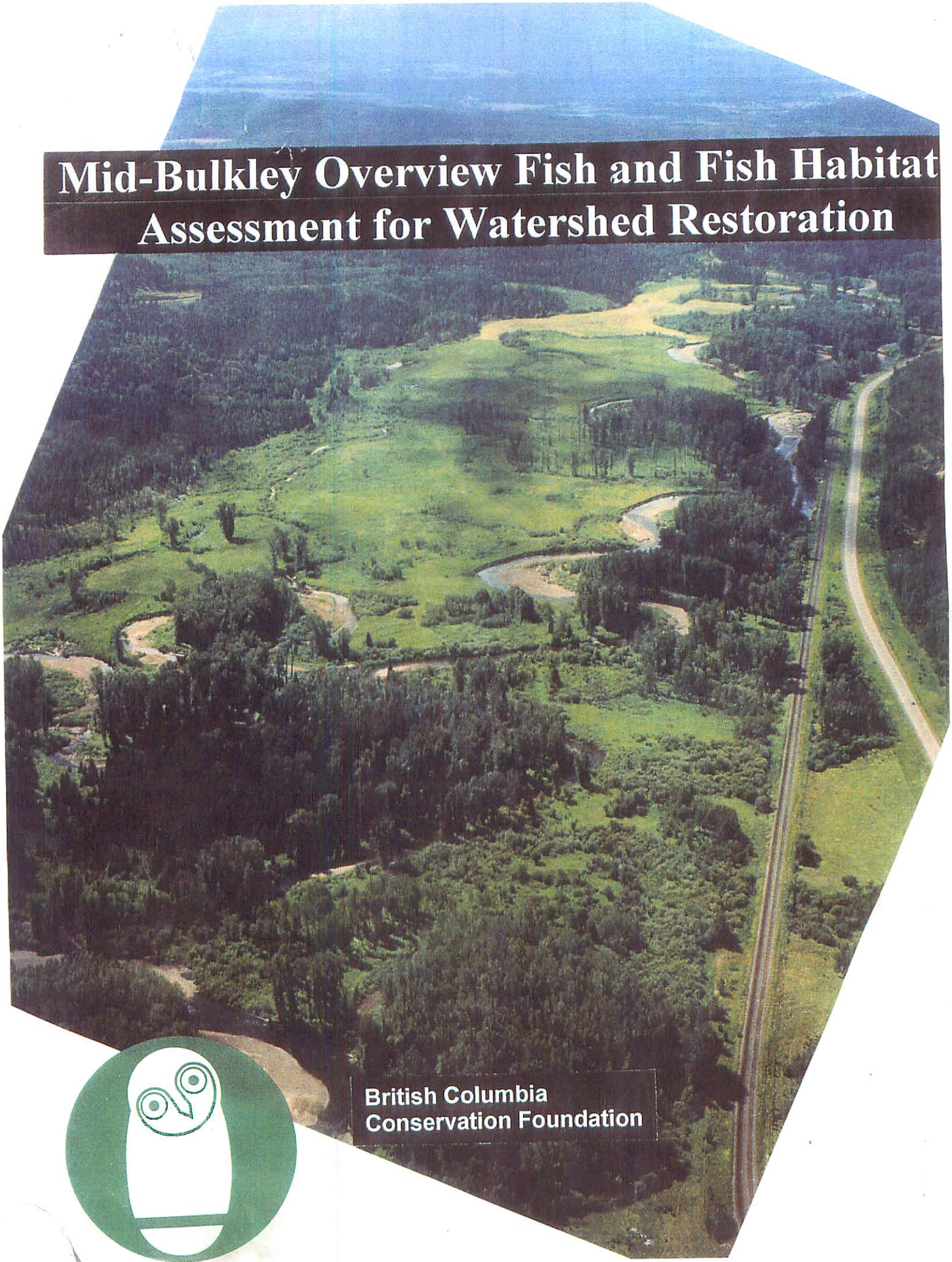
Mid-Bulkley Overview Fish and Fish Habitat Assessment for Watershed Restoration



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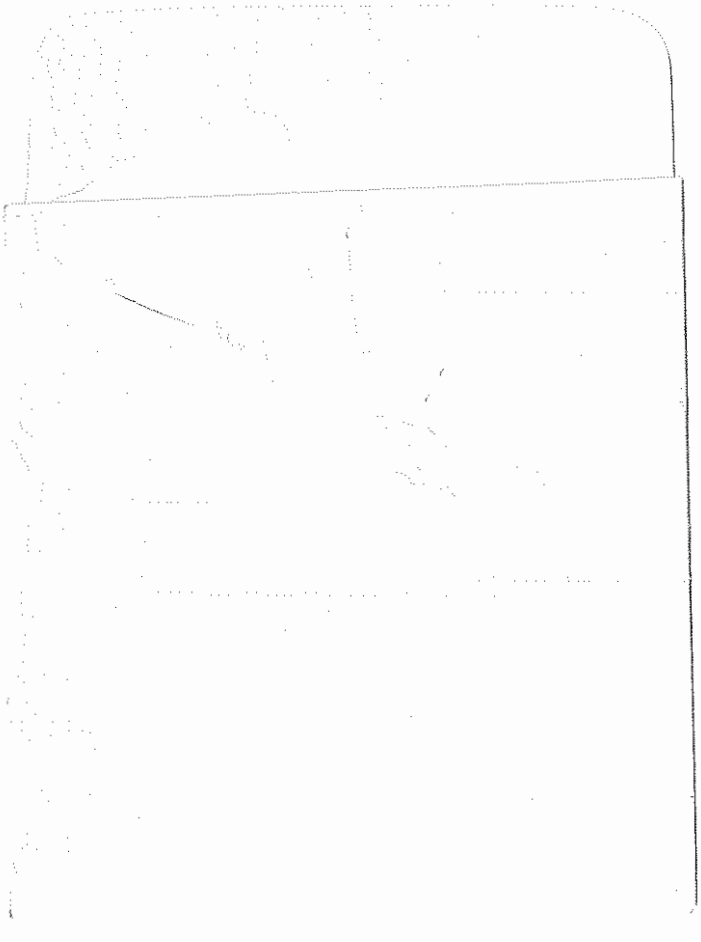

Executive Summary

Introduction

In the spring of 1997, the Nadina Community Futures Development Corporation (NCFDC) was designated as a proponent for FRBC funding in a Watershed Restoration Program (WRP) project in the Mid-Bulkley Watershed. The NCFDC is a non-profit community economic development corporation based in Houston, British Columbia. The implementing partner in this endeavor was the Ministry of Environment, Lands, and Parks, Skeena Region BC Environment office (MELP).

WRP is a provincial initiative under Forest Renewal BC to restore the productive capacity of forest, fisheries and aquatic resources that have been adversely impacted by past forest harvest practices, and thus to aid in providing long-term employment opportunities in resource-dependent communities (Johnston and Moore, 1995).

The Fish Habitat Assessment Procedure (FHAP) is a means of assessing watersheds with a history of anthropogenic activity for impacts to fish and fish habitats using a set of integrated physical and biological indicators. The assessment procedure extends from stream and river channels, to the riparian area, to upslope areas in which there is some level of connectivity to the channel. There are two levels of assessment in the FHAP. The first, known as the Overview Assessment, is a reconnaissance-level study compiling background data and using predominately remote-sensing techniques to prioritize sub-basins and waterbodies within those sub-basins for the second level of FHAP. This is known as the Detailed (or Level 1) Assessment, which involves more detailed field surveys of the channel and riparian areas, the end result of which is the formation of restoration prescriptions to restore or rehabilitate fish habitat, or mitigate impacts on that habitat.

The British Columbia Conservation Foundation (BCCF) was contracted by NCFDC to carry out a WRP Overview Fish and Fish Habitat Assessment in the summer of 1997 in the following sub-basins of the Mid-Bulkley Watershed (see figure 2):

- Bulkley River
- Buck Creek
- Richfield Creek
- Johnny David Creek
- McQuarrie Creek
- Byman Creek
- Aitken Creek
- Barren Creek
- Emerson Creek
- Dockrill Creek

The objectives of the Overview FHAP are:

- to determine what fish species (and life stages) are at risk to the impacts of poor land-use practices in the watershed,
- to identify areas of concern that need to be examined in quantitative field surveys of fish habitat,
- to identify preliminary restoration strategies (no action, restoration, rehabilitation, mitigation),
- where appropriate, to identify preliminary restoration opportunities (objectives, scope and priorities).

Watershed Characterization

The Mid-Bulkley watershed, as defined by the watershed boundaries of the sub-basins listed above, is a 167 300 hectare drainage basin situated on the Nechako Plateau physiographic region. Two sub-basins drain the Telkwa Mountains of the Bulkley Range physiographic region which borders the Nechako Plateau to the Northwest. Elevations range from 570 m (1900ft.) at the mouth of the Upper Bulkley to 1640 m (5400 ft.) at Tachek Mountain. The majority of land is within 800 and 1500m in elevation (LaRose and Rencoret, 1996). Watershed characteristics, and the fish and fish habitat therein, are defined by a complex and dynamic interaction of climate, hydrology, surficial and bedrock geology, vegetation, and land-use.

Study Area

The provincial location of the Mid-Bulkley watershed is depicted in Figure 1. A map of the watershed showing sub-basins and major tributaries is depicted in Figure 1A (not to scale) and Appendix 3, map 1-Study Area Boundaries (to scale). Appendix 3, Map 2-Reach Breaks shows the spatial structure that assessment results are organized by.

Target Species

Target species are defined here as economically or culturally important salmonids whose abundance has declined following past land-use practices, or which are known to be sensitive to the effects of logging. The following species, in order of priority, are thought to be in decline in the watershed (Jeff Lough, pers. comm., FHIIP, 1991, SKR Consultants, 1997, NCFDC, 1996, B. Donas, pers. comm.):

- *Oncorhynchus kisutch* (coho salmon)
- *O. tshawytscha* (chinook salmon)
- *O. mykiss* (steelhead)

The following species which use the watershed for one or more life stages, are known to be sensitive to the effects of logging (including those listed above) (Johnston and Slaney, 1996):

- *O. gorbuscha* (pink salmon)
- *O. nerka* (sockeye salmon)
- *O. mykiss* (rainbow trout)
- *O. clarki* (cutthroat trout)
- *Salvelinus malma* (Dolly Varden)
- *S. confluentus* (bull trout)

The latter species is also listed as rare and endangered by MELP. These are the target species whose habitats, distributions, and abundances are being investigated in this assessment.

Methods

The overview fish habitat assessment is completed through a number of different steps designed to focus field assessments and preliminary restoration plans on areas where substantial benefits to the fishery resource are likely (Johnston and Slaney, 1996). It can also be an effective means of gathering, generating, and organizing information about the state of watershed functions such as hydrology and sediment fluxes which are the "blood chemistry" of aquatic ecosystems, and thus fish habitat. These steps are as follows:

- Baseline information search on fish species distribution, abundance, critical habitats, specifics of life-cycle timing, land-use and land-use history, known land-use impacts, and watershed character (hydrology, geology, soils, climate, vegetation, physiography).
- Low-level helicopter aerial photography to gain a snapshot of present conditions
- Assessment of fish habitat condition and land-use impact/impact potential, including that of upslope land-use
- Fish habitat assessment
- Preliminary habitat assessment to summarize impacts, fish habitat value, land-use impact potential, **preliminary** restoration opportunities, and the priority of a given area within a tributary for detailed assessment and restoration.
- Prioritize sub-basins within the watershed relative to each other for detailed assessment and restoration and provide cost estimates for detailed assessment.
- Mapping of sub-basins, units of study (reaches), known fish species distribution, and known obstructions.
- Field checks

More detail on methods is provided in Johnston and Slaney (1996) and in section 2.0 of this document.

Results

A key to limiting factor codes for fish habitat tables presented below is as follows: F=siltation, C=lack of cover, PTR=lack of pool tailouts/riffles for spawning, AH= lack of

alternative habitats, T= unsuitable temperatures known or expected, DO=low dissolved oxygen indicated, A=poor access to adjacent areas, AAH=poor access to alternative habitats, WQ=other water quality concern (not DO/temperature), WL=low water levels, SC=scouring, VR=a lack of velocity refugia, I=good probability of frazl and/or anchor ice formation at low temperatures.

A key to land-uses for uplsope impact potential tables presented below is as follows: F= forestry, R= road(s), H= dwellings, A= agriculture, RR=railway, P=powerline corridor, I= industry (mining and/or commercial).

Information on Forest Practices Code stream/riparian classifications for known fish-bearing streams is found in appendix 9.

Bulkley River

The Mid-Bulkley River (a.k.a. Upper Bulkley, Little Bulkley) was photographed and assessed from its mouth (the POI) at the confluence of the Morice River to the confluence of Richfield Creek. It was segregated into 4 reaches over 68.81 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #3 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 3 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 2 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

The Bulkley River is known to be inhabited by all of the target species identified in this assessment (see section 1.2). This includes sockeye salmon, chinook salmon, pink salmon, coho salmon, steelhead, rainbow trout, cutthroat trout, and Dolly Varden/bull trout (FISS, 1995, FHIIP, 1991, Tredger, 1982, steelhead Society, 1989, N.C.F.D.C, 1996, N.C.F.D.C, 1997, MELP, unknown date, S.Schug, pers. comm., P. Perlotto, pers. comm.). The distribution of these species and their life-stages within the Mid-Bulkley River is as follows:

- Sockeye Salmon: Migrating spawners and smolts use the Bulkley River for passage and holding between the mouth and upstream habitat in Bulkley Lake and the Maxan Watershed (AGRA, 1996, S.Schug, pers. comm.). They are found throughout the mainstem in the mid- to late August period as adults run upstream, and in the late spring as smolts migrate downstream.
- Chinook Salmon: Juveniles are found throughout the mainstem (FHIIP, 1991). The heads of glides in reach 2 have been found to be very productive rearing habitat for chinook (Tredger, 1982). Known spawning sites are mapped in Appendix 3, Map 2. Spawners are found generally to Reach 4, at

infrequent pool tailouts. Reach 3 is the highest value spawning area due to higher gradient, and a more even pool:riffle ratio. Chinook in this watershed are summer-run Chinook, and migrate between July and August to spawn in the September to November period. Chinook generally overwinter in deep mainstem off-channel areas, given good access and water quality, and also in smaller tributaries, provided there is good water quality and a lack of frazl and anchor ice. For the latter reason, log jams are often avoided.

