distributed through most low gradient sections. The mainstem is productive with historically high fish values for coho and pink salmon, steelhead, bull trout, and cutthroat. BC 16 records indicated that pink salmon escapement fluctuated significantly, but was on average, substantial. Historical coho escapement ranged from between 200 to 500 spawners (DFO unpublished BC 16 records). Prior to the culvert installation in the 1960s, it appears the limiting factor to pink salmon production was summer low flows, which apparently restricted spawner entry some years.

Disturbance includes a loss of most of the riparian zone and channelization on the lower 1.7 km in Reaches 1 and 2 due to agricultural development. Excessive soil and bank erosion resulted from cattle grazing and watering. Logging in the upper portions of the watershed impaired the riparian zone and caused bank erosion, and in turn, caused aggradation in the lower reach. The Murder Creek culvert accommodating the Kispiox Trail crossing at 35 km has been a fish passage problem since installation in the early 1960s. The 2.5 m wooden stave culvert was lowered 4 feet in 1965 by the Forest Service (DFO 1966). Subsequent mitigating factors have primarily consisted of baffle installations on a discontinuous basis.

Overall, significant fish and habitat values upstream and downstream of the culvert have been impacted by this crossing. The culvert is undersized and is not likely to accommodate 100 year flood events or major beaver impoundment outbursts. The crossing has extreme velocities and an outfall drop that creates problems at a variety of discharge flows.

In 1997, baffles were re-installed in the culvert to lessen the culvert discharge velocities, a log weir was installed 30 m downstream of the culvert to decrease the culvert outfall drop, and a log deflector was installed 45 m downstream of the culvert to deflect the stream away from the eroding left bank. These completed site works are reported in Wadley and Wiley (1997). These installations were largely in-effective in dealing with the problem, which as noted above, is the undersized culvert.

Figure 5. Notched weir log 15 m downstream of culvert.
40 cm log was installed in 1997 to increase height of outfall drop pool.

In 1997, the culvert had been obstructing fish passage for 34 years, particularly for coho and pink salmon and steelhead. At low to moderate flows, the average creek velocity 50 m upstream and downstream of the culvert is 0.13 m/s. The average culvert water velocity is 1.32 m/s or approximately a ten-fold increase in discharge. From a design effectiveness perspective, baffling the culvert, decreasing the outfall pool drop, and providing bank protection does not make sense. In our opinion, the proper restoration recommendation would have been to install a bridge or an open bottom structure capable of passing Q100 flood events and then observing if downstream bank erosion events occurred.

In 2001, three comprehensive restoration activities and one bridge removal were implemented upstream and downstream of the Kispiox Trail crossing of Murder Creek. The restoration prescriptions are described in AMEC (2000) and the completed site works are reported by McElhanney Consulting Services (2001). Total project cost is estimated at $65,000.

The Murder Creek project goals were to build instream LWD structures that would reduce streambank erosion, create instream cover, and increase habitat complexity for fish. The four sub-sites are described as:

P7—Removal of a collapsing bridge 25 m upstream of the road crossing. The objective was to remove the abandoned bridge, which could become a barrier to fish passage.

P8—Tree revetment with brush traverse. The objective was to reduce the rate of lateral channel migration and to reduce sediment contributions to the stream from the site.

P6—Pullbank of bank and log cluster diversion. The objective was to stabilize the right bank in the area of the land owner's pump house. Pullback of the right bank for a distance of 5 m would resolve the oversteepened banks. The log cluster diversion structure would slow the stream velocity around the bend and prevent channel shifting.

P2—Tree revetment. The objective was to install a typical tree revetment along the outside bend to create some instream habitat and to slow the velocity of the stream around the meander.

The project took place on private land with all sites within 700 m of the Kispiox River. Prior to and during construction, all work sites had intensive environmental protection that consisted of fish salvage, sediment control measures, and erosion control measures. Following the site works, exposed soil was seeded, covered with loose hay, and the riparian area was fenced.

Site P8 is located approximately 120 m upstream of the Kispiox Trail crossing in Reach 2, which is a meandering low gradient section. Lateral channel migration caused by crossing and watering was occurring in a pasture. Three short sections for a total of 50 m were rehabilitated with tree revetments and instream log clusters.

P8-1 consists of 20 m of stream bank rehabilitated. This site utilized 11 revetment trees with rootwads and 5 m in length dug into and anchored to the bank. The revetment stems were spaced approximately 3 m apart with the rootwads faced into the stream and slightly overlapping. Footer and header logs were positioned and cable lashed below and above the stems. Boulder ballast was then cabled to each stem and then backfilled.

P8-2 consists of 12 m of rehabilitated stream bank and utilized the same technique as in P8-1. In addition, 2 full length 15 m trees were cabled and anchored into the bank to provide support. P8-3 consists of one tree revetment and three logs positioned parallel to the bank that support and protect it.

All structures site and conditions at site P8 remain integral and are achieving the restoration objectives of channel and bank stabilization. A functional riparian zone is slowly growing in and beginning to function.

Figure 6. View upstream at P8-1.

Figure 7. View downstream at P8-1.

Figure 8. View upstream at P8-1.

Figure 9. View downstream at P8-1.

Figure 10. Site P8-2.

Figure 11. View downstream at P8-2.

Figure 12. Site P8-3.

Figure 13. View upstream at P8-2.

Figure 14. Log-boulder cabling.

Figure 25. Boulder-rootwad placement.

Site P-6 is located just downstream of the Kispiox Trail crossing and adjacent to the land owner's pump house and water intake, which was threatened by lateral channel migration. A complex log cluster diversion structure was installed that would decrease stream velocity around the bend and prevent channel shifting. Pullback of the bank was originally prescribed, but was considered unnecessary during installation due to minimal bank disturbance.

Site P-6 was installed at the base of the eroding bank utilizing four footer logs, seven cluster logs, and approximately 18 large boulders as ballast. Two tree revetments were dug into the bank with their rootwads facing the stream.

The log cluster has worked out exceptionally well in achieving the objective of stabilizing the stream channel, and as well, providing cover and promoting riparian growth. The structure is integral and in excellent condition. Material recruited to the site is also performing well. When the Kispiox Trail culvert is replaced with a bridge or open bottom structure, this installation will require monitoring.

Figure 16. Site P-6 view downstream.

Figure 17. Downstream end of Site P-6.

Figure 18. Site P-6 view upstream.

Figure 19. Site P-6 view downstream.

Site P-2 is located on an outside channel bend approximately 120 m downstream of the Kispiox Trail crossing of Murder Creek. The site works installed consist of a six log tree revetment 20 m in length that would reduce bank erosion, create instream habitat, and lessen stream velocity at the bend.

Six tree revetments logs with rootwads exposed to the stream were dug into the bank and secured with duckbill anchors. These logs bedded on four footer logs. Each revetment was anchored by two moderate sized ballast rocks that were cabled together and also acted as rip rap. Large angular ballast was positioned at the upstream and downstream ends of the revetment placement to protect against erosion and back eddy scour.

The Site P-2 restoration installation is achieving its objectives of reducing bank erosion, creating instream habitat, and reducing water velocity. All structural components are integral with no sign of instability. There is minor bank erosion upstream of the installation as seen in Figure 31. It is recommended that angular rock could be hand-placed at this point for 4-5 m upstream to reduce any erosion in high flow events.

Figure 20. View downstream to Site P-2.

Figure 21. Downstream segment of P-2.

Figure 22. View upstream of P-2.

Figure 23. View upstream of P-2.

Figure 24. View upstream of P-2.

Figure 25. View upstream of P-2 and channel.

Figure 26. View of bank erosion at upper end.

Overall, this evaluation rates the Murder Creek restoration efforts that were implemented as a large success. The physical objectives have been met and continue to perform well. It is important to note that the prescribed riparian planting was not implemented and could be valuable at all the Murder Creek sites. The riparian planting as currently required and minor maintenance at Site P-2 could be performed in conjunction with the replacement of Kispiox Trail crossing of Murder Creek.

It is also noteworthy that the three site works were undertaken prior to mitigating the outstanding fish passage problem at the Kispiox Trail crossing. This is of course a matter of perspective on hierarchical strategies for prioritizing restoration on the watershed and sub-basin levels. The Murder Creek restoration work is valuable as a regional demonstration site in restoration techniques and process.

3.4.2.2 Dale Creek

Dale Creek is a relatively small third order watershed draining approximately 9.3 km^2 into the right bank of Kispiox River 1.3 km upstream of its mouth. Dale Creek is crossed by the Date Forest Service Road (FSR) at 0.7 km and passes through two – 1800 mm round CMP culverts to flow into Kispiox River. The road crossing at is located 60 m upstream from the Dale Creek-Kispiox River confluence.

Fish presence is confirmed to be rainbow trout and it is possible that other resident fish species utilize the habitat that is marginal to low quality. The stream was used in the past to supply domestic water to Kispiox Village, but presently the water supply system is defunct. The water supply dam is located approximately 630 m upstream of the mouth. The channel is generally high gradient dominated by boulders and cobbles with a riffle-step pool morphology. The soils adjacent to Dale Creeks are fine textured and unstable as indicated by the stream banks and the cut and fill slopes along Date FSR that contribute relatively significant sediment.

Restoration issues, design, and site works revolved around the partial barrier to fish passage. The culverts passing Dale Creek have a 0.67 m outfall drop into the plunge pool, of which the depth is insufficient. Nortec (1997) provided a prescription and in the 1997 field season installed a two-step pool series downstream of the culverts outlet reported on by Wadley and Wiley (1997). The two step pools are located 12 m and 21 m downstream of the culvert and were constructed with lock blocks and geotextile fabric.

Unfortunately, the design lacked engineering input and site works were ineffective in mitigating the outfall drop. The two step pools actually created additional fish passage problems. This instream restoration project is considered conceptually ill-conceived with no clear objectives or path forward given the degree of habitat quality and the limited quantity of potential habitat gained.

Recommendations for the Dale Creek site include:

1. Remove the lock blocks and any geotextile materials;
2. Seed all exposed banks and cut and fill slopes.

Figure 27. View downstream to culvert inlets.

Figure 28. View upstream from culvert inlets.

Figure 29. View upstream to culverts outlet.

Figure 30. View downstream from culvert outlet.

Figure 31. View upstream first lock block step.

Figure 32. Remnants of hay sediment traps.

Figure 33. View downstream to 2nd lock block set.

Figure 34. Dam spillway 630 m upstream.

3.2.4.3 Corral Creek

Corral Creek is a moderate sized third order stream, approximately 29.3 km^2, draining into Kispiox River. Coho and pink salmon, steelhead, trout, and char are found in the lower reach that is limited by a barrier falls. Bull trout, Dolly Varden, and cutthroat trout are distributed from the headwaters downstream to the Kispiox FSR.