- Pink Salmon: Pink spawners are found in Reach 1 and in the very lower end of Reach 2, and spawn at riffles. They do not make use of the Bulkley beyond this point. Pink juveniles migrate immediately to estuary habitat to smoltify following emergence.
- Coho Salmon: Juveniles are found throughout the mainstem (Tredger, 1982). There have been some spawners using the mainstem west of the fish fence (P. Perlotto, pers. comm.), but generally spawners exhibit preferences for smaller tributaries. Heads of glides in reach 2 have been found to be very productive rearing habitat for coho (Tredger, 1982). Coho often overwinter in large, deep (> 2m) off-channels providing there is good water quality and access, as well as at smaller tributaries.
- Steelhead: Steelhead use of the mainstem is very limited due to water temperatures, gradient, and water flow (Tredger, 1982). Adults are often found holding in the mainstem after spawning (they are present in the fall) in the Morice watershed, or in smaller tributaries of the Bulkley (P. Perlotto, pers. comm.). The Bulkley will also be used for outmigrations of juveniles in the summer.
- Rainbow Trout: The mainstem is used by adults for migration and holding.
- Cutthroat Trout: The mainstem is used by adults for migration and holding.
- Dolly Varden/Bull Trout: The mainstem is used by adults for migration and holding.

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 3 below).

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	Very High	Moderate	Moderate	Mod-Good	Poor	Excellent	F,C,PTR,AH,T,DO	Good	Moderate
	B	Very High	Poor	Mod-Good	Moderate	Poor	Good	CP,C,AAH,WQ,WL	Good	Moderate
2		Very High	Poor	Moderate	Good	Poor	Excellent	C,CP,WL,PTR,AAH,DO,T	Good	Moderate
3		Very High	Good	Good	Excellent	Good	Good	C,SC,CP,AAH	Good	High
4		Very High	Good	Mod-Good	Excellent	Excellent	Excellent	F,PTR	Good	High

Table 3: Primary and overall fish habitat value by reach and section, including limiting factors (see section 3.0 for key to codes)

There are no obstructions to fish movement in the mainstem. Log jams, particularly after flood years such as this spring, are often thought to be barriers to migrating spawners and even juveniles. This is usually untrue unless there is a marked increase in hydraulic head behind the jam (ie-water levels are much higher behind), as an indication of how impermeable it is. Basically, if water can freely get through, so can fish. To prove this theory, migrating Chinooks were able to negotiate all of the large log jams in the Mid-Bulkley in mid to low-flow conditions (field observations of spawner carcasses).

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 4. More detailed discussion will follow in Reach and Section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	A, H, R	Low	No	Low
	B	A, H, R, P	Moderate	Yes	Moderate
2		A, H, R, F, P	Moderate	No	Low
3		A, H, R, F, P	Moderate	No	Low
4		A, R, F, P	Low	No	Low

Table 4: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section.

The valley bottom of the Bulkley River is the most focused area for land-use in the watershed. With the exception of mining, all forms of land-use found elsewhere in the watershed are found here.

Buck Creek Sub-Basin

The Buck Creek sub-basin is located to the south of the Bulkley River mainstem and refers to the third-order basin area which is drained by Buck Creek and all of its tributaries (see Appendix 3, mapsheet 1). The mouth of Buck Creek is located at UTM 9.652100.6029200, and this defines the POI. The total watershed area is 56 333.4 hectares.

Table 5 below describes areas of mainstem Buck Creek and its tributaries which were assessed. The results for each of these tributaries will be described separately below.

Waterbody	Length Assessed	# of Reaches	UTM of Endpoint (Zone 9)	
Buck Creek	53.4	11	6003200	678560
Klo Creek	6.2	2	6011200	667300
Dungate Creek	12.5	4	6020075	663620

Table 5: Tributary information for the Buck Creek sub-basin

Buck Creek Mainstem

The Buck Creek mainstem was photographed and assessed from its confluence with the Bulkley River to the outlet of Goosly Lake, and from the inlet of Goosly lake south to UTM 9.6003200.678560. It was segregated into 11 reaches over 53.4 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. **Appendix 1, form 1, form #2** shows the distribution of known, suspected or historically present species by life stage and reach number. **Appendix 1, form 2, form #2** shows the results of habitat condition data by reach and section. **Appendix 1, form 3, form #3** shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Buck Creek is thought to be one of the most significant "nursery" streams for salmonids in the watershed. It is utilized by Chinook, coho , and pink salmon, rainbow and steelhead trout, Dolly Varden and bull trout, and numerous coarse fish species (FISS, 1995, FHIIP, 1991, Perlotto, pers. comm., J. Lough, pers. comm., Tredger, 1984, Bustard, 1989). Point sampling has shown relatively high densities of steelhead/rainbow fry, and resident rainbow trout have historically inhabited the upper mainstem and Klo Creek in its headwaters (Bustard, 1989, MELP, 1974). Known and suspected distribution of fish species and critical habitats are as follows:

- Pink Salmon: Near mouth (FHIIP, 1991). Reach 1 and 2 (suspected).
- Coho Salmon: To the falls in Reach 8 (suspected), possibly only to the cascade in Reach 3 (FHIIP, 1991) in some years due to water levels. Observed rearing in Reach 6, historically may have been present to Goosly Lake and in Upper Buck Creek (MELP, 1986).
- Chinook Salmon: To the falls in Reach 8 (suspected), possibly only to cascade in Reach 3 (FHIIP, 1991) in some years due to water levels. Observed spawning in Reach 6 (MELP, 1986) and Reach 1-3 (FHIIP, 1991). Fry densities indicate that the Dungate confluence is a critical rearing habitat (in the context of this watershed) (Tredger, 1982). High densities rearing behind beaver dams in reach 5/6 (MIC Notes, 1997).
- Steelhead: To the falls in Reach 8 (suspected), and to at least 10 km from mouth (cascade-reach 3) (FHIIP, 1991). Good steelhead fry, parr rearing, and spawning habitat up to 16 km from mouth (MELP, 1980). Observed spawning at Reach 6 (MELP, 1980). Buck Creek was stated as being the most significant tributary in Upper Bulkley for rearing area/habitat quality for steelhead (Tredger, 1982)
- Rainbow: No data for distributions below Goosly Lake. Suspected to use mainstem in selected sections of Reach 9 and 10 for rearing and spawning (similar channel morphology, gradient to areas above Goosly Lake, no major obstructions).

- Dolly Varden/Bull Trout: Known to be present at mouth of Dungate Creek (Tredger, 1982). Observed holding in Reach 1 (Perlotto, pers. comm.). Suspected rearing in Reaches 3 and 8 (higher gradient canyon areas). No definite bull trout/Dolly Varden/hybrid identifications using standard method of Haas (1997).

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 6 below).

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	Very High	Poor-Mod	Poor-Mod	Moderate	Poor	Moderate	CP,C,AH,VR,I	Good	Moderate
	B	Very High	Poor	Poor	Poor	Poor	Poor	SC,C,WL,VR,AH,T,I,CP	Moderate	Low
	C	Very High	Poor-Mod	Moderate	Poor-Mod	Poor	Moderate	WL,C,PTR,VR,AH,I	Good	Moderate
2	A	Very High	Moderate	Moderate	Moderate	Moderate	Good	CP,AH,I, WL, SC, VR	Good	Moderate
	B	Very High	Moderate	Moderate	Mod-Good	Good	Mod-Good	F,C,PTR,T,WL	Good	Moderate
	C	Very High	Moderate	Moderate	Moderate	Moderate	Good	F,C,PTR,T,AAH	Good	Moderate
3	A	High	Good	Mod-Good	Good	Poor	Good	LS,SC,AH,I	Moderate	Moderate
	B	Low-Moderate	Moderate	Poor	Poor	Poor	Moderate	LS,SC,AH,WL,VR,I	Moderate	Low-Moderate
	C	High	Moderate	Poor-Mod	Moderate	Poor	Moderate	SC,PTR,VR,AH	Moderate	Moderate
4	A	Very High	Moderate	Moderate	Good	Mod-Good	Good	F,C,T,WL	Good	Moderate-High
	B	Very High	Good	Moderate	Mod-Good	Moderate	Good	F,C,AH,T	Good	Moderate-High
	C	Very High	Moderate	Good	Moderate	Moderate	Moderate	F,AH,DO,VR	Good	Moderate
5	A	Very High	Moderate	Poor-Mod	Good	Good	Moderate	F,WL,T,A	Moderate	Moderate
	B	Very High	Poor	Mod-Good	Moderate	Moderate	Mod-Good	SC,C,AH,WL	Good	Moderate
	C	Very High	Moderate	Mod-Good	Mod-Good	Mod-Good	Mod-Good	F,C,PTR,WL,AAH,I	Good	Moderate-High
6	A	Very High	Moderate	Moderate	Moderate	Poor	Moderate	CP, SC, C,AH	Moderate	Moderate
	B	Very High	Good	Mod-Good	Mod-Good	Mod-Good	Good	SC,C,T,DO,AAH,A	Moderate	Moderate-High
	C	Very High	Moderate	Poor	Moderate	Poor	Good	F,DO,C,T,AAH,A	Moderate	Moderate
7		Very High	Moderate	Poor	Good	Moderate	Good	F,DO,C,T,A	Moderate	Moderate
8	A	High	Moderate	Good	Good	Good	Good	VR	Good	High
	B	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	PTR, AH	Moderate	Moderate
	C	Low	Low	Poor	Poor	Poor	Poor	VR,A	Poor	Low
9	A	Very High	Good	Good	Good	Good	Good	CP,AH,A	Moderate	High
	B	Very High	Good	Poor	Good	Moderate	Good	F,C,DO,T	Good	Moderate-High
10	A	Very High	Good	Good	Good	Mod-Good	Good	F,C,T	Good	High
	B	High	Poor	Poor	Excellent	Good	Good	PTR	Good	Moderate-High
11	A	High	Moderate	Poor	Moderate	Poor	Good	PTR,WQ,DO	Moderate	Moderate
	B	Very High	Good	Good	Excellent	Excellent	Excellent	F	Good	High-Very High

Table 6: Primary and overall fish habitat value by reach and section, including limiting factors (see section 3.0 for key to codes)

There are known obstructions to fish movement at mid-Reach 3 (cascade previously thought to be in Reach 2 according to FHIIP, 1991) which is not thought to be a barrier at higher flow conditions, and at the end of Reach 8 (originally thought to be in Reach 3 according to FHIIP, 1991) which is suspected impassable to all species. It is also thought to mark the boundary

between resident rainbow trout and anadromous steelhead. However, there may be some overlap in this distribution due to residents successfully migrating downstream.

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 7. More detailed discussion will follow in Reach and Section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	None	Low	No	Low
	B	H, R, RR	Low	No	Low
	C	H, R	Moderate	Yes	High
2	A	P, I	Moderate	Yes	High
	B	A, H, R	Low	No	Low
	C	A, F	Moderate	Yes	Moderate
3	A	None	High	No	Low
	B	None	High	No	Low
	C	None	High	No	Low
4	A	A, F	High	Yes	High
	B	A, R, P	Moderate	No	Low
	C	A, F, H	Moderate	Yes	Moderate
5	A	A, F, H	Moderate	Yes	Moderate
	B	A, F, H, R	Moderate	No	Low
	C	A, F, H, R	Moderate	Yes	Moderate
6	A	A, F, H, R, FI	Moderate	Yes	Moderate
	B	A, F, H, R, FI	Low	No	Low
	C	A, F, H, R, FI	Low	No	Low
7		A, F, R, FI	Low	No	Low
8	A	F, FI, R	High	No	Low
	B	F, FI, R	High	No	Low
	C	F, FI, R	High	No	Low
9	A	F	Low	No	Low
	B	F	Low	No	Low
10	A	F	Low	No	Low
	B	F	Low	No	Low
11	A	F, I, R	Low	No	Low
	B	F, R	Moderate	Yes	Moderate

Table 7: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section.

Buck Creek has experienced a considerable history of land-use for agriculture, urbanization, forestry and mining.

Klo Creek

Klo Creek was photographed and assessed from its mouth at Buck Creek to UTM 9.6011200.667300. It was segregated into 2 reaches over 6.2 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #15 shows the distribution of known,

suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 9 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 10 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Klo Creek is known to be inhabited by rainbow trout in its upper reaches, upstream of the Equity Mine Road Bridge, as well as in Buck Creek at the Buck/Klo confluence (MELP, 1974, Bustard, 1989). Due to their known presence in these areas and the gradient and morphology of Klo Creek in the study area, it is strongly suspected that it is used by rainbow trout for multiple life stages. It provides good rearing and holding habitats, as well as an abundance of good spawning gravels.

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 8 below).

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1		Very High	Moderate	Moderate	Good	Moderate	Good	F,C,WL,T	Good	Moderate-High
2	A	Very High	Moderate	Moderate	Good	Poor	Good	F,WL,T,AH	Good	Moderate
	B	Very High	Moderate	Moderate	Good	Poor	Good	SC,CP,WL,T,AH	Good	Moderate
	C	Very High	Moderate	Moderate	Good	Poor	Good	F,WL,T,AH	Good	Moderate

Table ___: Primary and overall fish habitat value by reach and section, including limiting factors (see section 3.0 for key to codes)

There are no known obstructions to fish movement in the study area, and no obstructions between the end of the study area and the area of known rainbow presence in the upper reaches (MELP, 1974).

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 9. More detailed discussion will follow in reach and section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1		F	Moderate	No	Low
2	A	F	High	Yes	High
	B	F	High	No	Moderate
	C	F	High	No	Moderate

Table 9: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by reach and section.

Klo Creek has experienced several types of land-use: forestry, mining, and road building.