Significant road deactivation has been conducted throughout the drainage and monitoring revealed a few excellent examples of wooden box culverts removal where material was placed instream to provide cover and general stream complexing as shown below.

Figure 35. Deactivated wooden box culvert on Corral Creek tributary.

3.2.4.3 Clifford Creek

Clifford Creek is a moderate sized third order watershed draining into Kispiox River approximately 47 km upstream of the mouth. The drainage is 35.54 km^2 with approximately 7.5 km of mainstem and an average gradient of 2% before natural barriers limit fish presence. Fish are distributed throughout 8.9 km of tributaries, however, quality habitat in the tributaries is dispersed and fish production is mostly limited to freshwater species. Fisheries values are high due to spawning and rearing by coho, sockeye, and pink salmon, steelhead, bull trout, Dolly Varden, and cutthroat. Coho spawning has been observed throughout up to 5.0 km and pink salmon spawn up to 1.5 km. Annual coho escapement estimates are fairly consistent from 1965 to 1993 and show a range between 25 and 8,000 fish (DFO unpublished BC 16 records). In most years, escapement fluctuates between 100 and 500 coho. Since 1980, Kispiox Hatchery has released a total of 106,000 coho in an effort to rebuild the depressed Clifford Creek stock. Clifford Creek has relatively high beaver activity, particularly in Reach 1 and 2, compared to other Kispiox tributaries.

Between 1999 and 2001, GWA maintained coho smolt counting fences on Clifford and Skunsnat creeks from May to July. During the period of coho smolt emigration, adult steelhead were moving in to the streams to spawn. The earliest steelhead recorded to enter the streams was May 10th. The last steelhead recorded to emigrate from the streams was June 13th. Steelhead likely moved in before the smolt fence was operational. The run timing is similar for both streams; they drain the same area and get the same weather so water events are similar. Gottesfeld *et al.* (2000) indicated that Clifford Creek had the most abundant juvenile steelhead density of surveyed streams in Kispiox Watershed.

Adult Steelhead in Clifford and Skunsnat Creeks 1999-2001						
	1999		2000		2001	
	Clifford	Skunsnat	Clifford	Skunsnat	Clifford	Skunsnat
Immigration	42	19	8		10	7
Emigration	29	33	13	24	18	2

Table 2. Adult steelhead in Clifford and Skunsnat Creeks 1999-2001.

Disturbance in Clifford Watershed is primarily from logging and road building activities. Overall logging related impacts to fish habitat are high for the 800 m reach downstream of the Kispiox Trail due to road, channel, and riparian disturbance. Mid-portions of the watershed were disturbed only by fire and had no development. In the upper half of the watershed, logging related impacts are considered moderate due primarily to the non-fish bearing first and second order creeks; however, Nortec (1997) noted logged riparian zones, bank erosion, and road related sediment generation and transport.

Clifford Creek culvert accommodates the Kispiox Trail at approximately 71 km. Since the early 1960s when the culvert was installed there have been recurring fish passage problems. Baffles were first installed in 1965 to assist fish in low and high flows; as well, it was recommended that the culvert be replaced by a bridge (DFO 1966, Hancock *et al.* 1983). The culvert is a, 2100 mm round wood stave, 26 m in length with a relatively high slope of 3.8%. Average in-culvert water velocities at moderate flow is 1.96 m/s, while stream water velocities 50 m upstream and downstream were 0.57 m/s and 0.60 m/s respectively. This represents more than a three-fold increase in water velocity and is more than conservatively recommended for juvenile and adult passage.

Since 1965, various attempts to mitigate the Clifford Creek fish passage problem at the Kispiox Trail crossing have included baffling and cutting a new channel downstream of the scoured culvert outlet pool (unknown date). Neither of these efforts has mitigated the fish passage issue.

Nortec (1997) stated the need for stream complexing with the purpose of restoring pool presence and improving rearing habitat in Reach 2, for 200 m upstream of the Kispiox Trail crossing. No restoration objectives to base the prescriptions on were noted. Wadley and Wiley (1997) reported that in the1997 field season instream structures were installed in Clifford Creek that included:

- Weirs built to develop pools for cover for juveniles and holding areas for adult salmonids;
- Structure was added to deep pools to create cover for salmonids;
- Deflectors were constructed to decrease the amount of sediments introduced to the stream from eroding banks and as a attempt to contain the stream from eroding banks and to provide clean gravel for adult spawning composed of 2 V-weirs, 4 bank deflectors, and 3 instream deflectors;

- Installation of 6 baffles in the culvert;
- Installation of a rock weir downstream of the culvert to build up the plunge pool and scour a pool downstream of the existing outlet pool;
- Installation of a bank deflector 40 m downstream of the culvert outlet;
- Securing all structures with rebar and cable.

Locating most Clifford Creek instream installations was difficult due to the lack of as built drawings, photographs, or coordinates. McElhanney (1999) conducted an assessment of Clifford Creek instream structures and designated Clifford Creek a high priority for modifications; 'with out immediate attention failure of the structures is inevitable'. This effectiveness evaluation found no instream structures intact or functioning as prescribed. Miscellaneous 0.3-0.4 m in diameter with cut ends and rebar attached were located but were not positioned to provide structural results.

The rock weir downstream of the culvert was easily located and shown in Figure 37. This weir installation was built on the base of the weir installed at an unknown date; likely at least 20 years old. This old weir was installed and the channel relocated to increase the outfall pool depth. The original channel flowed to the right as shown in Figure 38. McElhanney (1999) reported that the rock weir increased the water level in the outlet pool below the culvert, but needed to be increased in height to mitigate the outfall drop which is a partial barrier to fish passage.

Observations in 2006 indicate that the weir is not beneficial to raising the outlet pool depth, nor is it acting as an effective component in establishing a downstream scour pool. It is likely that the weir has degraded since installation in 1996 due to the excessive culvert velocities and the relatively small size of boulders utilized. Typical weirs or berms to backwater culverts built in this area degrade relatively quickly and do not provide moderate to long-term fish passage solutions.

McElhanney also reported that the modified log K dam installed 20 m upstream of the culvert inlet was functioning and had created a downstream scour pool.

Overall, this restoration effectiveness monitoring evaluation of the instream structures placed in Clifford Creek found a lack of integral or semi-complete structures nine years following installation. The installed structures have not lasted. The major issue appears to be fish and fish habitat assessments by unqualified field workers, led to unnecessary and improper restoration prescriptions and then was followed by poor instream placement practices. Conceptually, it is not sensible to improve habitat when there is a fish passage issue and the fish cannot easily get upstream to restored habitat.

It is important to note that after 43 years, the biggest problem, an undersized culvert with extreme culvert velocities and an outfall drop has not been addressed. A concrete bridge is recommended to restore suitable flows, ease fish passage, and provide low maintenance efforts. The original channel, with an average gradient of 1% and several bedrock outcrops controlling base levels, should be reestablished.

Figure 36. Clifford Creek outlet pool.

Figure 37. Rock weir at downstream end of pool.

Figure 38. Original channel shows to the right.

Figure 39. Clifford structure 3.

Figure 40. Clifford Structure 4.

Figure 41. Clifford Structure 5.

Figure 42. Clifford structure 7.

Figure 43. Clifford structure 8.

Figure 44. Clifford structure 9.

Figure 45. Clifford structure 12.

Figure 46. Clifford structure 13.

Figure 47. Clifford structure 14.

Figure 48. Clifford structure 15.

Figure 49. Clifford structure 17.

Figure 50. Clifford structure 18.

Figure 51. Clifford structure 20.

3.2.4.5 Skunsnat Creek

Skunsnat Creek is a small third order watershed draining into Kispiox River about 47 km upstream of the mouth. The drainage is 26.01 km^2 with the unique Skunsnat Lake located mid-point in the system. Skunsnat Creek is low gradient and less than three km long flowing from Skunsnat Lake to Kispiox River. The system is a known coho and steelhead producer. The lower section of the creek is used by coho and pink salmon and steelhead for spawning, while the upper portion is used by coho (scattered to 4.5 km from the mouth), bull trout, and Dolly Varden. Tributaries upstream of the mainstem and lake support Dolly Varden, rainbow trout, and robust populations of bull trout and cutthroat. Beaver impoundments are present in most parts of the drainage and the lake attenuates high flows to some degree.

Figure 52. Skunsnat Lake and outlet from the northwest

The drainage has been heavily harvested except for the mid-portion which is a burn area. Overall logging related impacts are rated moderate to high and primarily consist of road, channel, and riparian disturbance.

The Kispiox Trail crosses Skunsnat Creek at approximately 70.3 km. Since the early 1960s when the culvert was installed there have been recurring fish passage problems and implementation of short-term solutions. Baffles were first installed in 1965 to assist fish in low and high flows; as well, it was recommended that the culvert be replaced by a bridge (DFO 1966, Hancock *et al.* 1983). The fish ladder below the road crossing washed out in the October 1978 flood; a jump pool was constructed in 1979 by Department of Highways; and baffles needed to be replaced in 1981 (Hancock *et al.* 1983). Metal baffles were installed in 1998, but proved largely ineffective in slowing culvert water velocities.

Figure 53. Skunsnat Creek culvert outlet.
View of outlet from downstream with velocities over 3.1 m/s.

Skunsnat Creek culvert outlet pool and the channel for a short distance downstream are bedrock controlled. The culvert is undersized, extreme flow velocities create a velocity barrier, and the outfall barrier causes difficult or no fish passage. These factors combine together to work against fish passage.

In 1997, instream structures were placed in the Skunsnat Creek upstream and downstream of the Kispiox Trail. The objectives were to increase pool depths, scour gravels, deflect water from eroding banks, and to remove debris jams. Remnants of the rock weir positioned in the culvert outlet pool are visible. There is currently a 0.30 m culvert outfall drop.

A modified K log weir was placed upstream of the road crossing, but the structure has failed and there is currently no evidence of it. Logs were positioned downstream of the outlet pool to function as instream and bank deflectors, but these too have failed and are not visible. Individually, and as an aggregate, restoration efforts in Skunsnat Creek are rated poor with no tangible benefits to fish.

3.2.4.6 Twin Creek

Twin Creek is a relatively small basin (5.9 km^2) draining into Kispiox River adjacent to the Mitten Bridge. The system is lake headed, supports a healthy beaver population with many beaver dams from the lower lake outlet downstream to Kispiox River. The substrate is predominantly sand and organics with a minimal amount of gravel. Fish present are coho, rainbow trout, Dolly Varden, and bull trout.

A total of 32 instream structures were placed and include 19 instream deflectors, 3 bank deflectors, 9 log weirs, and 1 rock weir. Evaluations found no structures in place, though pieces were scattered around the stream banks and adjacent floodplain. Our observations indicated that floods or highwater had breached most beaver dams and had randomly relocated the relatively small sized material making up the instream structures. Log pieces from the placed structures are currently providing limited cover and stream complexity. Overall, restoration efforts in Twin Creek are rated poor with no tangible benefits to fish or habitat.

Figure 54. Typical beaver pond in lower Twin Creek

Figure 55. Twin Creek showing fine organics and naturally contributed woody debris.

3.2.4.7 Steep Canyon Creek

Steep Canyon Creek is a moderate sized watershed draining 36.8 km^2 into Kispiox River. Steep Canyon Creek supports coho, chinook, steelhead, rainbow trout, and cutthroat trout. In 1997, 6 instream structures were installed from the Mitten Main Bridge downstream for approximately 40 m and were comprised 1 log weir, 1 V-weir, and 4 instream deflectors. The objectives were to create pool presence and to clean spawning gravels.

No evidence of instream structures was located until approximately 100 m downstream of the bridge. Here, many large, cut logs were observed that appeared to be deposited by a highwater event and not related to displaced instream structures. This evaluation found no moderate or long-term benefits to fish in Steep Canyon Creek.

3.2.4.8 Beaverlodge Creek

Beaverlodge Creek is a moderate sized drainage (23.4 km^2) draining to Kispiox River. The lower reach of Beaverlodge Creek is swampy, was logged in the mid-1980s and supports a robust beaver population. Coho, cutthroat trout, rainbow trout, and steelhead are present in the lower two reaches.

Assessments in 1996 determined that there was a lack of spawning habitat and clean spawning gravels in Reach 2. Subsequently in 1997, 16 bank and instream deflectors were installed to clean gravels and decrease the amount of bank erosion. Three log and V-weirs were constructed to provide pool presence, create cover for rearing, and clean gravels for spawning. All structures utilized materials from an old bridge crossing.

This evaluation could not locate any of the instream structures and it is suspected that highwater flows carried the structures downstream.

Figure 56. Photo shows lower reach of Beaverlodge Creek.

3.2.4.9 Nangeese River

Nangeese River is one of the larger sub-basins in the Kispiox system and encompasses approximately 117 km^2 draining into Kispiox River. The Nangeese system is considered very productive habitat and supports chinook, coho, and sockeye salmon, cutthroat trout, bull trout, rainbow trout, steelhead, and Dolly Varden.

Two groundwater channels were excavated in 1997 on a tributary to lower Nangeese River. The objective was to provide spawning and rearing habitat over and above what was currently available in the tributary. These channels were constructed upstream of and provide access to an active beaver pond complex, which in turn is 1.3 km upstream of Nangeese River. The west channel is approximately 170 m in length, while the east channel is 210 m in length. Channel depth averages 1.10 m with a range between 0.5 and 2.1 m; the deeper areas function as pools. The majority of the mostly fine grained, silty materials excavated for the channels was placed on both side of the channel and subsequent erosion has infilled the channels on average 9 cm in depth. The channel side berms have revegetated; however there is basically no instream cover.

Figure 57. Photo shows beaver pond on the left, west channel at the top, and east channel in the middle.

Dissolved oxygen (DO) levels and water temperature were recorded, and juvenile trapping was conducted for a 11 month period starting in mid-May 2006 to April 2007. The results indicated that average DO levels were 3.6 mg/L from a mean of 4.2 at the top to 3.0 at the bottom of the west channel. The west channel temperature averaged 6.9 C^0 with seasonal ranges from 16.2 to 0.7 C^0. Juvenile trapping did not capture any fish.

Results from the east channel indicated that average DO levels were 2.45 mg/L from a mean range of 2.9 at the top to 2.0 at the bottom. Temperature in the east channel averaged 7.1 C^0 with seasonal ranges from 16.3 to 0.4 C^0. Juvenile trapping did not capture any fish.

This restoration effort suffers from a lack of site suitability, conceptual planning, and adult recruitment. The site should have been initially monitored with test pits that would indicate ground water DO levels, temperature regime, and seasonal water quantities. It is recommended that the site be abandoned.

Figure 58. View southward on east channel.

Figure 59. View northward on west channel.

Figure 60. View south into beaver pond complex.

3.2.4.10 Cullon Creek

Cullon Creek is a relatively moderate sized sub-basin that drains into the lower Kispiox River. Cullon Creek possesses high quality habitat and productive fisheries values supporting coho, chinook, and pink salmon, steelhead, cutthroat and rainbow trout, and Dolly Varden.

In 1997, a channel was excavated on the south side of Kispiox Trail close to the Cullon Creek/Kispiox River confluence. The objective of the channel was to provide rearing opportunities for juvenile fish. The 189 m in length excavated channel follows a high water channel located in the lower level of the Kispiox River floodplain and a 55 m channel forks off to the northwest 130 m from the Kispiox River. The initial 33 m from the Kispiox River was dry when surveyed in mid-August. The excavated channel depth was apparently 1.75–2.0 m with the excavated material piled adjacent to the channel. The bank slopes were hydro-seeded, but erosion is still occurring. The channel substrate is covered with silt and mud. Bank stabilization, planting riparian species, and providing cover structures such as LWD would have provided critical components to this project.

Figure 61. Excavated channel with Cullon Creek to the right and Kispiox River at the top.

During the course of summer 2006, observations indicated that water levels fluctuated, often day by day. Typical water depth recorded August 22 ranged from 0 to 0.79 m. Due to low water levels; fry trapped in shallow pools were being preyed on by birds. DO levels ranged from 5.1 to 2.9 mg/L, while water temperatures ranged from 11.9 to 13.2 C^0. DO levels measured by McElhanney (1999) in 1998 were all below 4.8 mg/L.

Overall, the conceptual design and site suitability for this project are rated poor. Critical physical characteristics needed such as appropriate DO levels and in-flowing water reflect poor planning. It is recommended that the site be abandoned.

Figure 62. View shows Cullon ground channel at the upper end.

Figure 63. View shows Cullon ground channel 34 m from the upper end.

Figure 64. View shows Cullon right fork ground channel midway.

Figure 65. View downstream of channel fork at 0+128 m.

Figure 66. View shows Cullon ground channel close to Kispiox River.

4.0 SUSKWA WATERSHED EFFECTIVENESS EVALUATIONS

4.1 ENVIRONMENTAL SETTING

The Suskwa River is a large tributary of the Bulkley River. It is bounded on the north and east by the Babine Watershed, on the south by the Bulkley Watershed, and to the west by the Skeena.

The Suskwa River cuts southwesterly through the Babine Range. Major tributaries into the Suskwa River include Natlan Creek, Thirty-One Mile Creek, and Thirty-Three Mile Creek flowing into the right bank, while Skilokis Creek and Harold Price Creek flow into the left bank. The Suskwa River mainstem is approximately 38 km in length; the 19 km reach upstream of the Harold Price confluence is usually referred to as the upper Suskwa. Generally, the stream channel is incised into the valley bottom, which is either bedrock or glacial deposits that pose no obstructions to fish passage.

From the mouth upstream, Reach 1 is characterized as being occasionally confined, with an active floodplain and back channels and an average gradient of 1.0%. It extends from the mouth of the river upstream about 3.5 km. The irregularly sinuous wandering channel has occasional islands and frequent point and mid-channel bars. Reach 2 runs upstream to Fifteen Mile Creek and is primarily a canyon entrenched into bedrock. Reach 2 has major bank or valley wall slump zones and an average gradient of 1.0%, with no or discontinuous floodplain. Reach 3 passes from Fifteen Mile to Natlan Creek, and has an average gradient of 1.0%. This reach presents an irregularly sinuous channel that is frequently confined by valley bottom rock outcrops, discontinuous floodplain, and sporadic terraces with alluvial veneer.

Reach 4 with an average gradient of 0.6% is upstream of Natlan Creek and is composed of the 1 km long canyon that is confined by the valley walls. Reach 5 has a wandering gravel bed river configuration and is generally sinuous and largely unconfined, except occasionally by valley bottom benches. This reach is relatively active, having changed channel position since 1975 (Gottesfeld 1995). Reach 5 has an average gradient of 0.6%, is almost 7 km in length, and is bordered upstream by the Harold Price confluence. Reach 6 extends 1.6 km upstream and is occasionally confined between high gravelly terraces. The channel is straight and braided, with extensive gravel and boulder deposition. Reaches 7 to 12 in the upper Suskwa are considerably steeper with gradients ranging from 2.5 to 3.3%. The channel is generally confined or entrenched upstream to Thirty-Three Mile Creek. Upstream of Thirty-Three Mile Creek, the floodplain is developed as the valley opens up into the relatively broad Suskwa Pass.

Natlan Creek is a large southward flowing tributary to the Suskwa River. Reach 1 extends upstream to the Denison Creek confluence. This reach presents a sinuous channel pattern that is occasionally confined or entrenched, with an average gradient of 1.7% and a discontinuous floodplain. Above Reach 1, Denison Creek, Natlan Creek, and Iltzul Creek are all confined or entrenched by valley walls, with moderate gradients that range from 3 to 10%. The channels are dominated by riffles with occasional pools and runs.

Since the late 1970s, the channel of Natlan Creek has been undergoing modification in the upper 7 km and from 2 km above Denison Creek downstream to the mouth

(Gottesfeld 1995). There is evidence of moderate widening along with a moderate increase in coarse sediment within the channel. This exists alongside a significant increase in landslide activity. The stream bank failures involve floodplain deposits and bluffs of fluvio-glacial terraces overlying thick till deposits.

Suskwa River chinook escapement estimates have been recorded discontinuously since 1960, and since that time, escapement has been generally low. In 1960, Suskwa chinook population was estimated at 400. Escapements from 1961 to the present range from 10 to 250 (DFO 2005). Suskwa chinook spawner numbers have not recovered in the past two decades as many other Skeena chinook stocks have.

Adult pink salmon usually migrate upstream on the Suskwa River arriving August 15, with the peak of spawning in mid-September. The principal spawning ground is the lower Suskwa mainstem in Reach 1 and 2, particularly from the mouth upstream for 2.8 km. Other minor spawning areas include Reach 3 up to the canyon cascade east of Natlan Creek. Jantz *et al*. (1989) noted pink salmon presence in Harold Price Creek, though this may only occur in years of high abundance. Spawner escapement has been recorded discontinuously since 1967. Spawners have ranged from 0-5,000, though most years between 100 and 500 pink salmon return.