Dungate Creek

Dungate Creek was photographed and assessed from its mouth at Buck Creek (UTM 9.6026350.654250) to the downstream end of the meadows on the uplands area. It was segregated into 4 reaches over 12.5 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #12 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 11 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 4 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Dungate Creek is known to be inhabited by chinook salmon (J/Sp suspected), coho (J suspected/Sp suspected due to use of the Buck mainstem to this point), steelhead (J/A suspected in Reach 1, Sp suspected), rainbow trout (J/A, Sp suspected), and Dolly Varden (J/A suspected, Sp suspected). It is assumed that, except where mentioned, this distribution extends to the second falls in reach 2B. It may extend only to the first falls in years with extreme low water. Late fall spawners are probably able to access it. This tributary could be especially important to steelhead, as the abundant canopy cover and topographic shading will preserve lower summer temperatures in the mainstem, and water levels are expected to be quite constant during baseflows due to the fairly intact riparian area and the large wetland area at the top of the creek. Tredger (1982) estimated a steelhead standing crop of 8550 fry and parr (to account for the strength of different runs). Chinook fry densities indicate that the Dungate confluence is a critical rearing habitat (in the context of this watershed) (Tredger, 1982).

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 10 below).

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	Very High	Poor-Mod	Moderate	Mod-Good	Mod-Good	Good	F,C,WL,A	Moderate	Moderate
	B	Very High	Moderate	Good	Good	Unknown	Good	F	Good	High
2	A	Very High	Good	Good	Good	Good	Excellent	F,AH,A	Moderate	High
	B	High	Good	Excellent	Excellent	Poor	Good	F, AH, A	Poor	Moderate-High

Table 10: Primary and overall fish habitat value by reach and section, including limiting factors (see section 3.0 for key to codes)

There are four permanent natural obstructions to fish movement in Reach 2. These are a set of (suspected) passable falls in Reach 2A, and a set of three

impassable falls in Reach 2B. Extensive beaver dams at the mouth may be a barrier to upstream migration during low flows in the summer.

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 11. More detailed discussion will follow in Reach and Section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	A, F, H, R	Low	No	Low
	B	A, F, H, R	High	Yes	High
2	A	A, F, R	High	Yes	High
	B	A, F, R	High	Yes	High

Table 11: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section.

Aitken Creek

Aitken Creek is a second-order basin located to the East and North of Houston. Its mouth is at UTM 9.6037200.660450 at the Bulkley River, Reach 2. It drains an area 11947.3 hectares in size and it has an intermediate bifurcation ratio. Aitken Creek is a lake-headed system comprised of Old Man Lake, Lars Lake, Swans Lake, and two unnamed lakes. It has a dammed outflow from the most northerly lake, and flows through a wetland complex before becoming a distinct channel. Typical of tributaries in this watershed, the alluvial fan has been cleared for range agriculture and is laterally very active, a steep canyon with falls follows with infrequent adjacent land-use, and headed by a low gradient meandering channel through mature mixed forest and a meadows area which has been logged extensively. Intermittent first-order tributaries deliver water and sediment to the larger channel from upslope areas during snowmelt and rain-event periods.

Aitken Creek was photographed and assessed from its confluence with the Bulkley to the outflow of the dam at the unnamed lake (UTM 9.6032060.666985). It was segregated into 3 reaches over 10.1 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #14 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 13 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 9 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Aitken Creek is known to be inhabited by rainbow trout in reaches 2 and 3 (DFO, 1997). Given the general distribution of target species using the Bulkley River, the water levels present in the creek at baseflows (stage at the time of aerial

photography), access to mid-Reach 2 and the gradient in Reaches 1 and 2, it is suspected that coho (J/Sp), steelhead (all) and cutthroat trout (all) are present in the lower reaches (FHIP, 1991). A double set of high, impassable falls (MELP, 1977) obstructs up and downstream migration of headwater and valley bottom fish populations.

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 12 below).

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1		Very High	Poor	Good	Moderate	Poor	Moderate	F,C,VR,WL,AH	Moderate	Moderate
2		Moderate-High	Good	Poor	Mod-Good	Poor-Mod	Poor	LS,SC,AH,A,I	Poor	Moderate
3	A	Very High	Good	Good	Moderate	Moderate	Good	F,C,T,DO,AAH	Moderate	Moderate-High
	B	Moderate-High	Poor	Poor	Moderate	Poor	Good	F,C,DO,AAH,A	Poor	Low-Moderate

Table 12: Primary and overall fish habitat value by reach and section, including limiting factors (see section 3.0 for key to codes)

The other possible obstruction to fish movement is the dam at the outflow of the first unnamed lake. Pictures taken of the dam indicate that there is a gabioned weir which is probably passable at good flows. This may change during summer. This outflow was historically dammed by beavers (MELP, 1977). Due to this fact, the rainbow population in this creek may not be adfluvial (juveniles and spawners in creek, adults in lake).

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 13.

Reach	Section	Upslope Land Use	Connectivity	Activity Observed	Upslope Impact Potential
1		A	Moderate	Yes	Moderate
2		A,F	High	Yes	Moderate
3	A	A,F	Low	No	Low
	B	A,F	Low	No	Low

Table 13: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section.

Barren Creek

The Barren Creek sub-basin is a second-order watershed which drains an area 2606 hectares in size. It has a high bifurcation ratio. The mouth of Barren Creek (the POI) is located at 9.6037600.660850 at its confluence with the Bulkley River, Reach 2. It is located north and east of Houston, BC on the north side of the Bulkley River. The real confluence of the creek is at an oxbow in the Bulkley

River floodplain, but the creek has filled this oxbow with alluvium, and the channel (now semi-confined) empties through a culvert under the railway and into the Bulkley.

Barren Creek was photographed and assessed from its confluence with the Bulkley River to the end of the most upstream land-use (an upslope cutblock). It was segregated into 3 reaches over 5.15 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #13 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 12 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 1 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.
Barren Creek is known to be inhabited by chinook salmon (J), coho salmon (J), and rainbow trout (J) to the outlet of the highway culvert. The following species and life-stages are suspected due to habitat preferences, channel type, gradient, and an absence of barriers to the end of Reach 2A, where there is a culvert obstruction at the North Road FSR: coho (Sp), steelhead (all to the end of reach 1, adults not in reach 2), rainbow (adults, spawners), and cutthroat (all). Fish habitat above the culvert is not limiting, and access is good for 2 km to the point of an impassable falls just above the Reach 2/3 break.

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 14 below).

Reach	Section	1° Habitat alue	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat alue
1		Very High	Poor	Poor	Moderate	Moderate	Moderate	F,C,WL,DO,AAH,A	Moderate	Moderate
2	A	Very High	Mod-Good	Good	Excellent	Unknown	Good	F,C,A	Poor	High
	B	Very High	Good	Good	Excellent	Unknown	Good	F,C,A	Poor	High

Table 14: Primary and overall fish habitat value by reach and section, including limiting factors (see section 3.0 for key to codes)

There are further obstructions to fish movement at the railway crossing culvert at the mouth. These two culverts are small-diameter concrete culverts which were obviously installed as a double unit to facilitate the passage of water, but not the passage of fish. One culvert is now completely blocked. This means that a culvert which already has poor roughness (and thus high water velocities) is now even more of a problem at high flows because it is passing the discharges of water which two culverts were originally designed to do. Therefore, this culvert is probably a barrier at high flows. The fine-textured alluvium dumped into the oxbow by the creek has also blocked fish passage to the high value overwintering and rearing habitat available there.

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 15.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1		N/A	N/A	N/A	Low
2	A	A, H, P, R	Moderate	Yes	Moderate
	B	A, P	Moderate	Yes	Moderate

Table 15: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section.

McQuarrie Creek

The McQuarrie Creek sub-basin is a third-order watershed which drains from the uplands north of the Bulkley River and East of Houston. It is a lake-headed system composed of McQuarrie Lake, Farewell Lake, and Hidden Lake, which is intermittently connected to the headwaters of the Deep Creek watershed through a series of wetlands. The watershed is 11 583 hectares in area. and has an intermediate bifurcation ratio. The mouth of McQuarrie Creek (the POI) is located at UTM 9.6043400.664400 at the Bulkley River, Reach 3.

McQuarrie Creek was photographed and assessed from its mouth to the crossing of the North Road FSR. It was segregated into 3 reaches over 12.65 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #6 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 6 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 8 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

McQuarrie Creek is known to be inhabited by chinook salmon, coho salmon, steelhead, and rainbow trout (FHIIP, 1991, FISS, 1995, MELP, 1982). Their distribution is as follows:

- Chinook: Known to be present in this creek (FISS, 1995). Distribution is thought to be from the mouth to the cascade in reach 2B due to good access, gradient, habitat quality, and usual distribution of this species in watersheds (mainstem and valley-bottom users).
- Coho: Juveniles and spawners known to be present in reaches 1 to 2B (FHIIP, 1991). Suspected to be present above the cascade barrier to the end of Reach 3 due to upstream habitat quality, gradient, lack of additional barriers in this section. The culvert at the North Road FSR (end of Reach 3) is thought to be a barrier to upstream migration (Tredger, 1982, field observations). Land-use and

habitat quality above the barrier appears to be ideal to the lakes (upstream canyon area may have a falls, but this could not be ascertained from small-scale stereo-pairs).

- Steelhead: Juveniles, adults and spawners known to inhabit this stream from the mouth to the end of Reach 3 at the FSR culvert barrier (Tredger, 1982, FHIIP, 1991).
- Rainbows: Known to be present in McQuarrie Lake. Suspected to be present in the entire mainstem due to habitat quality, gradient, no land-use and associated impacts upstream of the culvert barrier, and the likely good access downstream through this culvert.

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 16 below).

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	Very High	Poor	Mod-Good	Poor	Poor	Poor	PTR,C,VR,SC,WL,AH	Moderate	Low-Moderate
	B	Very High	Moderate	Mod-Good	Mod-Good	Poor	Moderate	PTR,WL,F,AH,VR	Good	Moderate
2	A	Very High	Good	Mod-Good	Good	Poor	Good	LS,F,AH,I	Good	Moderate-High
	B	Low-Moderate	Moderate	Poor	Moderate	Poor	Moderate	LS,SC,VR,AH,I	Moderate	Low-Moderate
	C	High	Good	Excellent	Good	Good	Good	F, AH	Good	High
3	A	Very High	Good	Good	Good	Moderate	Good	F,AH,WL	Moderate	High

Table 16: Primary and overall fish habitat value by reach and section, including limiting factors (see section 3.0 for key to codes)

As mentioned above, there are two obstructions to fish movement at a cascade in Reach 2B (suspected passable to most species at all but the lowest and highest flows), and the culvert at the North Road FSR . It is also expected that the channelized and homogenized section of Reach 1 poses a barrier at extreme flow conditions as well. The cascade in Reach 2 is suspected to be passable because it generally compares with the cascade in Reach 3 of Buck Creek, which is known to be passable at good flows to chinook and coho , and it is less severe.

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 17.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	N/A	N/A	N/A	Low
	B	A,H,F	Moderate	Yes	Moderate
2	A	A	High	Yes	High
	B	A	High	No	Moderate
	C	None	High	No	Low
3	A	R	High	Yes	High

Table 17: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section.

Most land-use in the McQuarrie Creek watershed is focused in Reaches 1 and 2. The alluvial fan is heavily used in particular, for residential purposes, range-use, hay cultivation, a powerline right-of-way, the highway crossing and the railway crossing. At this point, the creek has been channelized on both sides for flood control. In the upslope, there is a network of secondary roads and/or ATV tracks from which numerous mass movements appear to originate, and a cutblock.

Byman Creek

Byman Creek is a third-order watershed that drains the height of land east of Houston and north of the Bulkley River. The mouth (the POI) is located at UTM 9.604360.665600 at the Bulkley River, Reach 3. The watershed is 11 435.2 hectares in area and has a relatively high bifurcation ratio. It is wetland-headed.

Byman Creek was photographed and assessed from its mouth to the North Road FSR. It was segregated into three reaches over 12.3 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #7 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 10 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 7 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Byman Creek is known to be inhabited by the target species coho salmon (J/Sp suspected), chinook salmon (J/Sp suspected), steelhead (J/A), and rainbow trout (J/A) in Reach 1 to the highway (FISS, 1995, FHIIP, 1991, Tredger, 1982, SKR Consultants, 1997). Steelhead and rainbow are known to inhabit the lower reaches, which is more than likely to the cascade/falls in reach 2A. Tredger (1982) reports a standing steelhead crop (the lowest of those streams surveyed in this study in the Mid-Bulkley) of 1890 fry and parr. It is thought that water temperatures would be too warm for steelhead spawning, as they spawn in the early summer and their eggs incubate throughout the period of warmer temperatures. Water levels at summer flows would also be inhibitive. All species

are thought to have historically inhabited the lower reaches of this creek up to this barrier due to gradient, channel type, and a lack of natural barriers. It is unlikely that this creek supports a productive salmonid population above the highway crossing due to widespread habitat degradation by range-farming, land-clearing, and bank erosion.

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 18 below).

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	Very High	Poor	Moderate	Poor	Poor	Moderate	F,C,T,WL,AH,VR,A	Moderate	Low
	B	Very High	Poor	Poor-Mod	Poor-Mod	Poor	Poor-Mod	F,C,T,WL,AH,VR,A	Moderate	Low-Moderate
	C	Very High	Moderate	Mod-Good	Mod-Good	Poor	Moderate	F,WL,C,AH	Good	Moderate
2	A	Moderate	Good	Moderate	Excellent	Poor	Good	LS,F,SC,AH,I	Moderate	Moderate-High

Table 18: Primary and overall fish habitat value by reach and section, including limiting factors (see section 3.0 for key to codes)

There are 14 obstructions to fish movement in this creek. There are 11 waterfalls (plates 42, 43, 44, 53, 54 of the photo mosaic), one cascade and/or falls which may be passable at some flows (plate 28 of the photo mosaic- there are some difficulties with photo interpretation here as to passability), the highway culvert, which is suspected to be impassable at extremes in flow, and finally, the straight stretch of stream below the highway was found to be almost dry in the low flow period of field checks this year due to aggradation and sub-surface flows. Since this was not a hot, dry summer, it is almost certain that this is a barrier in most years during the August-September period. Th stream bed is known to have been dry frequently (FHIIP, 1991).

Due to obstructions, fish habitat will only be described up to Reach 2A.

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 19.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	R,A,H	Moderate	Yes	Moderate
	B	A,H	Moderate	No	Low
	C	A,R	High	Yes	High
2	A	A,R	High	No	Moderate

Table 19: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section.

Land-use in the Byman Creek watershed includes agriculture (hay and cattle farming), and forestry.

Johnny David Creek

The Johnny David Creek Sub-Basin is a second-order watershed which drains the height of land east of Houston and north of the Bulkley River. It is 4571 hectares in area and has a low bifurcation ratio. The mouth (the POI) is located at UTM 9.6043500.670300 at the Bulkley River, Reach 4.

Johnny David Creek was photographed and assessed from its mouth to the end of valley bottom land-use at 5.1 km upstream. It was segregated into 2 reaches over 5.1 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, and 4 show the positions of reach breaks and known obstructions. There was no solid fish presence data for this creek, so there was no mapping of the suspected fish distributions. Appendix 1, form 1, form #1 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 1 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 11 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Johnny David Creek is thought to be inhabited by similar species to Richfield Creek (MIC Notes, 1997). These would be chinook salmon (J/Sp), coho salmon (J/Sp), and steelhead (all). A rancher who lived adjacent to the creek, and has since the 1950's has noted steelhead adults (holding below the highway) and rainbow/steelhead juveniles, rainbow trout adults, cutthroat trout (J/A) and Dolly Varden (J/A). He has never witnessed any spawning fish in the creek. It is thought that water temperatures would be too warm for steelhead spawning, as they spawn in the early summer and their eggs incubate throughout the period of warmer temperatures.

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 20 below).

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1		Very High	Mod-Good	Moderate	Good	Poor	Moderate	DO,WL	Moderate	Moderate
2	A	Very High	Mod-Good	Poor	Moderate	Poor	Good	WQ, WL, DO	Moderate	Moderate
	B	Very High	Good	Good	Good	Moderate	Good	WQ, AH	Good	High

Table 20: Primary and overall fish habitat value by reach and section, including limiting factors (see section 3.0 for key to codes)

There are no natural obstructions to fish movement in the study area. The culvert at the highway crossing may be a barrier at extremes in flow.

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 21.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1		A	Low	No	Low
2	A	A	Moderate	Yes	Moderate
	B	A	Moderate	Yes	Moderate

Table 21: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section.

Richfield Creek Sub-Basin

The Richfield Creek Sub-Basin drains the Nechako Plateau west of Topley and north of the Bulkley River. It marks the north western boundary of the Mid-Bulkley watershed, and includes the highest point in the watershed, Tachek Mountain (1656m). The sub-basin area is 21634.8 hectares and the watershed has a low bifurcation ratio. The mouth of Richfield Creek (the POI) is located at UTM 9.6043000.672100.

Table 22 below shows the tributaries assessed in this sub-basin:

Waterbody	Length Assessed	# Reaches	UTM of Endpoint (Zone 9)	
Richfield Creek	6.4 km	4	6049590	674875
Robert Hatch Creek	4.8 km	1	6047800	669825

The results for each of these tributaries will be described separately below.

Richfield Creek

Richfield Creek was photographed and assessed from Its mouth at the Bulkley River , Reach 4 to the bridge at the Granisle Highway, 6.4 km upstream. This was the last known point of land-use. It was segregated into 4 reaches, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #4 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 4 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 5 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Richfield Creek is known to be inhabited by the target species coho salmon, chinook salmon, steelhead, rainbow trout, cutthroat trout and Dolly Varden (FISS, 1995, FHIIP, 1991, Tredger, 1982, and A. McCracken, pers. comm.).

This tributary is thought to be a critical habitat for coho , steelhead and chinook within the Mid-Bulkley, as indicated by past productivity, sampling densities of fry, and the stable flow rates and cooler temperatures provided by the large wetland at the mouth of Robert Hatch Creek (MIC Notes, 1997, Tredger, 1982).

Spawning, rearing, overwintering and holding habitat value was assessed for reaches 1 and 2A using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 23 below).

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	Very High	Moderate	Good	Mod-Good	Mod-Good	Moderate	C,VR,T,WQ	Good	Moderate-High
	B	Very High	Poor	Moderate	Moderate	Poor	Poor	PTR,C,SC,WL,AH,VR	Moderate	Low-Moderate
	C	Very High	Moderate	Mod-Good	Moderate	Poor	Good	F,C,DO,AH	Good	Moderate
2	A	High	Excellent	Good-Exct	Good-Exct	Good	Excellent	AH,A,WQ	Moderate	High

Table 23: Primary and overall fish habitat value by reach and section, including limiting factors (see section 3.0 for key to codes)

There are three obstructions to fish movement at waterfalls in Reach 2 and 3. The most downstream falls was confirmed in field checks to be a barrier to upstream migration for all species at all flows, contrary to information reported by FHIIP, 1991. This was a determined as a function of vertical sections, a lack of resting points, and height (18.2 metres).

The target species listed above are known to occur only in the lower reaches of Richfield Creek, with the exception of rainbow trout which are found above Findlay Falls (Tredger, 1982). The creek between the falls barriers may support a productive population of resident fish, based on habitat quality and assuming access to lakes on Holmes Creek, but this data has not been gathered. The lower reaches are assumed to be defined by the mouth to the first falls in Reach 2A, below which there are no barriers. Contrary to the work of Tredger, 1982, Findlay Falls, located at the Reach3/4 break is not the first impassable barrier.

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 24.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	N/A	N/A	N/A	Low
	B	A, H	Low	No	Low
	C	A	Moderate	Yes	Moderate
2	A	A	High	No	Moderate

Table 24: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section.

Land-use is limited mostly to the valley bottom of this creek.

Robert Hatch Creek

Robert Hatch Creek was photographed and assessed from its mouth at a large wetland area adjacent to Richfield Creek, to the end of its alluvial fan, which also marked the end of cleared land and range-use. It is composed of 1 reach which is 4.8 km long, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #5 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form #5 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form #6 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Robert Hatch Creek is not known to be inhabited by any fish. This is a high priority data gap to fill. However, the accessibility from Richfield Creek, the lack of permanent natural barriers in the area studied, and the gradient imply that this creek may have the same species present as Richfield Creek (MIC Notes, 1997). The value of habitat here suggests that it would be used mostly by juveniles, and the wetland at its mouth could provide significant rearing and overwintering values provided water quality was good. The species thought to inhabit this tributary are chinook (J), coho (J/Sp suspected), steelhead (J), and cutthroat trout (all historically) (A. McCracken, pers. comm.). It is thought that water temperatures would be too warm for steelhead spawning, as they spawn in the early summer and their eggs incubate throughout the period of warmer temperatures.

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 25 below).

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	Very High	Mod-Good	Moderate	Moderate	Poor	Good	F,WL,DO,WQ,A	Moderate	Moderate
	B	Very High	Good	Unknown	Good	Poor	Good	DO,WL,WQ	Good	Moderate-High

Table 25: Primary and overall fish habitat value by reach and section, including limiting factors (see section 3.0 for key to codes)

There are no permanent natural obstructions to fish movement in the area of this creek studied. The large fan at the mouth of the creek appears to be a seasonal barrier, but a field survey would be required to confirm this. There could be a barrier upstream of the study area in the long canyon connecting the Nechako Plateau to the valley bottom.

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 26.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	A	Low	No	Low
	B	A	Low	No	Low

Table 26: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section.

The only land-use on Robert Hatch Creek in the study area is cattle grazing with associated land-clearing and ATV/cattle stream crossings.

Emerson Creek

Emerson Creek is a moderately steep, incised, cold stream with low TDS draining the east slope of the Telkwa mountain range into the Bulkley River north of the Morice River confluence. It was photographed and assessed from its mouth at UTM 9.6035783.641953 to the upstream end of the most upstream cutblock (openings #6 and 24). It was segregated into 3 reaches over 13.1 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #8 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 7 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 12 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Emerson Creek is not known to be inhabited by any fish species. This is a significant data gap. It has been assessed as having a high potential for steelhead, Dolly Varden, and bull trout due to its colder year-round temperatures and generally higher gradient (MIC Notes, 1997). Mid-Bulkley Fish Fence staff who

have walked the lower reach of this creek report that it was being used by pink spawners, although no spawning was taking place (P. Perlotto, pers. comm.). Given the gradient and habitat quality, and assuming use by species which are known to prefer lower water temperatures for spawning, it is suspected that the following species use the creek up to the cascade/falls in reach 2: pink salmon (holding and possibly spawning), steelhead (all), rainbow (all), Dolly Varden (all), and bull trout (all).

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 27 below).

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	Very High	mod-good	good	mod-good	mod-good	mod-good	T, F, I, VR	good	moderate to high
	B	Very High	good	good	good	mod-good	good	T, F, I	good	high

Table 27: Primary and overall fish habitat value by reach and section, including limiting factors (see section 3.0 for key to codes)

There is a cascade/falls obstruction at the beginning of reach 2 which is documented as being impassable to fish (MELP, 1977). Fish habitat will only be described to the end of reach 1 for this reason.

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 28. More detailed discussion will follow in Reach and Section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	R	Moderate	Yes	Moderate
	B	None	Moderate	No	Low
2		F	High	Yes	High
3		F,R	Moderate	No	Low

Table 28: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section.

Emerson Creek sustains a moderate level of forestry and road building.

Dockrill Creek

Dockrill Creek is a moderately steep, incised, third-order glacier fed creek which drains the Telkwa mountain range to its confluence at the Bulkley River north of the Morice River confluence. Dockrill Creek was photographed and assessed from its mouth at UTM 9.6036776.640775 to the upstream end of cutblocks 6 and 24. The latter was the most upstream land-use on the creek. It was segregated

into 2 reaches over 9.6 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #9 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 8 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 13 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Dockrill Creek is not known to be inhabited by any fish species, but has been noted as having a high potential for Dolly Varden, bull trout, and steelhead (MIC Notes, 1997). Mid-Bulkley Fish Fence staff who have walked the lower reach of this creek report that it was being used by pink spawners, although no spawning was taking place (P. Perlotto, pers. comm.). Given the gradient and habitat quality, and assuming use by species which are known to prefer lower water temperatures for spawning, it is suspected that the following species use the creek up to the cascade/falls in reach 2: pink salmon (holding and possibly spawning), steelhead (all), rainbow (all), Dolly Varden (all), and bull trout (all).

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 29 below).

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	High	Poor	Good	Moderate	Poor	Moderate	VR, SC, T, I	Good	Moderate
	B	Very High	Good	Good	Good	Mod-Good	Good	F, T, I	Good	High
2	A	High	Good	Good	Mod-Good	Poor	Good	T, I	Good	Moderate to High
	B	Moderate	Good	Poor	Moderate	Poor	Moderate	T, I	Good	Moderate
	C	High	Good	Good	Mod-Good	Poor	Good	T, I	Good	Moderate to High

Table 29: Primary and overall fish habitat value by reach and section, including limiting factors (see section 3.0 for key to codes)

There are no obstructions to fish movement in the study area.

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 30.

Reach	Section	Upslope Land Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	R, RR	Low	No	Low
	B	F	Moderate	Yes	Moderate
2	A	F, R	High	No	Moderate
	B	F	High	No	Moderate
	C	F	High	No	Moderate

Table 30: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section.

The Dockrill Creek basin is used primarily for forestry. The railway and the Telkwa FSR both cross it in Reach 1, and it appears from small-scale air photos that the creek was diverted to mitigate flood danger to the railway. There was originally a long meander at the bottom of the creek, but this has been cut off, and the creek now runs straight down to the Bulkley from a corner just beyond the FSR crossing.

Recommendations

Sub-basins in the Mid-Bulkley Watershed were prioritized for Level 1 field assessments based on the following criteria:

- Relative use by target fish species
- % of reaches and sections which are high and moderate priority (see section 4-Results)
- The nature of impacts (riparian, in-stream, upslope (mass movements), hydrology (peak flows)) and land ownership status.

The latter is to filter out those sub-basins where there are only restoration opportunities on private land, or where the responsibility for assessment and restoration rests solely in the jurisdiction of the Ministry of Forests' watershed restoration program.

Sub-Basin priority is as follows:

1. Buck Creek
2. Bulkley River
3. McQuarrie Creek
4. Richfield Creek
5. Aitken Creek
6. Byman Creek
7. Barren Creek
8. Emerson
9. Dockrill

Johnny David Creek was filtered out due to riparian and upslope impacts on private land.

Tributary priority within Buck Creek Sub-Basin is as follows:

1. Buck Creek
2. Dungate Creek
3. Upper Buck Creek
4. Klo Creek

Robert Hatch Creek was filtered out of the Richfield Sub-Basin priority list due to riparian impacts on private land. This leaves Richfield Creek as the only priority tributary in that sub-basin.

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1.0 Introduction

In the spring of 1997, the Nadina Community Futures Development Corporation (NCFDC) was designated as a proponent for FRBC funding in a Watershed Restoration Program (WRP) project in the Mid-Bulkley Watershed. The NCFDC is a non-profit community economic development corporation based in Houston, British Columbia. The implementing partner in this endeavor was the Ministry of Environment, Lands, and Parks, Skeena Region BC Environment office (MELP).

WRP is a provincial initiative under Forest Renewal BC to restore the productive capacity of forest, fisheries and aquatic resources that have been adversely impacted by past forest harvest practices, and thus to aid in providing long-term employment opportunities in resource-dependent communities (Johnston and Moore, 1995).

The Fish Habitat Assessment Procedure (FHAP) is a means of assessing watersheds with a history of anthropogenic activity for impacts to fish and fish habitats using a set of integrated physical and biological indicators. The assessment procedure extends from stream and river channels, to the riparian area, to upslope areas in which there is some level of connectivity to the channel. There are two levels of assessment in the FHAP. The first, known as the Overview Assessment, is a reconnaissance-level study compiling background data and using predominately remote-sensing techniques to prioritize sub-basins and waterbodies within those sub-basins for the second level of FHAP. This is known as the Detailed (or Level 1) Assessment, which involves more detailed field surveys of the channel and riparian areas, the end result of which is the formation of restoration prescriptions to restore or rehabilitate fish habitat, or mitigate impacts on that habitat. There are four general steps in both FHAP's:

1. Identification of fish species at risk in the watershed,
2. A quantitative description of fish habitat conditions,
3. Evaluation of fish habitat conditions,
4. Identification of opportunities for effective fish habitat rehabilitation.