Discontinuous records show aggregate coho escapements for the Suskwa sub-basin that range between 25 and 2,500, with no recorded escapements since 1992. Coho spawning is principally located in the upper half of the wandering gravel bed (Reach 5) in the Suskwa mainstem. Dispersed spawning occurs upstream to 10 km on Natlan Creek and possibly in the Suskwa mainstem 1.5 km upstream of the Harold Price confluence, though channel morphology in the latter reach has greatly changed over the last decade due to a combination of natural and logging-related flood events.

Figure 67. Beaver pond on lower Jumbo Creek.
This site is a highly productive coho nursery pond.

In 1999, the Suskwa Coho Synoptic Survey was established to provide information on coho salmon abundance and distribution in the Suskwa River Watershed (McCarthy 2000). This short-term program established and assessed twenty-one sample sites focused on side-channels and tributaries along 20 km of the Suskwa River and Harold Price Creek. The site on lower Jumbo Creek (Figure 128) had juvenile coho densities over 1.0 fish/m^2; the densities at all other sites had less than

0.5 fish/m^2. Sites sampled in Blunt Creek yielded coho juveniles in very low numbers.

Suskwa steelhead are summer-run fish that enter the Suskwa system in late August or early September. Suskwa steelhead are noted for their large body size, deepness through the body, and in the past, their abundance. This made them the basis of an international sport fishery that continues into the present, though on a smaller scale (Chudyk 1978).

The 1979 steelhead radio telemetry project noted that all steelhead wintered at or below the canyon just upstream of Natlan Creek or relatively close to the Suskwa–Bulkley confluence (Lough 1980). Steelhead spawning occurs the following March through May, coinciding with warming water temperatures and an increase in Suskwa River flows. Spawning is concentrated primarily in the lower 3 km of Reach 1, Reach 3 particularly adjacent to the mouth of Jumbo Creek, and the lower 5 km of Harold Price Creek. Sporadic spawning occurs in Reach 3 downstream of Natlan Creek and in Reach 6 upstream of Harold Price Creek. Results from the radio-tagging program indicated spawning is dispersed in side and main channels on the mainstem throughout the system below Harold Price Falls (Lough 1980).

In 1982, the average age of 27 steelhead spawners sampled was 4.2 years, while the repeat spawners averaged 8.6% for 1977, 1979, and 1982 (Schultze 1983). Steelhead fry emerge between mid-August and mid-September and widely disperse throughout the system and in the smaller tributaries that offer suitable refuge.

In the mid-1970s, lack of angler success and conservation concerns in regard to Suskwa steelhead initiated a revitalization program under the auspices of the Salmon Enhancement Program (SEP). Through SEP, the BC Fish and Wildlife Branch (BCFW) developed a three-point program designed to increase the number of returning steelhead and thereby improve angler success (Chudyk 1978). The three-point program included an assessment of potential stocks and habitat within the watershed, the removal of Harold Price Falls as a fish barrier, and the colonization of steelhead in the upper Harold Price. Presently, adult steelhead do not appear to pass above the falls.

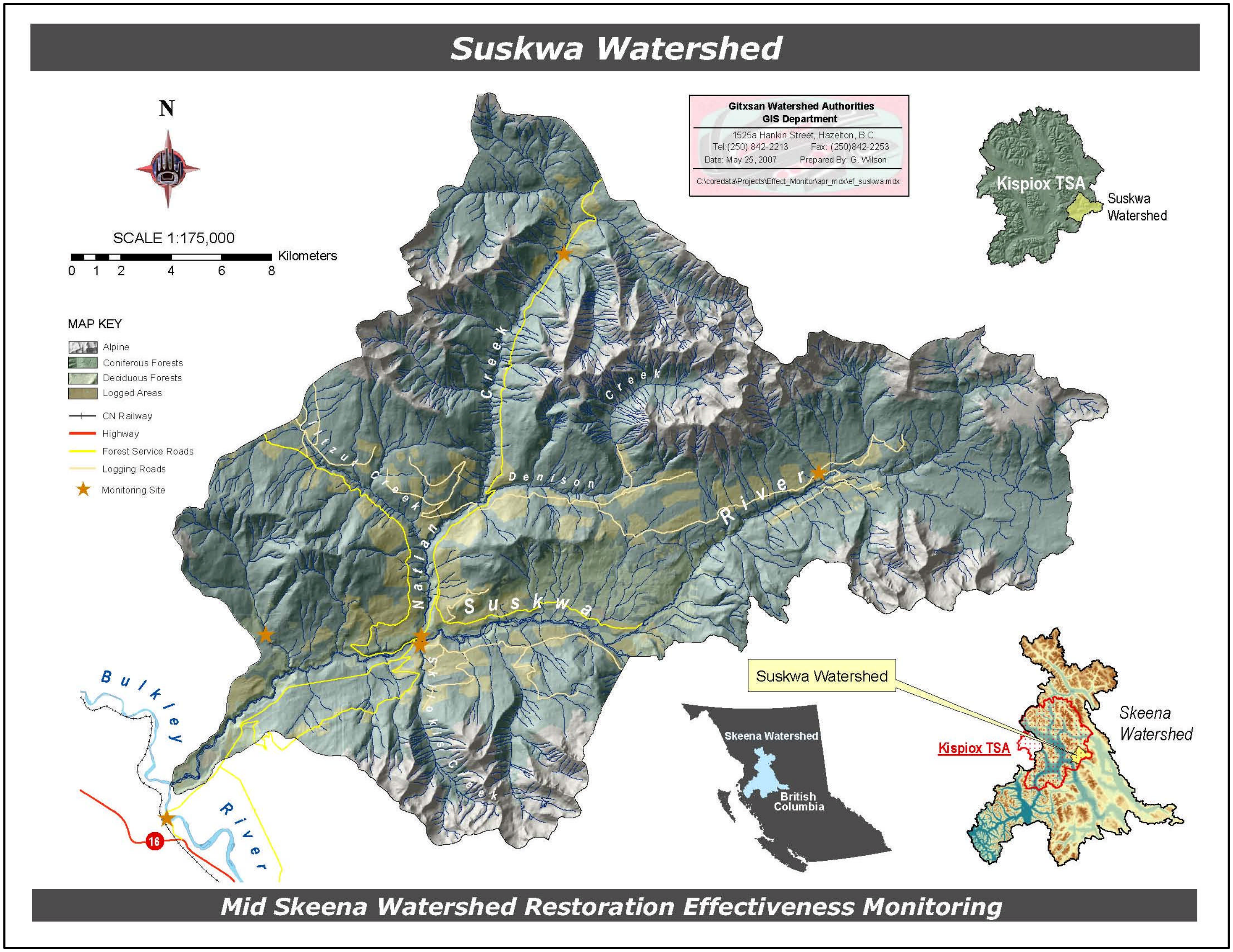

Figure 68. Suskwa Watershed.

4.2 SUSKWA WATERSHED RESTORATION PROGRAM

The Suskwa Watershed Restoration Program was initiated in 1995 and continued intermittedly until 2001 when FRBC was repealed. From 1995 to 2001, an unknown amount was invested in assessments, treatments and monitoring of upslope, road, riparian, and instream components to reduce forestry impacts and future risks.

4.2.1 EFFECTIVENESS MONITORING RESULTS

This watershed restoration effectiveness monitoring project screened all restoration projects completed since 1995. The majority of completed work consists of road deactivation; assisting fish passage with culvert replacement and outlet pool weirs, breaching debris jam and beaver dam, enhancing off channel habitat with instream structural placements such as log weirs, and deflector logs, as well as hillslope stabilization.

4.2.2 DEACTIVATION AND HILLSLOPE STABILIZATION WORKS

Deactivated road systems and sites were assessed for field indicators that are commonly associated with slope instability and erosion. Sites were also evaluated for overall effectiveness. The residual risk at the sites was also assessed with respect to fish habitat and water quality. The majority of deactivation works consist of waterbars, cross ditches, deactivating stream crossings, and pullback of debris on oversteepened fillslopes or encroaching on streambanks.

Across hundreds of sites, deactivation work was consistently good with the results showing minimized erosion, good effectiveness of grass seeding, and deactivated stream crossings showing good work and streams running clear. Few sediment related problems were observed at stream crossings. Maintenance of deactivated works is lacking and causing sediment delivery problems; a road inspection schedule and reporting system needs to established and implemented. A minor amount of the proposed deactivation includes culverted stream crossings that exhibited signs of being plugged by debris or the crossing was overtopped by beaver dam failure outburst flows.

There is small quantity of road deactivation needed that would be beneficial to water quality; it is spatially sporadic and spread throughout developed areas of the watershed. Our observations indicate that the culvert at the avalanche runout zone at 27 km on the Suskwa FSR be replaced with a bridge structure that allows debris to freely move past it.

4.2.2.1 Suskwa FSR 1.5 km Hillslope Stabilization

In 1967, the Suskwa Forest Service Road (FSR) was constructed alongside the Bulkley River through the toe of unstable glacial lacustrine silty material, which also underlies the CN Rail grade. Since then, the road work has caused chronic surface slides. CN Rail stabilized their tracks in the late 1980s by installing sheet piling and drain works across the top of the slide. Two attempts at stabilization were conducted with bioengineering techniques by BC Ministry of Forests in the late 1980s; however, the results were weak.

In 1997, this chronic slide on the Suskwa at 1.5 km was stabilized with a lock blocks to reinforce the slope toe and a combination of bioengineering techniques. The objective was to provide surficial stability and hold the chronic sediment that flowed into Bulkley River. The three project phases consisted of:

1) Planning and engineering with the objectives of maintaining fish habitat, controlling erosion, and utilizing bioengineering techniques.
2) Technical preparation that ensured the toe of the slide was stabilized and provided sufficient drainage.
3) Bioengineering that involved installation of brush layers, wattle fences, live gully breaks, live pole drains, and live staking.

Soil bioengineering is the use of living plant material to perform an engineering function such as holding eroding banks and unstable slopes. On some sites in northwestern B.C., this method can be effective in treating problem sites and providing appropriate natural successional processes. For a complete description of this site and methodology, see Rabnett (1997).

Figure 70. CN Rail tracks at the top, hillslope stabilization structures completed in 1997, and brown drainage berm at the toe of the slope.

Structures installed included 248 modified brush layers, 383 m of wattle fence, 48 m of live pole drain, 54 gully breaks, 320 live willow stakes, and grass seeding spread over four face units and three gullies. In 1998, structures that failed following spring snowmelt were repaired. Periodic maintenance has occurred since that time, which has mostly consisted of removing sediment from the drainage berm at the toe. This evaluation found 78% of the bioengineering structures intact and functioning. Seepage from high on the slope was not channeled appropriately and continues to provide surficial slides as shown in Figure 71. These surface slides primarily affected the modified brush layers by either burying or removing them. Approximately 52% of the bioengineering structures installed failed to sprout or sprouted and then died. However, the physical structures have maintained hillslope stability.