The British Columbia Conservation Foundation (BCCF) was contracted by NCFDC to carry out a WRP Overview Fish and Fish Habitat Assessment in the summer of 1997 in the following sub-basins of the Mid-Bulkley Watershed (see figure 2):

- Bulkley River
- Buck Creek
- Richfield Creek
- Johnny David Creek
- McQuarrie Creek
- Byman Creek
- Aitken Creek
- Barren Creek
- Emerson Creek
- Dockrill Creek

The objectives of the Overview FHAP are:

- to determine what fish species (and life stages) are at risk to the impacts of poor land-use practices in the watershed,
- to identify areas of concern that need to be examined in quantitative field surveys of fish habitat,
- to identify preliminary restoration strategies (no action, restoration, rehabilitation, mitigation),
- where appropriate, to identify preliminary restoration opportunities (objectives, scope and priorities).

1.1 Watershed Characterization

The Mid-Bulkley watershed, as defined by the watershed boundaries of the sub-basins listed above, is a 167 300 hectare drainage basin situated on the Nechako Plateau physiographic region. Two sub-basins drain the Telkwa Mountains of the Bulkley Range physiographic region which borders the Nechako Plateau to the

Northwest. Elevations range from 570 m (1900ft.) at the mouth of the Upper Bulkley to 1640 m (5400 ft.) at Tachek Mountain. The majority of land is within 800 and 1500m in elevation (LaRose and Rencoret, 1996). Watershed characteristics, and the fish and fish habitat therein, are defined by a complex and dynamic interaction of climate, hydrology, surficial and bedrock geology, vegetation, and land-use. Each of these will be broadly described below.

1.1.1 Climate

Climate will be defined here as temperature and precipitation, and the general temporal trends in these variables. Based on temperature records at nearby stations, it experiences temperature extremes between 37 and –46.7 degrees Celcius (Telkwa and Decker Lake stations respectively) (Atmospheric Environment Service, 1980). Coldest temperatures generally occur in late December/early January, and warmest temperatures generally occur in mid to late July. Extreme precipitation events occur during the winter as mixed rain/snow when temperatures hover around 0 degrees Celcius. The extreme precipitation at the Houston climate station for both rain and snow occur in January, 1962 on two consecutive days (42.4 mm rain and 21.3 mm snow) (Atmospheric Environment Service, 1985). Two periods of rainfall generally occur in the watershed in April-May and October-November (Perlotto, personal comm.).

1.1.2 Hydrology

There are two gauging stations in the Mid-Bulkley watershed from which annual trends can be constructed. These are just East of Houston (station WSC08EE003), and at the lower end of Buck Creek (station WSC08EE013). The mean monthly discharges from these stations (see figures 3, 3a) show that the peak flows in the watershed generally occur during the month of May (average peak of 74 m^3/s in the Bulkley) due to precipitation patterns and snowmelt, and the low (or base) flows in the watershed generally occur in September (average peak of 2 m^3/s in the Bulkley) due to precipitation patterns and evaporation from elevated summer temperatures.

The Bulkley River is the only fourth-order basin in the watershed, with mean annual discharges between 73.81 and 2 m^3/s. Buck Creek is a third-order basin. This is a stream order representative of the majority of sub-basins in the watershed. Buck Creek has mean annual discharges of 21.8 and 0.86 m^3/s. We also have low flow data for the period August 30-September 3 for the mouths (or points of interest) of McQuarrie Creek (0.075 m^3/s), Byman Creek (0.034 m^3/s), and Richfield Creek (0.2 m^3/s), which indicates that low flows can vary by at least an order of magnitude within this stream order class.

Figure 3: 39-year Mean Monthly Discharge for the Bulkley River near Houston (WSC 08EE003) for the months of April-October

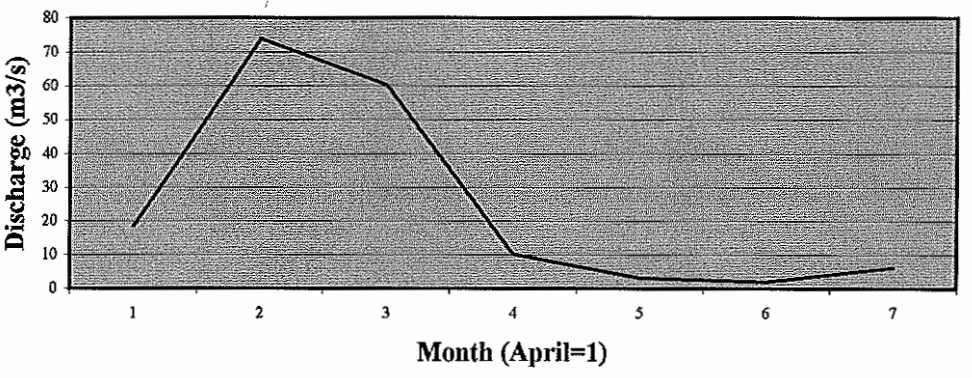
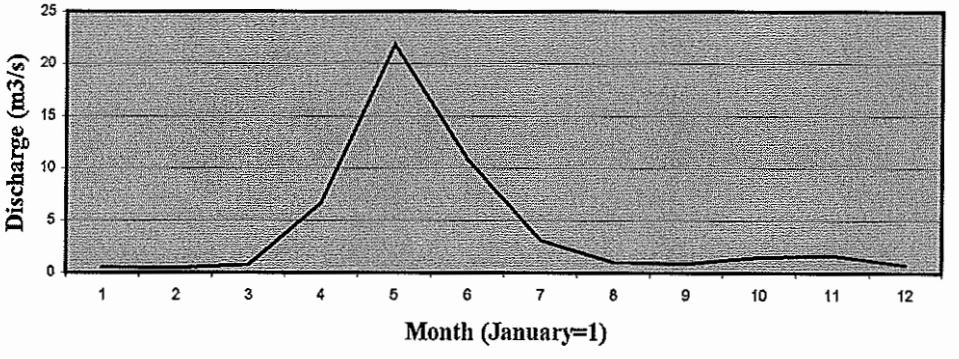


Figure 3A: 13-Year Mean Monthly Discharges for Buck Creek (Station WSC 08EE013)



Peak flows occur in parallel with the melting of mid to high elevation snowpacks and are exaggerated by rain-on-snow events and high temperatures. This is known

as synchronicity of snowmelt. It refers to the rate at which higher elevation snowpacks melt when waterbodies are already near or at bankfull discharge due to lower elevation melting. The high elevation snowpack in this watershed is coincident with the change in forest ecotypes at approximately 1000m (see section 1.1.4) (Wilford, 1984). A desynchronized snowmelt occurs when these snowpacks, for whatever reason, melt prior to or after the peak streamflow. Snowpack data from a high-elevation snow course at Equity Mine shows that these snowpacks have usually begun to melt by May 1st, with the rate of melt increasing through May 15th, and the snowpack is usually gone by June 1st (Wilford, 1984). Extreme peak flows on record which have occurred due to a well-synchronized snowmelt have been as high as 127 m^3/s in the Bulkley River, and 75.3 m^3/s in Buck Creek (Water Survey of Canada, 1997). Floods in the watershed which have not been gauged have been noted in May, 1924, June, 1962, and May, 1967 (Houston Centennial '71 Committee (HCC), 1971). The flood of 1962 was estimated to be the largest known flood at the time, and was also a rain-on-snow event. Extreme low flows on record are 0.37 m^3/s in the Bulkley River, and 0.066 m^3/s in Buck Creek (Water Survey of Canada, 1997). Other streams (Richfield, Byman) are on record as being completely dry in some years (FHIIP, 1991)

Hydrometric records in the watershed do not provide continuous data to analyze flood flows and basin responses. It has been noted that the Bulkley River at Houston generally responds to inputs of precipitation approximately two days after the precipitation begins (Perlotto, pers.comm, N.C.F.D.C., 1996). However, the bifurcation ratio of a basin indicates the relative rate at which runoff occurs without factoring in storage variables (see figure 4).

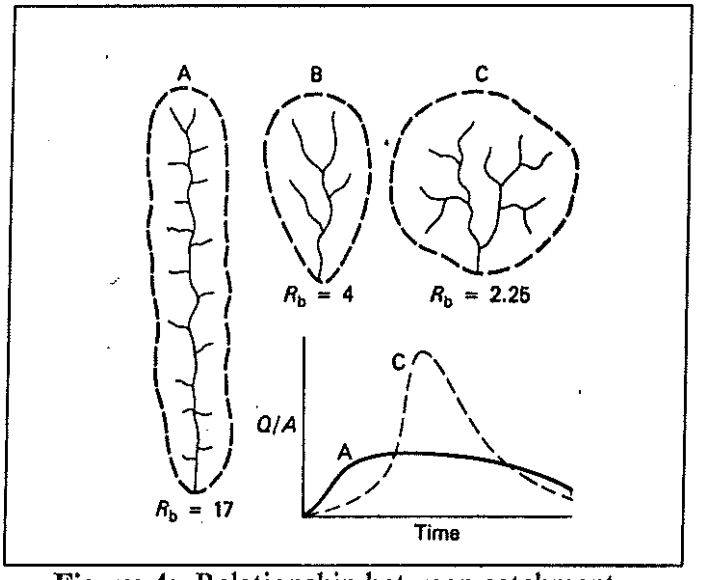


Figure 4: Relationship between catchment size, bifurcation ration (R_b) and the shape of the flood hydrograph (Q=discharge, A=area).

Basin response, peak flows, and low flows are all buffered by the effects of lakes, wetlands, and floodplains. These areas store water and the output to the channel is dampened by an increased surface area for evaporation and infiltration to the water table, greater soil moisture storage, and transpiration by vegetation. All of the sub-basins in the watershed are either lake or wetland headed, with the exception of Emerson Creek. Some (Richfield/Robert Hatch, McQuarrie, Barren) have an uncommon element of water regulation in their valley bottoms as well (wetlands, springs, oxbows). All of these areas provide similar buffering to sediment inputs.

1.1.3 Geology and Soils

Bedrock geology in the Mid-Bulkley is comprised of volcanics of the Tertiary to Jurassic age (AGRA, 1996). Surficial geology will vary throughout the sub-basins, as a function of erosion and deposition during and following glaciation. The watershed was completely glaciated during the most recent Fraser glaciation. This gave rise to the many rounded hilltops and the veneer of basal and meltout tills and glacio-fluvial sediments which are forming and will continue to form the dominant

soil associations. One can expect to find fine to coarse-textured alluvium in the valley bottom floodplains, with moderately fine glacial tills and medium to coarse colluvial soils on the valley sides (AGRA, 1997, Wilford, 1984). Almost every sub-basin has sections of canyon with numerous bedrock outcrops. Organic soils are extensive on the upper plateau areas and sporadically throughout the rest of the sub-basins There are also infrequent glacial depositional features such as eskers and kames.

1.1.4 Vegetation

The Mid-Bulkley watershed is in a transitional area between the coastal and interior plateau regions, and its biogeoclimatic zones are, according to Ministry of Forests classification, the Sub-Boreal Spruce (SBS), Englemann Spruce-Sub-Alpine Fir (ESSF) zones. The SBS is split into two sub-zones: dry cool (bk) and moist cold (mc), based on slope aspect and topographic shading. Valley bottom "climax" forests are SBS combined with young to mature cottonwood and alder/willow stands which are diverse and well-stratified. The increase in forest diversity occurs here due to the frequency of disturbance, and productive soils with high wetness and fine texture. Conifers succeed as areas become more stable, and are disturbed by the lateral activity of the river in flood. Remnants of true valley bottom forest can be seen in Reach 4 of the Bulkley River, and this would provide a good template for riparian restoration in the watershed.

1.1.5 Land-Use

1.1.5.1 First Nations Land-Use

The Mid-Bulkley Watershed falls within the House Territory of the Wet'suwet'en nation. Unfortunately little has been documented on their land-use in this particular watershed. However, it is commonly known that the Wet'suwet'en have a long history tied to anadromous salmon populations. Fishing was generally carried out at large gathering places where there were bottlenecks to

migrating spawners. Although Moricetown is the most well-known of these areas, Topley falls below Bulkley Lake, the Babine River at Babine Lake, and areas in the Maxan watershed were also traditional fishing grounds (S. Schug, pers. Comm., HCC, 1971). Fishing was carried out using spears and/or fish fences, until the first fish warden arrived in the region in 1911, and forced first nations peoples to abandon the use of fish fences and instead use nets (HCC, 1971). This was unfairly accomplished by the jailing of any who opposed the order. Wet'suwet'en would have likely used this watershed for fishing and hunting while en route to these fishing grounds (Schug, pers. comm.). Some time later (early 1900's) there was a known First Nations encampment that existed with some permanence at the confluence of Buck Creek and the Bulkley River, apparently at the site of the present shopping mall (HCC, 1971). Activity here might have included fishing, and possibly indicates the historical significance of Buck Creek as a productive salmon stream.

(Note- information in the following four sections is mostly drawn from HCC, 1971. Assume this reference unless otherwise noted)

1.1.5.2 Agriculture

Settlement and agriculture, with associated land-clearing did not begin until 1904, with the arrival of the first homesteader, Harry Davis. In the early 1900's, ranching, haying, sheep and cattle farming were all noted in the vicinity of Houston (then Pleasant Valley) and at Buck Flats. In 1903, a large cattle ranch was started at North Bulkley, and in 1908 another at Glenview farm for sheep and cattle. The prevalent attitude at the time was to burn the land for the purposes of farming, and thus attract more settlers to "idle land". Thus, the land was only valued for its agricultural capability and nothing else. In 1910, there is record of hay farming in natural clearings along the Bulkley River floodplain. This indicates that either the clearings had been burned much earlier, or that natural grassland openings existed throughout the floodplain. Most of the farming at the time was known as "stump farming", meaning land was cleared and stumps left, between which the farmer planted and harvested their crops and worked the

fields. Prior to 1920, grasses, oats and small plots of vegetables were grown, combined with small herds of cattle. In the 1920's, cattle farming began more intensively, and Timothy seed harvesting was prevalent. The farming of Timothy continued for only a few years due to the invasion of the fields by Oxeyedaisy, a species with no economic value. At this time, many Timothy farmers switched to livestock ranching. In 1938, an influx of farmers from the Netherlands boosted the agricultural community, and many failing or abandoned farms were bought up and rejuvenated. World War II began, and species which were only available in occupied countries, such as Spinach and Turnip, were grown in the Houston area until the end of the war.

In the late 1940's, haying and beef cattle were the prime agricultural pursuits in the watershed, with more land clearing in the valley bottom and adjacent uplands for summer grazing, and more clearing of the floodplain for hay lands. This is still the predominate agricultural practice today. In 1945 (or 1948, there are conflicting dates here), the BC government provided bulldozers to those interested in clearing land at a per-cost rate (no profit margin). This greatly increased the rate and extent of land clearing in the watershed, and paved the way for more mechanized farming. To put a perspective on the extent of cattle ranching and hay farming, and thus show the temporal trends in possible impacts to the watershed, it was noted that between 1947 and 1967, that the number of cattle in the Houston area increased from 60 head of cattle to 1500.
Cattle ranching is even more an economy of scale today. With the low value that is now assigned to cattle products, ranchers are forced to keep many more cattle and to have a greater area of productive hay land than in the past (cattle rancher Norbert Klaasen, pers. comm.). It is important to note that all of this activity has been focused in the valley bottom of the Bulkley River, on alluvial fans of most tributaries (excluding Emerson and Dockrill), and on the Buck Flats. These areas have endured almost a century of land clearing and land-use for agriculture.

1.1.5.3 Mining

The first mineral exploration and placer operations were carried out on a small scale by Chinese prospectors in the early part of the 1800's. A prominent landmark in the region, China Nose, is so named for this reason. They left little trace of their passage except bits of rusty equipment scattered throughout the bush. The next phase of mineral exploration began in 1914 at claims on Bob Creek, a small tributary of Buck Creek. This was a placer mining operation for lode minerals (silver, lead, copper, gold, zinc). Coal and iron also attracted a great deal of exploration in the watershed, but none of these options were ever developed. In the late 1960's, large tonnage, low grade ore bodies arose as a possible exploitable resource. Exploration and work on some showings occurred on Klo Creek, and near Goosly Lake. No significant resource extraction occurred until the opening of Equity Silver in the late 1970's in the headwaters of Buck Creek. The waste rock ponds of this mine, which is now closed, are drained by Bessemer Creek which flows into Upper Buck Creek. This creek was the pathway for a huge acid mine drainage spill (H_2SO_4 and associated high levels of metals) of 108 metric tons in November, 1981 (FHIIP, 1991).

Gravel quarries are located above Buck Creek on both sides in Reach 2, in the headwaters of Klo Creek, adjacent to Barren Creek at the North Road FSR crossing, and near the mouth of Byman Creek. These are of unknown age. BV Concrete was located at the mouth of Dungate Creek in the late 1970's/early 1980's. It was located and operated wholly on the alluvial fan and adjacent upslope area. There was a road crossing or bridge at the creek. This area is now private range land.

1.1.5.4 Forestry

Logging has been going on since 1914 in the Mid-Bulkley watershed. It was at this time that the first stand of timber was cut near the present site of the Houston cemetery for railway ties. In the 1920's and 30's the Bulkley, Dungate, Buck , and Buck Flats valley bottoms were harvested and possibly the alluvial fans of other tributaries entering the Upper Bulkley floodplain, for railway ties by farmers. It is important to note that this was probably selective horse-logging of lodgepole pine, because at the time it was the only merchantable species that could compete with coastal cedar and fir on the lumber market. This fact, combined with population in the watershed and a lack of mechanized equipment, kept logging to a minimum. However, in 1940 the first profitable portable sawmill operation was started by the Buck River Lumber Co., and soon six planers and the first gang mill were running. By 1949, the district had a total annual cut of 18 447 436 board feet, processed by 42 sawmills and 6 planer mills. This was still mostly for the harvesting of lodgepole pine, and thus selective harvesting was likely the method of extraction. These sawmills also only cut in nearby areas, and there were no road networks purely for forestry established. The peak period for portable sawmills was in 1958, when there were 67 in operation. At approximately the same time, the first logging road was run up the Buck watershed to the Goosly Lake area by the Buck River Lumber Co.. It was not until 1964, that production of wood from the district matched the new Annual Allowable Cut. 90% of this wood came from the Buck Creek watershed. Spruce and fir were increasingly harvested for pulp and lumber.

It was beginning in 1963 that industrial forestry truly came to the Houston area. A group of local businessmen lobbied the government to create Pulp Harvest Area #4, a large forest tenure created with the express purpose of creating a huge pulp and lumber mill in Houston. This was followed by a buy-out of the remaining mills in existence at the time, and Bulkley Valley Forest Industries Ltd. (previously BV Pulp and Timber Ltd.) emerged as the sole extractor of timber resources in the area. Many new Forest Service Roads (FSR's) in the Mid-

Bulkley were built in the mid to late 1960's, focused to the North of the Bulkley River and to the South and East of Goosly Lake in the Buck Creek watershed. (Information on lengths of FSR, secondary and tertiary roads in the watershed can be found in LaRose and Rencoret (1996)). A large timber products complex was built and operating by 1970. This is the site of the present Northwood mill. A pulp mill was successfully opposed by residents of the Bulkley Valley in the early 1970's. Mechanized forestry began in earnest at this point and continues today. The method of logging has changed from selective to clearcutting, and more recently and infrequently, to other treatments such as patch or strip cutting. Silviculture began in 1968, with the first regeneration plots near Goosly Lake. Silvicultural practices for the purpose of regeneration have varied widely over the past three decades, beginning first with broadcast burning and piling slash in various manners (piles, windrows), to mechanical scarification, beetle control via harvesting and pesticide use, as well as pesticide use on various "weed" species to name a few. All of these practices may have had an influence on water, water quality, terrain stability, and sediment fluxes in the watershed.

Table 1 shows the known Equivalent Clearcut Areas of most of the sub-basins, and whether future harvesting will be low, moderate or high.

Sub-Basin	Tributaries	ECA (%)	Future Harvesting
Buck	Klo	38	high
	Dungate	16	
	Upper	31	
	Buck	22	
Aitken		30	low
Barren		15	low
Byman	Byman	25	low
	Perow	14	
McQuarrie		14	low
Johnny David		14	moderate
Richfield/Rob't Hatch		14	low

Bulkley	McKilligan	30	low
	Summit/	30	low
	Raspberry		
Emerson		21.5	low
Dockrill		21	low

(Source: Morice Forest District IWAP Round Table Committee Meeting Notes (MIC), 1997)

Table1: Equivalent Clearcut Areas (ECA) and extent of future harvesting for sub-basins and tributaries in the Mid-Bulkley Watershed.

The present licensees in the watershed include:

- Houston Forest Products
- Northwood Pulp and Timber
- Small Business Forest Enterprises Program (SBFEP) operators
- Woodlot owners

Each of these licensees is obliged to create a five-year forest development plan (FDP) which includes information on past and future harvesting locations, roads , forest status relative to timber harvesting interests, other Crown Land licenses (range, trapping, guiding, etc.) and the location of private lots.

1.1.5.5 Urban and residential land-use

Land used for residential and urban purposes is focused in two areas in the Mid-Bulkley. These are Houston, on the Buck Creek and Bulkley River floodplains and adjacent uplands, Topley, which is located on the border of the watershed but extends into the floodplain of Richfield Creek. Associated land-uses include roads and parking lots, water withdrawal and waste disposal, and power and communication corridors.

Given maps, pictures and descriptions of Houston prior to its incorporation as a village in 1957, there was little in the way of residential development. It is known however, that the BC Power Commission began servicing Houston with power in 1950, and that in 1952, smaller powerline corridors were cut to service nearby homesteads. Thus, the age of some of the hydro right-of-ways noted in this assessment may be as old as 45 years. The street network of Houston was first laid out about 1958 and roads were graveled and graded. A water system from a dug well was also developed about this time. Between 1962 and 1967, the large power corridor that crosses the tributaries North of the Bulkley River in the watershed was cut and developed to deliver power from Prince George. In 1969, Houston was reorganized as a District Municipality, and planning and development of the Houston townsite began in anticipation of the thousands of new jobs which were to be provided by the large timber products complex of the BV Forest Industries Ltd. Full sewage and disposal services, housing, apartment dwellings, the shopping centre, and heavy and light industry areas were built and developed in the early 1970's. The channelized section of Buck Creek was also engineered in 1973, with the removal of tons of gravel, sand and cobble substrate from within it (Gov't of BC, 1973). Urbanization of the area has continued steadily since that time.

1.1.5.6 Forest Fires/Salvage Logging

The Mid-Bulkley watershed also has a history of large forest fires. The most well-known of these is the Swiss Fire. A list of fires which affected the watershed, their age, location, and extent are shown in table 2 below.

Name	Date	Extent (Ha)	Sub-Basins Affected
Row	1958	1179	Johnny David, Robert Hatch
Paul	1961	2600	Buck (Klo)
Row	1982	1266	Byman, Johnny David
Swiss	1983	18000	Buck
Griz	1991	332	Dockrill

(Source: E. Saunders, Morice Forest District, pers. comm.)

Table 2: Name, age, extent of forest fires in the Mid-Bulkley watershed, and the sub-basins they occurred in.

Salvage logging was carried out after the Swiss fire, the Griz fire, and the Row fire with the intention of Spruce Bark Beetle control and to harvest wood which is still more than 50% "sound". This usually involves a high density of road building over a short period of time to reach patches of merchantable timber and often for silviculture work in the first decade or two following the fire. In salvage logging, skid trails are often bladed instead of roads built, and logs are skidded much further than in conventional logging. Although this is often carried out in the winter on the snowpack, when it is not there are often consequences to soils (compaction, erosion), and terrain stability.

1.2 Target Species

When fish are defined in the context of this assessment, what is really being referred to are target species. Target species for fish habitat assessment and restoration are economically and/or culturally important salmonids whose abundance has declined following past forest practices, or which are known to be sensitive to the effects of logging (Johnston and Slaney, 1996). The Mid-Bulkley has a complex history of land-use, and a short history of data gathering in relation to fish. In our case, it is difficult to separate the effects of one land-use from another at this level of assessment. Target species are therefore defined here as economically or culturally important salmonids whose abundance has declined following past land-use practices, or which are known

to be sensitive to the effects of logging. The following species, in order of priority, are thought to be in decline in the watershed (Jeff Lough, pers. comm., FHIIP, 1991, SKR Consultants, 1997, NCFDC, 1996, B. Donas, pers. comm.):

- *Oncorhynchus kisutch* (coho salmon)
- *O. tshawytscha* (chinook salmon)
- *O. mykiss* (steelhead)

The following species which use the watershed for one or more life stages, are known to be sensitive to the effects of logging (including those listed above) (Johnston and Slaney, 1996):

- *O. gorbuscha* (pink salmon)
- *O. nerka* (sockeye salmon)
- *O. mykiss* (rainbow trout)
- *O. clarki* (cutthroat trout)
- *Salvelinus malma* (Dolly Varden)
- *S. confluentus* (bull trout)

The latter species is also listed as rare and endangered by MELP. These are the target species whose habitats, distributions, and abundances are being investigated in this assessment.

1.3 Study Area

The provincial location of the Mid-Bulkley watershed is depicted in Figure 1. A map of the watershed showing sub-basins and major tributaries is depicted in Figure 1A (not to scale) and Appendix 3, map 1-Study Area Boundaries (to scale).