Evaluation results indicate that the seepage zones located high on the hillslope need to be drained by mechanical or bioengineering methods if full restoration is to occur. It is recommended that a rock filled drainage ditch that directs water to the side of the slide and into the gullies with rock blankets installed over the seepage zones and applied from the CN Rail grade would likely be successful in stabilizing the slope. Future bioengineering projects could benefit from the addition of fertilizers or manure.

Figure 71. Photo shows the two areas of chronic wasting that need to be drained and rock blanketed.

Figure72. Photo shows drainage berm at the bottom and stabilized and failed brush layer areas.

Figure 73. Photo shows drainage berm at the bottom and stabilized brush layer area.

Figure 74. Photo shows stabilized Gully #1.

Figure 75. Photo shows drainage berm at the bottom, stabilized brush layer area, and seepage zone above.

Figure 76. Photo shows a close-up of functioning gully breaks in Gully #2.

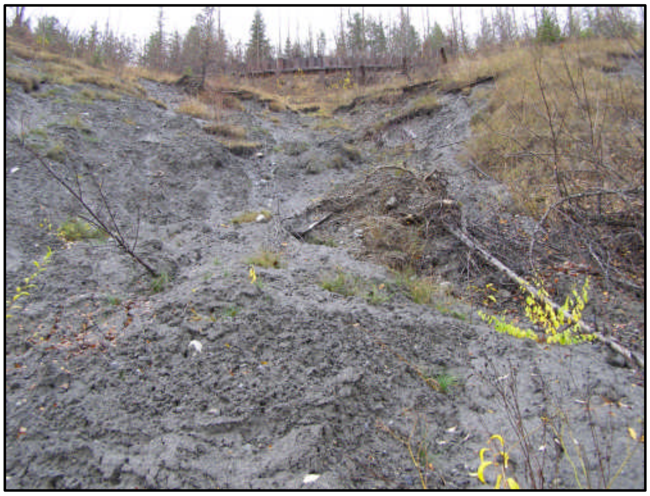

Figure 77. Wasting in Area #4.

Figure 78. Photo shows functioning wattle fences in Area #4.

Figure 79. Photo shows modified brush layers with willows established.

4.2.3 RIPARIAN RESTORATION WORKS

Since 1995, various detailed riparian surveys and prescriptions have been suggested but never conducted in the Suskwa Watershed.

4.2.4 INSTREAM STRUCTURE WORKS

Within Suskwa Watershed, five sites received instream structures and include Skilokis Creek, Natlan groundwater channel, Thirty One Mile Creek, an unnamed creek located at 34 km on the Suskwa FSR, and Fifteen Mile Creek.

4.2.4.1 Skilokis Creek

Skilokis Creek is a tributary of Suskwa River draining 16.4 km^2. This stream is known to provide good quality habitat for rearing steelhead. A relatively heavy rain-on-snow event on May 26, 1998 led to significant peak flows in the Suskwa River and its tributaries. In Skilokis Creek, a cobble/gravel debris flow caused a complete channel diversion slightly upstream of the Hamblin Main Bridge with the flow running down the road, through the forest and into the Suskwa river and the Suskwa River Bridge abutment fill. The Skilokis Creek channel downstream of the Hamblin Main Bridge was filled to the bankfull level with 1.5 to 2.1 m of gravel for a length of 156 m. Hamblin Main road crosses the fan approximately 170 m downstream of the poorly defined fan apex. The Hamblin Main Bridge does not allow for any upstream lateral channel movement and has since the early 1970s effectively choked bedload movement and alluvial deposits. In 1997, the Suskwa Watershed restoration Program constructed two stone lines just below the bridge to improve and diversify habitat conditions for steelhead, trout, and Dolly Varden; these were subsequently buried in the 1998 highwater event.

The original Skilokis Creek channel was reinstated in mid-October, 1998 with the restoration design and prescription described in Weilland 1998. An estimated 1500 m3 was removed from the channel bed and hauled to a nearby storage site. Six boulder clusters-four downstream and two upstream of the bridge with an approximate spacing of 30-35 m were installed. These boulder cluster-riffle structures were to provide suitable habitat for salmonid juveniles, particularly coho and steelhead. The function of these is to stabilize riffle and pool habitat where it was disrupted and lacking. As well, the left bank upstream of the bridge and the right bank downstream of the bridge at the snout of the debris aggradation were excavated to lengthen the radius and extend meanders.

This evaluation results indicated that these boulder clusters functioned as installed and lateral channel migration was nearly normal. This project and situation were well-planned out. We recommend that no further instream works be carried out. The Hamblin Main forestry road should be relocated to the fan apex.

Figure 80. View upstream from bridge.

Figure 81. View downstream from bridge.

Figure 82. View 112 m upstream from bridge. Note the abundance of cover.

Figure 83. View downstream to bridge-152 m.

Figure 84. View downstream to bridge-130 m.

Figure 85. View downstream to bridge-90m.

Figure 86. View downstream – 30 m from bridge.

Figure 87. View upstream – 109 m down from bridge.

Figure 88. View upstream – 69 m to bridge.

4.2.4.2 Natlan Groundwater Channel

The Natlan groundwater channel is located upstream of the Natlan Creek crossing of the Suskwa Forest Service Road (FSR) at 15.1 km. The channel parallels the FSR for approximately 210 m before entering Natlan Creek. In 1990, the Salmon Enhancement Program identified the site as a juvenile coho rearing area and pools were established prior to funding cut implementation. In 1996, the channel was assessed and pool creation as well as the addition of LWD was prescribed. In 1997, twenty-odd pieces of LWD were distributed over the lower 89 m of the channel and three pools were excavated to a depth of 0.5 m and distributed 40, 46, and 68 m upstream of the mouth at Natlan Creek.

The channel is groundwater fed by Natlan Creek subsurface flows. In this evaluation study, unidentified fry were noted utilizing the lower 147 m of the channel. Pools depths measured 0.45 to 0.5 m in depth and didn't appear to be infilled to any degree. The LWD mostly provided cover and did not substantially add to structural complexity of the stream. Low water levels precluded access into or out of the ground channel and Natlan Creek. The minimum dissolved oxygen concentration measured was 9.2 mg/L and the water temperature was $3.2C^0$. Overall, this site was suitable for instream works, well-planned, and is providing low cost and high value benefits.

Figure 89. View upstream of pool and LWD, 38 m from mouth.

Figure 90. View upstream. Note the low water level.

4.2.4.3 Thirty Mile Creek

Thirty Mile Creek drains the south slope of Thoen Mountain into Suskwa River. The creek crosses the Grizzly Main FSR at 0 km where there is a abundance of juvenile bull trout. The creek at the site has an average gradient of 9% and is located on a mostly inactive fluvial fan. The creek is bordered to the west by mature timber and to the east by a cutblock.

The site was originally assessed in 1996 due to a small avulsion into the cutblock (93M035-015) that threatened to reroute itself across the clearcut fan area. The instream site is located 423 m upstream of the road crossing and consists of deflector logs that functioned to keep the stream in it original channel.

Investigations for this evaluation could find no trace of any deflector logs. This high energy creek has a relatively large amount of windblown trees strewn across it for approximately 700 m upstream of the Grizzly Main FSR, and as a result, multiple channels have formed. The following photos show the amount and frequency of the LWD. Further restoration efforts at this site should be abandoned.

Figure 91. View upstream on Thirty Mile Creek 330 m from road.

Figure 92. View upstream on Thirty Mile Creek 187 m from road.

4.2.4.4 Natlan Creek Tributary—Suskwa FSR 34 km

The 34 km tributary is relatively small draining 5.35 km^2 into upper Natlan Creek. The creek crosses the Suskwa FSR approximately 265 m upstream from Natlan Creek. Fish presence is noted with Dolly Varden and bull trout; it is possible that other species utilize the water. In 1979, the creek was bridged, and then replaced by a 2500 mm multiplate elliptical arch culvert in 1988. In 1998, eight channel spanning outlet pool boulder steps along with a series of seven culvert baffles were prescribed and subsequently installed in 2000. In 2001, the culvert outlet was assessed for fish passage with results that indicated satisfactory fish passage; however, sediment had filled in between the baffles and also filled the uppermost outlet pool.

This effectiveness evaluation found high elevation, low quality habitat with 1.3 m falls and shallow, swift flows upstream and downstream of the culvert. The stream gradient upstream for approximately two km averages 14%. Currently Dolly Varden and bull trout are negotiating the 1.3 m falls framing the crossing site. Currently the culvert outfall drop is 15 to 20 cm depending on water levels. Velocities range from 0.85 to 2.13, again depending on flow levels. The outlet pools have been scoured out by high flows and don't function as step pools presently. Our recommendation is to install an open bottom structure, be it a culvert or bridge.

Figure 93. View is upstream to culvert outlet.

Figure 94. Side view shows 17 cm culvert outfall drop.

4.2.4.5 Fifteen Mile Creek

Fifteen Mile Creek is a moderate sized tributary encompassing 22.4 km^2 that drains into lower Suskwa River. The stream supports resident freshwater fish such as Dolly Varden and rainbow trout. The old road to Fort Babine crosses Fifteen Mile Creek approximately 1.72 km upstream of its mouth. The east and west road cuts approach through glacial lacustrine soil that has failed into the channel for approximately 150 m on both sides of the crossing. The stream crossing originally consisted of a wooden box culvert that failed and was overlaid by a log stringer bridge. Around 2000, an 1.6 m x 17 m ATV bridge was constructed over the two failed crossings.

At some point in the near future, the old crossings will sink into the channel and exacerbate the bank failures that have occurred in the past. The ATV bridge instalment indicates poor planning and conceptual development. It is recommended that the ATV bridge be pulled, the old crossing structures be pulled out of the channel and the ATV bridge be repositioned. The streambank failures need to be assessed by a geomorphologist in regard to drainage and stabilization.

Figure 95. View downstream of collapsed structures.

Figure 96. Close view downstream of collapsed structures Fifteen Mile Creek.

Figure 97. View eastward across Fifteen Mile Creek ATV bridge.

5.0 KITSEGUECLA WATERSHED EFFECTIVENESS EVALUATIONS

5.1 ENVIRONMENTAL SETTING

The Kitseguecla Watershed is located in north-central British Columbia, south of Gitsegukla Village, which is approximately 25 km southwest of New Hazelton, BC. on Highway 16. It is bounded to the east by the Roche Deboule and the Nechako Plateau, and to the south by the Zymoetz River. To the west and north it is bounded by Skeena River drainages.