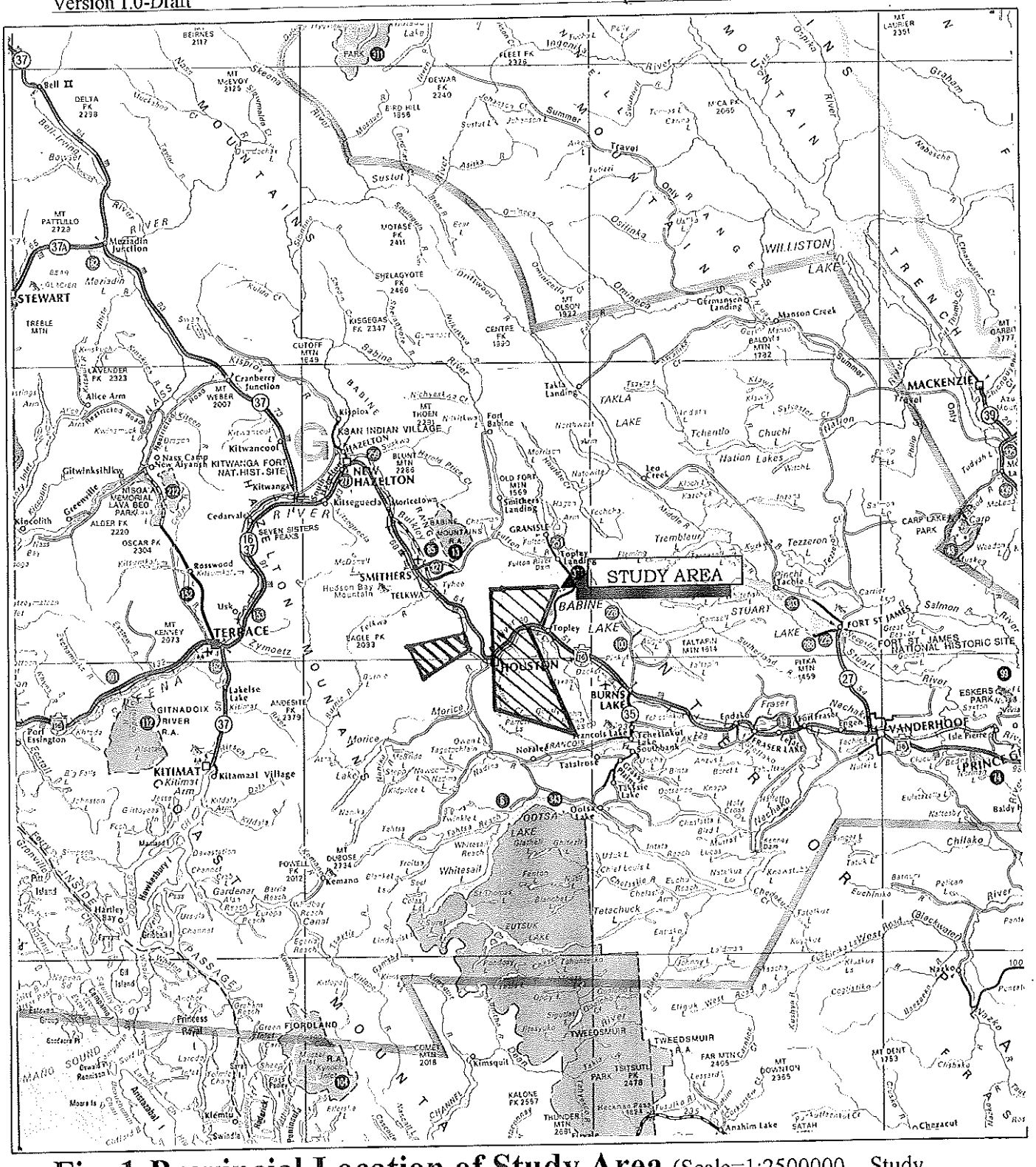
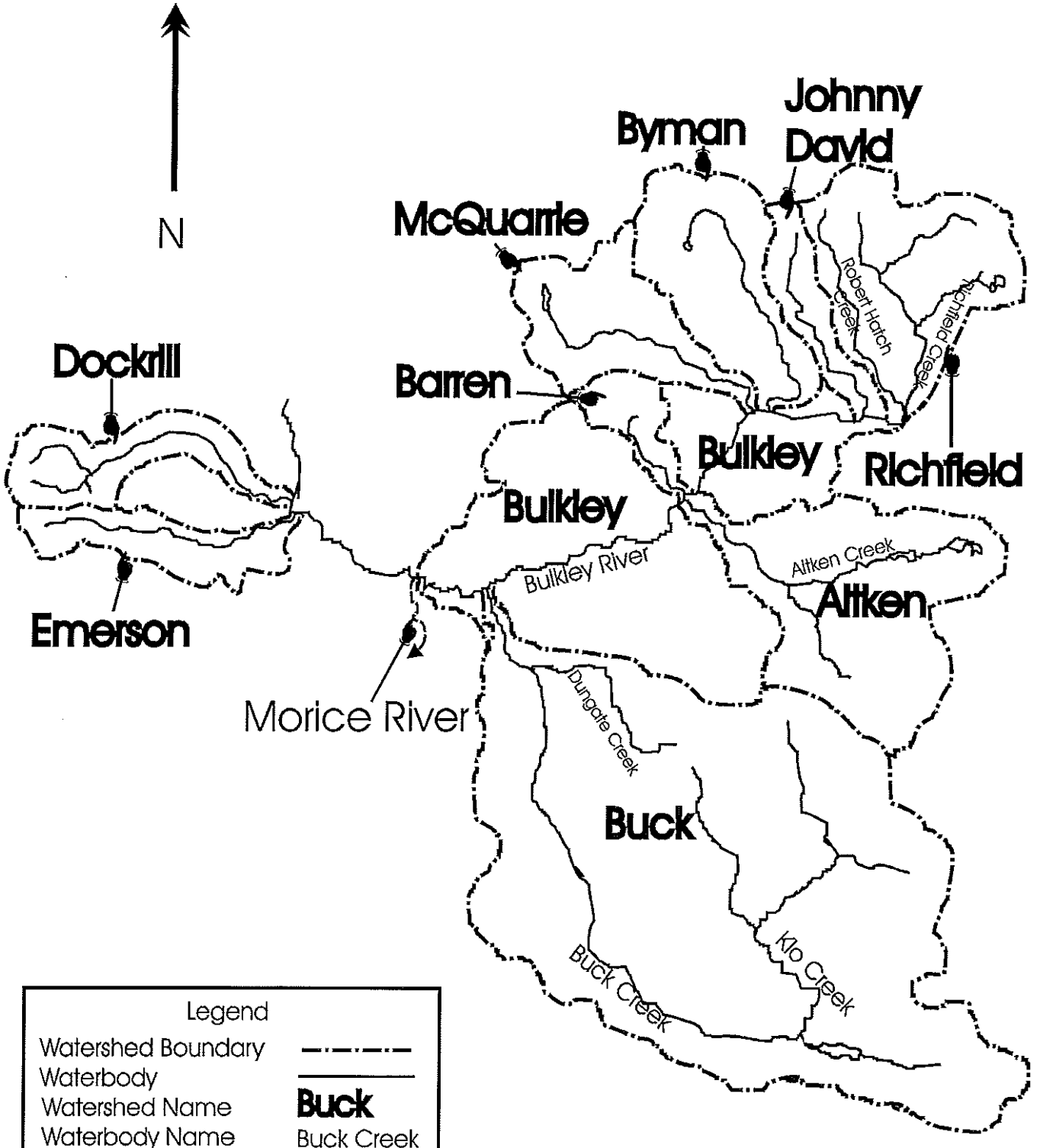


Fig. 1:Provincial Location of Study Area (Scale=1:2500000. Study area boundaries are representative only, neither accurate nor to scale)

Figure 1A: Watershed Boundaries and Major Tributaries
(map not to scale- see Appendix 3-Map 1)



(Note: Assume waterbody name is same as watershed name when not given)

2.0 Methods

The overview fish habitat assessment is completed through a number of different steps designed to focus field assessments and preliminary restoration plans on areas where substantial benefits to the fishery resource are likely (Johnston and Slaney, 1996). It can also be an effective means of gathering, generating, and organizing information about the state of watershed functions such as hydrology and sediment fluxes which are a part of the "blood chemistry" of aquatic ecosystems, and thus fish habitat. These steps are as follows:

- Baseline information search on fish species distribution, abundance, critical habitats, specifics of life-cycle timing, land-use and land-use history, known land-use impacts, and watershed character (hydrology, geology, soils, climate, vegetation, physiography).
- Low-level helicopter aerial photography to gain a snapshot of present conditions
- Assessment of fish habitat condition and land-use impact/impact potential, including that of upslope land-use
- Fish habitat assessment
- Preliminary habitat assessment to summarize impacts, fish habitat value, land-use impact potential, preliminary restoration opportunities, and the priority of a given area within a tributary for detailed assessment and restoration.
- Prioritize sub-basins within the watershed relative to each other for detailed assessment and restoration and provide cost estimates for detailed assessment.
- Mapping of sub-basins, units of study (reaches), known fish species distribution, and known obstructions.
- Field checks

A more detailed methodology is provided below.

2.1 Baseline Information Search

Baseline information is necessary to gain an understanding of how target species are distributed in order to narrow down the scope of helicopter aerial photography. It collects data on fish species abundance, that if rigorous enough over time and space, can be applied with some confidence to changes in the nature and intensity of land-use in the watershed. It allows comparison of channel conditions at different times if historic information is available. It allows a construction of how land-use has evolved in the watershed, and where and when impacts may have occurred and be still occurring. It also provides information on obstructions to fish migration, and where known or potentially critical habitats for different species and life-stages exist that explain the continued viability of populations in a degraded habitat, or conversely, a sudden plunge in abundance.

The following resources were searched in this stage of assessment:

- Skeena Region MELP Stream Files
- SISS (Stream Information Summary System) for subdistrict 4D (Smithers)
- FISS (Fish Information Summary System) maps of known fish distribution
- Skeena Region MELP library
- Roads, Hillslopes, Gullies Level 1 WRP report for the Mid-Bulkley
- The Overview and Level 1 Fish Habitat Assessments for the Maxan watershed, (including the Bulkley River to Bulkley Lake area within the Lakes Forest District)
- "Marks on the Forest Floor", a history of Houston and area.

The following resources were acquired for the area of study:

- 1:20 000 TRIM maps

- 1:50 000 BCGS maps
- 1:20 000 Roads, Hillslopes, Gullies (R/H/G) Level 1 maps for the Mid-Bulkley
- 1:20 000 Forest Cover Maps
- 5-Year Forest Development Plans from the various licensees in the watershed
- 1:10 000 and 1:50 000 scale stereoscopic air photos for the periods 1973, 1977, 1986, and 1991. Full watershed sets of photos could not be acquired for all periods in question.

The following knowledgeable individuals were interviewed:

- Skeena Region MELP WRP Fisheries Specialist
- Skeena Region MELP Fisheries Biologists, Fisheries Technicians, and Fisheries Inventory Biologist
- Prince Rupert Forest Region Regional Hydrologist
- Morice Forest District FES's
- Morice Forest District WRP Technician
- Morice Forest District Land Information Officer
- DFO Habitat Protection Officer
- DFO Community Advisor
- Paul Perlotto, Bulkley Fish Fence technician, and long-time Houston resident
- Al McCracken, small coho hatchery operator and long-time Topley resident
- Glenda Ferris, Buck Flats Residents Association member, and long-time resident of the Buck Creek watershed.
- Anonymous rancher, long-time resident on Johnny David Creek.

This information was compiled on summary sheets by tributary and the information was used to constructed known, suspected, and historical fish distributions (Appendix 1, form 1) in the watershed, and was used in part to form the flight plan for helicopter air photos.

2.2 Helicopter Aerial Photography

This stage consisted of flight planning and photography. Air photos were planned using standard texts and guidelines on remote sensing (RIC, 1996, Lillesand and Kiefer, 1994). They were carried out with a Bell Jet Ranger helicopter (Westland Helicopters, Houston) with a bubble-mounted 35 mm camera and Kodak™ Royal Gold 200 ASA film. The photos were taken over three days on July 30, 31 and September 13. Conditions are as follows (discharges from Water Survey of Canada gauging station WSC08EE003 on the Bulkley River near Houston):

- July 30, 31: Hazy with some sunny periods, Bulkley River discharge=2.90 m^3/s
- September 13: Clear skies, sunny. Bulkley River discharge=0.46 m^3/s

Flight planning was carried out to determine altitude based on a fixed focal length (38 mm in this case), air speed to get a 15% endlap across photos, and to know the time interval between photos. The amount of film required was calculated based on lengths of stream to photograph, ground coverage per photo, air speed, and ground separation between photo centers.

Due to the timing of photography, deciduous leaf-out had already occurred in July, and leaves were not off the trees in September. Photos done at the standard 1:5000 scale would not have yielded all of the information desired on streams with high deciduous canopy closure, so most of the tributaries were done at 1:3000 scale, while the Bulkley River was done at 1:5000. Altitudes and air speeds are presented below:

- 1:3000: flown at 114m above the ground surface at 65 km/h (3 seconds between photos)
- 1:5000: flown at 190m above the ground surface at 70 km/h (5 seconds between photos)

Oblique photos and field notes of land-use impacts were also taken during the helicopter flights and referenced to roll numbers on photo mosaic plates.

2.3 Fish Habitat Condition and Land-Use Impact Potential Assessment

The standard procedure to assess fish habitat condition for Watershed Restoration is outlined in WRP Technical Circular #8 (Johnston and Slaney, 1996). This method uses air photo interpretation (API) of physical indicators such as channel width, gradient, pool area, Large Woody Debris (LWD), riparian characteristics and off-channel areas to assess impact. Impacts are indicated by comparison to an expected set of characteristics and primary habitat value to target species found in a broad Channel Type category. Any deviation from the expected characteristics is investigated to assess whether adjacent, upslope, and/or upstream land-use has inflicted damage to fish habitat and channel functions. This is done in units called reaches and sections. Reaches are relatively homogeneous lengths of channel with similar confinement, gradient and substrate. Sections are smaller units within reaches which are different from the whole from the perspective of land-use, riparian characteristics, or channel features. While reaches allow generalizations to be applied, sections allow a finer resolution and are used when generalizing may smooth over important details of a small length of stream, especially when it may have a significant effect on the whole. Reaches were set in this assessment using TRIM maps and small-scale air photos, while sections were set using the large-scale helicopter air photo mosaics. For further details on the methodology used in the habitat condition assessment, see WRP Technical Circular #8 (WRTC#8).

Adjacent and upslope land-use impacts were also assessed using API of both small and large scale air photos, as well as Forest Cover Maps, and the R/H/G maps. This was especially useful when the ground coverage of helicopter photos was not enough to capture the source of mass movements or the extent and location of land-use in the upslope area. This information was used to formulate an uplsope impact potential

rating (see section 2.5 below). A list of stereo-pairs used in this assessment can be found in Appendix 8.

2.4 Fish Habitat Assessment

Fish habitat for different life-stages (spawning, rearing, overwintering, holding) as well as for overall productivity (access to adjacent sections, complexity) was assessed using the following criteria:

Spawning:

- Are there good gravels/cobbles for spawners?
- Is there good cover? (Overhead vegetation, boulders, cutbanks, LWD, in-stream vegetation)
- Does the channel look like it remains fairly stable, or do exposed bars and sediment show that it moves around fairly often in bankfull (water to the top of the bank such as in a large rainstorm) flood events?
- Do areas of deposited fine material indicate that the substrate may be compacted?
- Do water levels and dissolved oxygen (DO) look sufficient for egg survival? This is indicated by known water levels at the time of helicopter photography compared to the range of mean annual discharges expected, and the amount of turbulence in the stream.
- What is the frequency of stable pool tailouts and riffles?

Rearing:

- What amount of refuges from swift flowing water are there (pools, large boulders)?
- Are there alternative places for fish to escape to if there was suddenly a high discharge, turbidity or frazl ice event? Basically, off-channel areas.

- Does the amount of LWD and coarse substrate look like it would be good for invertebrate (insects) growth. Basically do they have something to grow on in the stream, or is there probably just allochthonous inputs? Is there a canopy of vegetation overhanging the stream for insects to fall from? Does the stream look clear or does there appear to be algae growing on the bottom? All of these things should say something about the quality of food available for rearing fry.
- Is there good cover (all of the types listed above).

Overwintering:

- Will there be sufficient DO to survive for the winter- turbulent areas such as riffles, cascades and falls indicate this.
- Does it look like there will be open water in the winter (same criteria as above will indicate open water)
- Are there off-channel areas to move to when it gets very cold and fish have to both conserve energy and avoid ice flows in the stream?
- Is there good in-stream cover (boulders, LWD, vegetation). This is for the purposes of feeding and not being fed upon.