The Kitseguecla Watershed area possesses a catchment area of 808 km^2. The Kitseguecla Watershed is for the most part mountainous with high relief, with elevations that range from 2,421 m in the Roche Deboule Range to 196 m at the Skeena–Kitseguecla River confluence. Major tributaries draining into the Kitseguecla River include Juniper Creek and Laura Creek, flowing into the right bank, while Kitsuns Creek, Deep Canyon Creek, and Jack Mould Creek flow into the left bank.

The surrounding glaciated mountains help to maintain moderate summer stream flows. Originating from glaciers, these streams produce moderate amounts of natural sediment and are the primary contributors to the wide and rapid variation in water flows, particularly in Juniper Creek, Laura Creek, Kitsuns Creek, and West Kitsuns Creek. Kitseguecla Lake and Jack Mould Lake are mid-elevation lakes situated on the low relief upper Kitseguecla area contributes to hydrological storage and more-regulated stream flows.

The hydrology is dominated by snowmelt. The precipitation pattern usually results in a moderate stormflow distribution and accounts for the lack of non-snowmelt high-flow events in the annual peak flow series. Mountains in the Roche Deboule Range and the Bulkley Range exert major hydrological influences, with tributary streamflows having a moderately high response from water input due to the high gradients of the major tributaries.

5.1.1 Stream Channels

The tributaries flowing into the Kitseguecla River are for the most part short, high-energy, and steep-gradient streams that level out only in the last kilometer, or less, before entering the larger trunk stream. Sharp relief, with well-defined drainages, marks most of these tributaries, with many streams possessing both stable and unstable channel conditions throughout their length. Active and inactive fans characterize the majority of tributaries in their lower reaches.

Overall, the Kitseguecla drainage is complex in that there are a great variety of surficial materials. The general arrangement is characterized by glacial till and glaciofluvial deposits laid down during the last glaciation (Gottesfeld 1985). Glacial till tends to be found in the valley floors and was laid down beneath the ice, while the glaciofluvial sediments are found along the edges of narrower valleys and show the reworking of glacial deposits has taken place by meltwater during glacial retreat. Streams channels are typically V-shaped when associated with non-cohesive sediments, or U-shaped when associated with underlying cohesive materials.

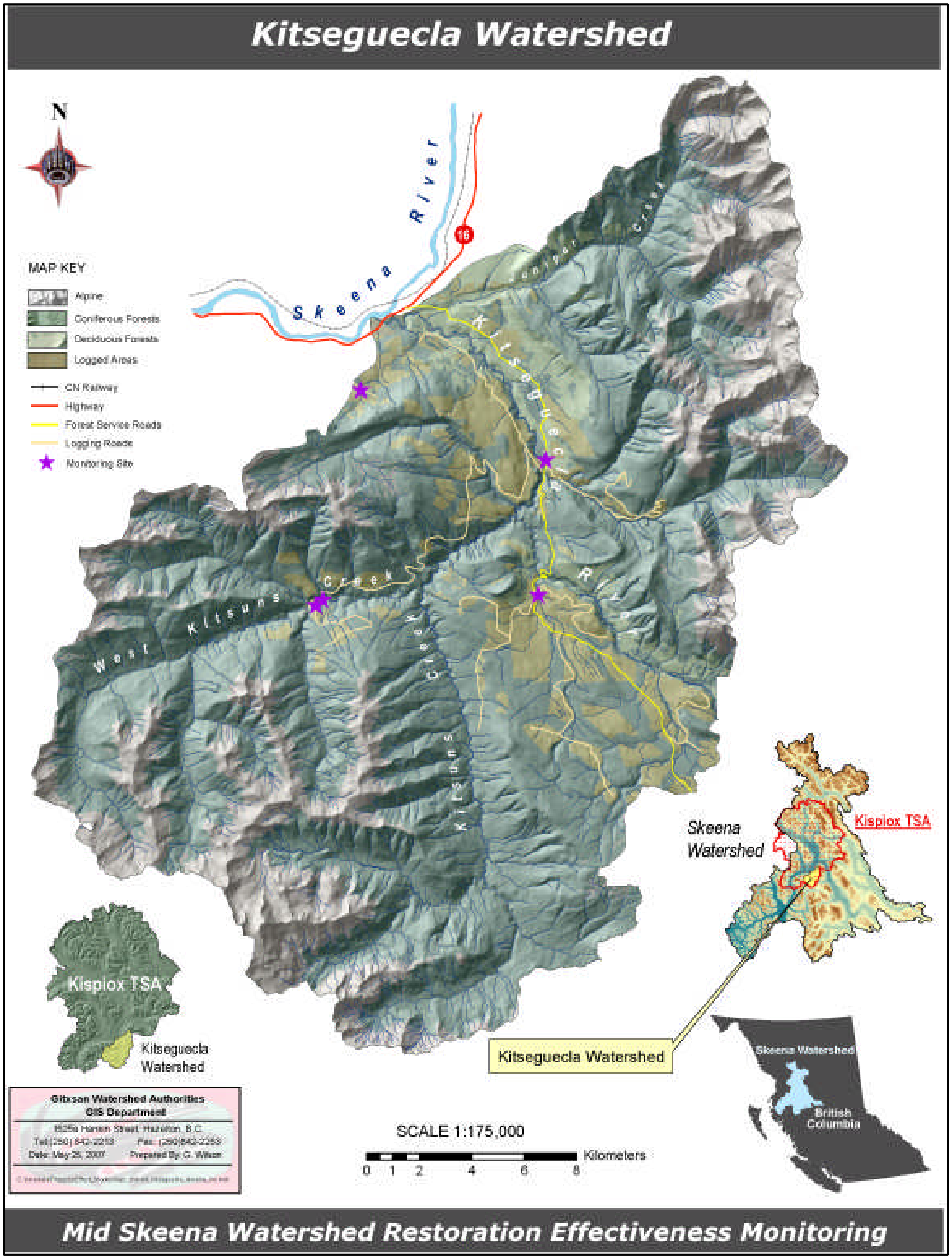

Figure 98. Kitseguecla Watershed with monitoring sites.

Kitseguecla River

Reach 1 of the Kitseguecla River extends from the mouth at the Skeena River upstream to the Kitsuns Creek confluence. This reach is characterized by a regularly, confined single-thread channel with an average gradient of 1.2%. A 0.5 km canyon is bisected by the mouth of Laura Creek and the crossing of the 400 Road. Reach 1 habitat is considered complex. The channel is incised and exhibits significant bedrock control.

Reach 2 is represented from Kitsuns Creek 2.5 km upstream. In this reach the valley becomes more entrenched with the stream gradient averaging 2%, with some sections up to 6%. The stream morphology of Reach 2 is mainly composed of riffle-glide type habitat with the substrate composed of boulders and cobbles.

Reach 3 is classed as a slightly irregular meandering channel confined by steep valley walls with an average gradient of 1.7%, extending upstream to Jack Mould Creek. Stream morphology is characterized by riffle-pool-glide type habitat with the substrate composed of boulders, small cobbles, and the occasional pocket of gravels and fines. Both sides of the channel appear to be unstable, with numerous natural failures.

Reach 4 extends to Kitseguecla Lake, with the upper portion essentially a wide low-gradient wetland complex that is an extension of Kitseguecla Lake. The substrate is predominantly fine organic matter.

Kitsuns Creek

Reach 1 of Kitsuns Creek is approximately 5.2 km in length, which includes the channel upstream to the West Kitsuns Creek confluence. The channel has an average gradient of 1.5% that ranges from 1% to 3% (Acer and GBC 2000). The reach has a general wetted width of 15 m, is aggrading, confined and entrenched throughout with very steep bedrock walls rising for the most part directly from the edge of the active channel. Disturbance indicators include many failing banks, numerous debris jams, and elevated bars, which imply periodic high-energy flows with major movements of debris and bedload occurring. Kitsuns Creek becomes glacial downstream of the first major left bank tributary (Lorenz 1998).

Reach 2 of Kitsuns Creek passes upstream from the West Kitsuns Creek confluence for approximately 11.7 km in a stepped confined profile with an average gradient of 1.5%. The channel receives considerable glacial and bank failure sediment from the west fork draining Ashman Ridge.

West Kitsuns Creek

West Kitsuns Creek generally flows north and east, draining into Kitsuns Creek 5.6 km upstream of the confluence of Kitsuns Creek and Kitseguecla River. The drainage is characterized by various sized, natural mass wasting events that are often coupled to West Kitsuns or tributary stream channels. Reach 1 is approximately 4.0 km in length with an average channel gradient of 3%. The stream is deeply incised into bedrock and is generally bedrock controlled. The substrate is comprised mostly of boulders and cobbles with excellent riffle/pool habitat. There is significant bank erosion and natural mass wasting from unstable soils that contribute to the high turbidity during high water events.

Reach 2 extends 1.6 km upstream to the bridge on the 700 Road and is characterized by frequently confining bedrock sidewalls and fast flowing water. The average channel gradient is 2.5% with the substrate dominated by cobbles and boulders. Naturally unstable soils contribute to the mass wasting shown by a number of slides into the stream channel. The reach has been altered for about 0.5 km by the bridge-crossing site.

Reach 3 of West Kitsuns Creek extends upstream for approximately 3.0 km to a 4 m falls over bedrock that is considered an upstream migration barrier to all salmonids at all flow levels. The channel exhibits riffle/pool morphology with an average gradient of 2 to 3%. Cobbles and boulders dominate the substrate with gravels in pools. The stream channel is frequently bounded with bedrock walls on both sides and there is evidence of natural bank instability. Except for one road-related slide into the channel, the reach is considered to be in its natural condition.

Juniper Creek

Juniper Creek flows west and enters the Kitseguecla River right bank approximately 2.8 km upstream from its confluence with the Skeena River. The Juniper sub-basin is generally characterized as being confined by steep sloped terraces, bedrock, and hillsides throughout, except for the narrow, gentle sloping fan as it nears the Kitseguecla River. The drainage hydrology is considered flashy, and the mainstem often experiences a large amount of bedload movement.

Reach 1 of Juniper Creek covers the stream channel as it crosses its alluvial fan and is approximately 2.7 km in length. The stream channel exhibits a regular longitudinal profile with an average gradient of 4.0%. Naturally unstable soils contribute to streambank failures and high turbidity.

Reach 2 extends approximately 5.6 km upstream to the confluence of Brian Boru Creek, the major tributary. The reach is entrenched and confined within the valley walls. The stream shows a stepped profile and the substrate is dominated by boulders and cobbles. Natural mass wasting resulting from steep slopes and pockets of lacustrine soils characterize this reach.

5.1.2 Fisheries Values

Fisheries values are rated as high within the Kitseguecla Watershed. Chinook, sockeye, coho, pink, and chum salmon, as well as steelhead, characterize anadromous fish presence within the Kitseguecla drainage. Anadromous fish species within the Copper River drainage area of interest include sockeye, coho, and steelhead (FISS 2002). Cutthroat trout, Dolly Varden, rainbow trout (steelhead), mountain whitefish, bull trout, and a variety of coarse fish represented freshwater resident fish presence (FISS 2002). In general, the most widely dispersed salmon species is coho, while Dolly Varden and rainbow trout are located in most fish bearing waters.

Information concerning Kitseguecla River chinook spawners is scant; however, known spawning occurs on selected pockets of the mainstem up to 19 km. Chinook have also been observed spawning in Kitsuns Creek one km upstream from its confluence with Kitseguecla River.. Kitseguecla River chinook escapement estimates have been recorded discontinuously since 1966, and over the forty years since that time, escapement has been generally poor. Escapements for the mainstem have ranged from 25 chinook in 1966 and 1978, to 300 spawners in 1987 (DFO 2001). There are no escapement counts concerning Kitsuns Creek.

Pink salmon escapement has been recorded discontinuously since 1954. The lack of consistent observations precludes odd and even year comparisons or overall escapement trends. Spawners have ranged from a high of 5,000 in 1991, to averages in the low range of 25 fish. From 1983 to 1993, the ten-year average on even years was 1,020, with the odd years averaging 1,858 chinook spawners.

Little is known about the sockeye that spawn for approximately 2 km downstream of Kitseguecla Lake. Escapement of 50 spawners was recorded in 1982, and their presence since then has been noted by Fishery Officers (Woloshyn 2003). It is not known if sockeye fry, after hatching, migrate upstream to the lake, or move out of the system downstream to the Skeena estuary.

Sockeye have been noted spawning in West Kitsuns Creek in the upper portion of Reach 2 and the lower portion of Reach 3, close to the twin bridges crossing site (Woloshyn 2003). These spawners appear to be "river type sockeye," which are unusual in the Skeena system, but have been observed in the Stikine River (Northwest Enhancement Society 1985, Burgner 1991). In addition, West Kitsuns sockeye are unique in that their spawning colours are atypical of other Skeena sockeye stocks except Gitnadoix. When mature, these sockeye possess a silver body colour with only a dull red stripe. Timing and enumeration data is scant.

Adult chum salmon returning to spawning grounds in the Kitseguecla River make up less than 1% of the total reported Skeena system chum escapement. Escapement enumerations have occurred in only four years: 25 chum in 1986, 100 in 1987, and 25 chum in 1989 and 1990. Chum salmon stock status in the Kitseguecla drainage is basically unknown.

Chum salmon typically return to their Kitseguecla River spawning grounds in mid to late August. Principal chum spawning occurs in the lowest reach of the river; chum have not been observed spawning upstream of the mainstem bridge crossing at 10 km. Upon emergence as fry, the juveniles migrate directly to sea.

Kitseguecla steelhead are summer run fish that enter the Kitseguecla system in late August or early September; it appears that an unknown percentage of these steelhead overwinter in the mainstem lower reach or close to the mouth in the Skeena River. The population status of Kitseguecla steelhead is unknown.

Steelhead spawning occurs the following March through May, coinciding with warming water temperatures and an increase in Kitseguecla mainstem flows. Documented spawning is dispersed in side and main channels on the mainstem, particularly in the mid-reach, between Kitsuns Creek confluence and the mouth of Jack Mould Creek and in the lower reach of Kitsuns Creek. There is no data to assess percent of repeat spawners or the number of years spent in freshwater before smolting. Results from The near by radio-tagging program on the Kitwanga River (Lough 1983) indicates that kelts generally migrate downstream promptly following spawning. Recent reconnaissance level (1:20,000) fish and fish habitat in the Kitseguecla drainage show rainbow trout (steelhead) well distributed in accessible, low gradient habitat (Triton 1998a, Lorenz 1998a, Biolith1999, Lorenz 1998b).

5.2 KITSEGUECLA WATERSHED RESTORATION PROGRAM

The Kitseguecla Watershed restoration Program was initiated in 1995 and carried through to 2001. The program invested in assessments and works for riparian areas, aquatic habitat, hillslope stabilization, road deactivation, and instream site, survey, and design in order to reduce forestry impacts and future risks. As well, minor amounts of monitoring occurred. In 2001, Johnston (2001) com0pleted a restoration plan that proposed future high priority works that focused on implementation and monitoring works.

5.2.1 Effectiveness Monitoring Results

This watershed restoration effectiveness monitoring project screened all restoration projects completed since 1995. Some projects conducted by forest licensees were not screened due to the lack of documentation, particularly slope stabilization and drainage rehabilitation in the West Kitsuns area. The majority of completed work consists of road deactivation and hillslope stabilization.

5.2.2 Deactivation Works

Deactivated road systems sites were assessed for field indicators that are commonly associated with slope instability and erosion. Sites were also evaluated for overall effectiveness. The residual risk at the sites was also assessed with respect to fish habitat and water quality. The majority of deactivation works consist of waterbars, cross ditches, deactivated stream crossings, and pullback of debris encroaching on streambanks.

Across hundreds of sites, deactivation work was consistently good with the results showing minimized erosion, good effectiveness of grass seeding, and deactivated stream crossings showing good work and streams running clear. Little sediment related problems were observed at stream crossings; however it is clear that maintenance of deactivated works is lacking and causing sediment delivery problems. A centralized road inspection schedule and reporting system needs to established and implemented.

There is a moderate amount of road deactivation needed that would be beneficial to water quality; it is spatially sporadic and spread throughout developed areas of the watershed except for the West Kitsuns Creek. West Kitsuns Main, West Branch Main, and the Slim Jim roads need to be deactivated and un-built in unstable areas; this endeavour needs to be carefully planned and executed.

It is likely that the most important and beneficial road deactivation work conducted and completed in 2001 was in Kits Creek. Kits Creek is the designated community watershed for Gitsegukla Village and flows into the Kitseguecla River approximately 200 m upstream from the Skeena River confluence.

5.2.3 Hillslope Stabilization Works

5.2.3.1 Kitseguecla FSR 9.5 km

The Kitseguecla Forest Service Road was built in the early 1970s and at 9.5 km the road traverses across unstable glacial outwash materials with bedding layers that include permeable coarse gravel, sand, and relatively impermeable silty sand and gravel located adjacent to Kitseguecla River. The road was built using the 'cut and sidecast' method and there is considerable water seepage on both the cutslopes above the road and the fillslopes below. A history of stability problems was due to the three slides above the road that delivered surficial sediments onto the road and the three slides below the road that were chronically eroded by the river.

In 1995, remedial efforts were undertaken: to remove the excess sidecast and oversteepened materials from the lower slides, to realign the road into the hillslope, pullback, re-contour and rock blanket portions of the slope above the road, and to rock blanket the downstream slide below the road, and construct a 150 m long rip-rap berm along the river edge to protect the toe of the slide from future erosion.

In 1996, remedial efforts consisted of two components machine works and bioengineering. Machine works included installing two 500 mm culverts to redirect drainage, additional pullback above and below the road with an excavator and dragline, and endhauling spoil material. Bioengineering work included installing: 231 modified brush layers, 304 lineal m of live pole drains, and 62 lineal m of wattle fence. Additionally, alder and cedar plugs, hemlock bare root seedlings, and willow and cottonwood cuttings were planted. The entire area was dry seeded and hydro seeded to provide complete ground cover and minimize surface erosion.

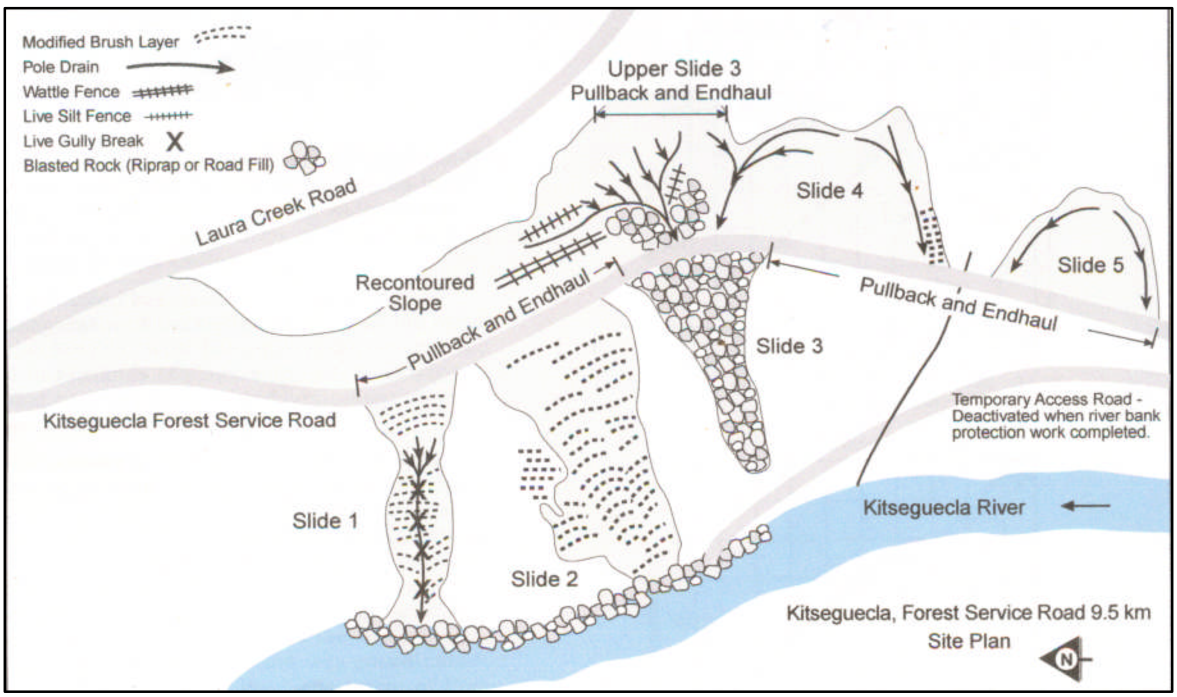

Figure 99. Drawing shows simplified plan of Kitseguecla FSR 9.5 km site.

This evaluation project reviewed the project objectives and primarily focused on how much sediment was being delivered from the site and how effective were the conventional and bioengineering methods that were utilized. 92% of the installed structures are still intact and functioning. Sediment delivery to ditchline drainage and the Kitseguecla River has been reduced by 86%. Approximately 61% of the brush mats, live pole drains, and wattle fences sprouted and then died due to moisture deficit. These results were related to location rather than technique or method. The majority of Slides 1, 2, and 3 have stabilized with the largest problem presently being ravelling. On Slide 3, the upper, northern portion has experienced light slumping. The southern portion of Slide 4 and Slide 5 are experiencing active wasting and the live pole drains are no longer functional. These sections need to be reconstructed and then maintained. We recommend a hydrologist visit the site and make recommendations on potential drainage solutions that may be an opportunity upslope of Slides 4 and 5. If drainage solutions aren't apparent, we recommend installing a rock blanket the lower portion of Slide 5 and the southern lower section of Slide 4. Overall, this effectiveness evaluation rates the site as fair to good.

Figure 100. View upstream with Kitseguecla River on the right and berm at base of slides on the left.

Figure 101. View down Slide 1 to Kitseguecla River.

Figure 102. View up Slide 1.

Figure 103. View down Slide 1 from the roadside.

Figure 104. View of the upper, northern portion of Slide 2.

Figure 105. View down southern side of Slide 2.

Figure 106. View of upper Slide 2.

Figure 107. View across the lower portion of Slide 3 that received a rock blanket.

Figure 108. View up Kitseguecla FSR and the upper, northern portion of Slide 3. Note minor slumping above rock blanket.

Figure 109. View down northern side of Slide 4 to the road.

Figure 110. View across the upper portion of Slide 5.

5.2.3.2 West Kitsuns Creek Slide

In the late 1980s, forest development activities entered into the northern slopes of Kitsuns Creek and by the early 1990s were into the northern slopes of West Kitsuns Creek, which was crossed in 1992. Over the next decade a series of slides into West Kitsuns Creek or onto its floodplain occurred. The slides are in general related to the sidecast method of road construction whereas soil and debris were sidecast overloading the slope on existing unstable terrain. Water management issues include drainage diversion, water collecting in ditchlines, and culvert and cross locations along the road on both sides of the creek.

There are multiple impacts from development in this area: loss of riparian vegetation; sediment deposition from the complex slide close to the intersection of the 700 and 400 Roads; sediment deposition from the overburden placed between the 700 Road and the stream near the northern end of the bridge; and bank erosion and slides between the road and stream channel for approximately 500 m downstream of the bridge. A large area adjacent to the three bridges is heavily impacted and destabilized, with mass wasting on both sides of the stream from road building activities. It is important to note that coho, chinook, and sockeye have known spawning presence upstream and in and around this area.

Many of the slides and subsequent erosion are not documented, this also includes remediation efforts. In August and September 1998, SCI the developer with the license and liability undertook a major project to stabilize road sections that included pullback of excess sidecast, installing subsurface seepage collection structures, and planting and seeding. Other remediation efforts occurred from 2000 to 2002; however, our study results indicate that these efforts appeared minimal and lacking strategic direction given the nature of the ground, and the magnitude and complexity of the problem. It is likely that the roads in the area could be un-built and historic wasting areas vegetated.

This effectiveness evaluation noted that while some areas appeared to be stable and sediment production was quiescent, instability is an ongoing problem. An overall sediment source and production investigation that includes surface erosion potential and sediment transfer capability should be commissioned with sufficient resources to plan and implement appropriate restoration activities as needed.

Figure 111. View downstream from bridge on West Kitsuns Creek. Slim Jim Road (aka: W7 Branch, Kitsuns 701) ascends the hill on the right. Much of the right streambank has slid into the creek and was subsequently covered with rock blankets.

Figure 112. View across slope located at Slim Jim 0+467. The slope has been rock blanketed.

Figure 113. View southward downslope and across West Kitsuns Creek 500 m downstream of the bridge. The slope has been pulled back to a certain degree.

Figure 114. View northward across West Kitsuns Creek to slide area shown in Figure 113 above.

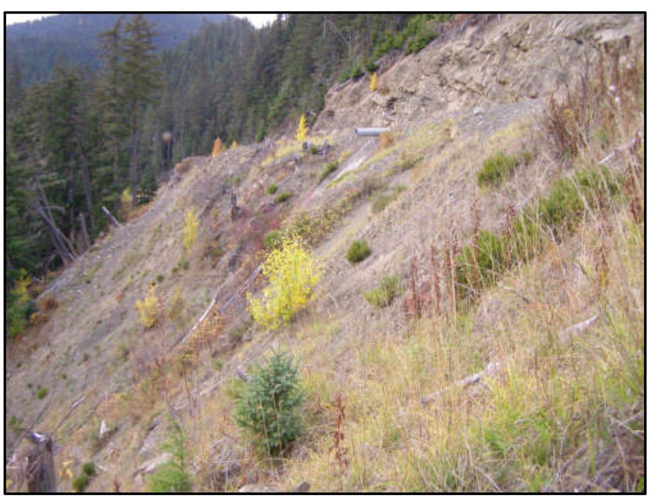

Figure 115. View westward across slide located 340 m downstream of the bridge crossing West Kitsuns Creek. Note over-extended perched culvert delivering drainage to unstable slope.

5.2.4 Riparian Restoration Works

Since 1995, various recommendations and assessments have been made in regard to riparian restoration; however, no prescriptions have been implemented.

5.2.5 Instream Structure Works

Tributary 1, Site 3

Tributary 1 is a relatively small, low elevation tributary to the Kitseguecla River located of 17 km on the Kitseguecla 200 Forest service Road. Logging occurred over much of the watershed beginning in 1974 and continuing into the mid-1990s. In many places, logging occurred over both banks with subsequent debris flows, bank erosion, and loss of habitat complexity. Site 3 was the location of a collapsed bridge structure and was selected for restoration efforts. The objectives were to reduce erosion at the crossing, create more habitat variety, and to provide learning opportunities through monitoring.

The bridge deck and approaches were removed in 1997. In 1998, the banks were pulled back further and approximately 18 pieces of LWD, mostly trees with root wads attached, were installed. The installation included one channel spanning piece to function as a weir, seven pieces to act as deflectors and to produce scour, and four clusters to function as deflectors and flow concentrators, and nine debris catchers to catch wood to build up a protective mat of woody debris. The riparian area was assessed, a prescription treatment was built; however, no riparian works were implemented. The installed structures were documented with an as-built survey.

This evaluation survey found that the project was well planned and implemented, but appeared to be a large-scale effort given the benefits to unknown species, population composition, and abundance of fish and the approximately 300 m^2 habitat restored. All structures were intact and remain integral and are achieving the restoration objectives. It was noted that no boulder ballast and cable structures were utilized. A functional riparian zone is slowly growing in and beginning to function.

Figure 116. View southward across Tributary 1 crossing from Photo Point 2.

Figure 117. View upstream from Photo Point 2.

Figure 118. View downstream from Reference Post 2.

Figure 119. View upstream from Tree #10.

Figure 120. View upstream from Reference Post 6.

Figure 121. View upstream from Photo Point 1.

Figure 122. View downstream from upstream end of installed structures.

6.0 DISCUSSION

Natural freshwater habitats of Pacific anadromous salmonids have undergone massive alterations in lower and middle Skeena Watershed since the early 1900s. These changes have been due primarily to forest harvesting activities and linear transportation development. Overall, past land management practices have lessened the productive capacity of forest lands, and particularly, fish producing waters. In 1994, the B.C. Government introduced the *Forest Practices Code* and Forest Renewal BC (FRBC), an initiative aimed at rehabilitating B.C. watersheds. Restoration activities funded under the Watershed Restoration Program (WRP) adopted a process-oriented approach that attempted to reduce the generation and delivery of sediments from hillslopes to stream channels, re-established natural drainage patterns and water quality, replaced lost channel-structuring elements within streams, and restored habitat within selected terrestrial, riparian and stream ecosystems towards pre-logging conditions.

WRP program goals, objectives, and intents were a significant move forward to improving salmonid habitat and the rate of habitat loss has declined. However, the science and how-to implementation of habitat restoration is not well-known in the Skeena Basin. Insufficient understanding and/or information of ecological processes and their context at the basin and sub-basin levels is still common. Three key observations came out of this project:

1. Developing baseline information on habitats and their use, salmonid species preferences by life stage, and gaining an understanding of factors that limit salmonid production requires multi-year pre-improvement inventories because of natural variability in fish populations and the environment.
2. Complications arise when conceptualizing and predicting the effects of habitat improvements without extensive experience.
3. Any restoration work that is to be monitored and evaluated needs to be clearly and explicitly documented as to location, objectives, prescription, and completed work with as-built documentation.

Effectiveness monitoring in the mid-Skeena Basin is an essential, but neglected component of restoration activity. Having baseline data and inventories of pre-development conditions is essential if restoration activities are to occur. It is near impossible to restore a site to natural conditions when they are unknown.

The second point to be discussed is: complications arise when conceptualizing and predicting the effects of habitat improvements without extensive experience. The deactivation and hillslope remediation efforts in the Kispiox, Suskwa, and Kitseguecla watersheds were on the whole, well implemented and effective at reducing the generation and delivery of sediment from hillslopes to stream channels.

Overall, instream structure placements were a failure in the mid Skeena area. The Murder Creek and Trib 1 sites were well designed, surveyed, and implemented, but it is debatable whether they restored critical habitat and improved fish production. In the case of Murder Creek, our observations indicated that fish passage and reducing the high water velocity from the Kispiox Trail crossing would be more productive and beneficial to the underlying restoration program goals. In our opinion, instream structure installations should be prioritized for critical habitat only when a clear biological response(s) to the restoration work can be measured.

A limiting factor in conducting this project was the lack of as-built documentation in regard to all road deactivation in the basin, the hillslope stabilization projects in West Kitsuns Creek, and the various instream structures installed in Kispiox Watershed other than Murder Creek.

This evaluation of mid-Skeena restoration techniques indicates that knowledge in regard to cost, site suitability, effectiveness of techniques, and fish production potential and reality is incomplete and comprehensive research and monitoring are needed. We suggest restoration efforts be guided and prioritized by watershed processes, protection and conservation of existing high quality habitats, and lastly by understanding and knowledge of the effectiveness of specific techniques.

7.0 GENERAL AND CITED REFERENCES

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APPENDIX 1 PHOTOGRAPHS

Photographs submitted under separate cover.

APPENDIX 2 FINANCIAL STATEMENT OF EXPENDITURES

Financial Statement submitted under separate cover.

APPENDIX 3 MAPS

Three 1:50,000 maps in pockets.