Holding:

- Are there deep pools after longer riffle or glide sections?
- Do these pools have good cover and look like they would provide sufficient food?

Complexity:

- How diverse are pool/riffle/cascade/glide/off channel habitat features (as an indication of how productive the reach/section will be)? This is assuming that greater habitat diversity within an area cuts down on energy costs to move to different areas for different life-stages, and also decreases the stress of defending territory and resources.

Access to Adjacent Sections:

- Are there barriers or energy disincentives to move to habitat here?

By combining and weighing these factors relative to target species use, a qualitative rank of Excellent, Good to Excellent, Good, Moderate to Good, Moderate, Poor to Moderate, and Poor was assigned to each habitat qualifier. By giving each of the ranks a nominal value (4, 3.5, 3, 2.5, 2, 1.5, 1 respectively) an average of all of the habitat qualifiers could be calculated and an Overall Habitat Value could be assigned (see section 2.5).

2.5 Preliminary Habitat Assessment

To prioritize reaches and sections within a tributary for detailed assessment and restoration, a preliminary habitat assessment is done. This involves combining upslope impact potential, habitat value, fish species known or suspected to use the reach/section, and impacts from land-use to arrive at a high, moderate or low priority rating. The specifics of assigning a ranking as a combination of these factors is outlined in WRTC#8.

Overall Habitat Value (described in section 2.4) was used in the preliminary habitat assessment, as opposed to the salmonid Habitat Value of the given Channel Type (see pg. 24 of WRTC#8). This way, impacts could be linked to a perceptible decrease in habitat value by comparing the Primary Habitat Value (the salmonid Habitat Value of a given Channel Type in a stable state) to the Overall Habitat Value. In some cases, habitat value was degraded by specific natural features of the channel (such as poor access due to a cascade, or low water temperatures year-round). These situation were explained in the text of results, and the priority was adjusted accordingly.

Uplsope Impact Potential was determined by comparing connectivity of the stream channel with the upslope area, upslope land-use (F= forestry, R= road(s), H=

dwellings, A= agriculture, RR=railway, P=powerline corridor, I= industry (mining and/or commercial)) and whether mass movement activity was observed. A rank of high, moderate, or low was applied.

Restoration opportunities presented here describe the suite of possible restoration techniques which could be used, without consideration of access, land ownership, or budgets. **No single restoration technique should be prescribed nor can it be estimated for cost without first carrying out a detailed assessment to determine the site-specific requirements and feasibility of a given technique.**

2.6 Prioritizing of Sub-Basins

Methods used to prioritize sub-basins and estimate cost are outlined in section 5

2.7 Mapping

Mapping of reach breaks, fish distribution and obstructions was carried out on hardcopy TRIM maps, and then point files describing their attributes and spatial coordinates were created on a computer spreadsheet program. Watershed and sub-basin boundaries were delineated on hardcopy maps, and labeled with a number that corresponded with data in another point file that described the name of the sub-basin. The four point files and set of hardcopy TRIM maps were sent to a GIS subcontractor, and GIS mapping was carried out as per the *Fish Habitat Assessment Procedure Digital Data Specifications (April, 1997)*. Attribute data was entered into the WRP Data Entry System (DES) from forms 1-3 of the Overview FHAP (see WRTC #8), and the output from this is presented in hardcopy in Appendix 3, and on disk in Appendix 5.

2.8 Field Checks

Field checks were carried out over five days to confirm whether some obstructions identified in the habitat condition assessment were actual barriers (log jams, culverts, dams, falls, cascades), to verify land-use impacts or to investigate certain aspects of them, to obtain representative oblique photos of tributaries, and to check for land-use impacts in headwaters areas which may be having an impact on downstream fish habitat.

3.0 Results

A key to limiting factor codes for fish habitat tables presented below is as follows: F=siltation, C=lack of cover, PTR=lack of pool tailouts/riffles for spawning, AH= lack of alternative habitats, T= unsuitable temperatures known or expected, DO=low dissolved oxygen indicated, A=poor access to adjacent areas, AAH=poor access to alternative habitats, WQ=other water quality concern (not DO/temperature), WL=low water levels, SC=scouring, VR=a lack of velocity refugia, I=good probability of frazl and/or anchor ice formation at low temperatures. Information on Forest Practices Code stream/riparian classifications for known fish-bearing streams is found in Appendix 9.

3.1 Bulkley River Sub-Basin

General Description

The Mid-Bulkley River (a.k.a. Upper Bulkley, Little Bulkley) was photographed and assessed from its mouth (the POI) at the confluence of the Morice River to the confluence of Richfield Creek. It was segregated into 4 reaches over 68.81 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #3 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 3 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 2 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Fish Species Distribution, Abundance, and Habitat Values

The Bulkley River is known to be inhabited by all of the target species identified in this assessment (see section 1.2). This includes sockeye salmon, chinook salmon, pink salmon, coho salmon, steelhead, rainbow trout, cutthroat trout, and Dolly Varden/bull

trout (FISS, 1995, FHIIP, 1991, Tredger, 1982, steelhead Society, 1989, N.C.F.D.C, 1996, N.C.F.D.C, 1997, MELP, unknown date, S.Schug, pers. comm., P. Perlotto, pers. comm.). The distribution of these species and their life-stages within the Mid-Bulkley River is as follows:

- sockeye salmon: Migrating spawners and smolts use the Bulkley River for passage and holding between the mouth and upstream habitat in Bulkley Lake and the Maxan Watershed (AGRA, 1996, S.Schug, pers. comm.). They are found throughout the mainstem in the mid- to late August period as adults run upstream, and in the late spring as smolts migrate downstream.
- chinook salmon: Juveniles are found throughout the mainstem (FHIIP, 1991). The heads of glides in reach 2 have been found to be very productive rearing habitat for chinook (Tredger, 1982). Known spawning sites are mapped in Appendix 3, Map 2. Spawners are found generally to Reach 4, at infrequent pool tailouts. Reach 3 is the highest value spawning area due to higher gradient, and a more even pool:riffle ratio. chinook in this watershed are summer-run chinook, and migrate between July and August to spawn in the September to November period. chinook generally overwinter in deep mainstem off-channel areas, given good access and water quality, and also in smaller tributaries, provided there is good water quality and a lack of frazl and anchor ice. For the latter reason, log jams are often avoided.
- pink salmon: pink spawners are found in Reach 1 and in the very lower end of Reach 2, and spawn at riffles. They do not make use of the Bulkley beyond this point. pink juveniles migrate immediately to estuary habitat to smoltify following emergence.
- coho salmon: Juveniles are found throughout the mainstem (Tredger, 1982). There have been some spawners using the mainstem west of the fish fence (P. Perlotto, pers. comm.), but generally spawners exhibit preferences for smaller tributaries. Heads of glides in reach 2 have been found to be very productive rearing habitat for coho (Tredger, 1982). coho often overwinter in large, deep (> 2m) off-channels providing there is good water quality and access, as well as at smaller tributaries.
- steelhead: steelhead use of the mainstem is very limited due to water temperatures, gradient, and water flow (Tredger, 1982). Adults are often found holding in the

mainstem prior to overwintering and after spawning (they are present in the fall) in the Morice watershed, or in other tributaries of the Bulkley (P. Perlotto, pers. comm.). The Bulkley will also be used for outmigrations of juveniles in the summer.

- rainbow trout: The mainstem is used by adults for migration and holding.
- cutthroat trout: The mainstem is used by adults for migration and holding.
- Dolly Varden/bull trout: The mainstem is used by adults for migration and holding.

In reference to the latter three species, it has been shown that progeny of these species generally rear in tributaries until the age of 3+ parr, when they will enter mainstem rivers (Slaney et al., 1997). This has also been shown to be true for 1+ and 2+ steelhead parr (Tredger, 1982). In this case, the mainstem habitat is limiting to steelhead, so it is thought that these fish may outmigrate from the watershed to more favourable mainstem habitat (ie-the Bulkley or Morice systems downstream). Thus, spawners and juveniles would not be found generally in the mainstem.

Some generalities can be made about fish habitat in the Bulkley River. First, the first two reaches of the mainstem are **generally** not a productive area for salmonids. This is because the long pools and glides have very little moving water, which impacts invertebrate abundance, water quality (DO and temperature), and substrate size (fine sediments are abundant). Pool and glide tailouts and riffles are small islands of critically important habitat within these reaches. Furthermore, there are few tributaries entering Reach 1 and 2 which are flowing all year round, providing better water quality to these near-standing sections. Of these, only Aitken Creek, and Buck Creek are easily accessible, higher quality habitats.

This is another generality which can be made about the mainstem and the watershed as a whole. The most critical habitat for target species occurs at the confluences of the mainstem and tributaries because both types of waterbodies provide distinct advantages to different life-stages that are combined at these crossroads. The mainstem provides a lower energy habitat that does not require a great deal of effort to maintain position in, with deeper and more constant flows during low-flow periods. The tributary theoretically

provides better water quality (cooler and more oxygen due to higher gradients, larger substrates, more turbulence), more food due to better and more frequent invertebrate habitats, and both may provide an alternative habitat when there is either high concentrations of suspended sediments or ice in the water column. The mainstem floodplain may provide critical overwintering habitat when there is a lack of deep pools, large substrates, and/or deep, groundwater fed off-channel areas in the tributary.

That being said, Reaches 3 and 4 are very productive areas of the mainstem because they provide a number of freely flowing tributaries, larger substrates and a greater frequency of riffles, and excellent wall-base groundwater fed off-channel areas which are adjacent to the mainstem. These reaches also generally have a moderately more intact riparian area.

Sites of groundwater upwelling are usually particularly productive sites. Given the number of wall-base groundwater ponds visible along the base of slopes intersecting the Bulkley floodplain east of Houston, it would probably be a safe guess that sections of river which are directly adjacent to the valley wall will be more productive salmonid habitats.

As a final general statement on fish distribution in large channels such as the Bulkley, it has been found that most mainstem-rearing salmonids have lateral distributions that are skewed to the banks rather than the middle of a given channel cross-section. This distribution provides a refuge from higher velocities in the mid-channel area, and also provides better cover from predators (both instream and overhead), and maximizes feeding returns (terrestrial and in-stream sources of food). In this way, stream banks play an extremely important role in the survival of species inhabiting the mainstem.

Records of salmonid abundance in the mainstem are sporadic, and it is difficult to construct definite trends of stable or declining abundances. However, a number of different records will allow us to attach a range of abundances to the different species. It is important to note that the recreational sport fishery has been closed in this watershed since approximately 1982. Therefore, declines in numbers can be mostly attributed to a

combination of ocean survival, overfishing by commercial fleets and downstream inland fisheries, predation, and **loss and/or degradation of freshwater habitats by land-use**. Records of escapement are found from FHIIP (1991), the steelhead Society (1989), and N.C.F.D.C. (1996 and 1997). The means of enumeration has generally been by seining or a fish fence located just downstream of the Buck Creek confluence. No basinwide smolt enumerations have been made to assess freshwater survival in this watershed (this is a good measure of habitat quality). Resource managers cite steelhead, coho, and chinook salmon as target species in this assessment which are generally declining in abundance in the Bulkley River watershed (J. Lough, pers. comm., D. Atagi, pers. comm., P. LeMieux, pers. comm., B. Donas, pers. comm., M. Biere, pers. comm.). bull trout are already listed as a rare and endangered species. Ranges of abundances for different species (based on escapement) are as follows (FHIIP, 1991, Tredger, 1991, MELP, unknown date, steelhead Society, 1989):

- chinook: mean=400, maximum=2000, minimum=14
- coho: mean=191, maximum=10 000, minimum=0
- steelhead: mean=2431, maximum=11388, minimum= 7
- pink salmon: mean=51, maximum=500, minimum=0
- bull trout: 6 in 1997 (late August to October 15th)

(Note: these escapements are to the entire Upper Bulkley to Mid-Bulkley Lake, and not just the Mid-Bulkley watershed)

Tredger (1982) also made estimates of basinwide smolt outputs and adult escapements based on estimated standing crops of fry, which were in turn based on the output of carrying capacity models derived from minnow trapping data.:

- coho: 11583 fry:3700-4150 smolts:140-160 adults
- chinook: 10671 fry:3700-3900 smolts:140-150 adults
- steelhead: 92100 fry: 4100-11800 smolts: 155-1260 adults

Records of escapement data can be compared to this information (see figure 5). No firm conclusions can be drawn based on this data, because timing of enumeration and abiotic conditions at the time of enumeration are unknown. However, assuming that both of these sets of variables are constant from year to year, it appears that without any rigorous statistical testing nor description of the sample, that coho are certainly in decline.

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent

ESCAPEMENT : BULKLEY RIVER

WATERSHED-CODE : 46-0000-000-000-000-000-992

YEAR	SOCKEYE	COHO	PINK	CHUM	CHINOOK	STEELHEAD
1953	0	5000	100	0	800	UNK
1954	0	7500	0	0	1500	UNK
1955	0	5000	N/O	0	900	UNK
1956	0	7500	N/O	0	1500	UNK
1957	0	750	N/O	0	200	UNK
1958	0	1500	0	0	400	UNK
1959	N/O	3500	0	0	400	UNK
1960	200	3500	0	0	750	UNK
1961	UNK	UNK	UNK	UNK	UNK	UNK
1962	400	2500	0	0	1500	UNK
1963	600	300	0	0	2000	UNK
1964	300	200	0	0	2000	UNK
1965	100	500	0	0	800	UNK
1966	0	1000	50	0	300	UNK
1967	0	600	250	0	200	UNK
1968	0	1000	150	0	125	UNK
1969	0	1500	200	0	1200	UNK
1970	50	600	0	0	150	UNK
1971	0	600	100	0	100	UNK
1972	300	2500	450	0	55	UNK
1973	300	1000	500	0	850	UNK
1974	200	200	N/O	0	N/O	UNK
1975	64	28	N/O	0	500	UNK
1976	0	22	0	0	15	UNK
1977	200	280	0	0	250	UNK
1978	50	1200	0	0	400	UNK
1979	600	0	0	0	500	UNK
1980	0	0	0	0	500	UNK
1981	0	0	0	0	250	UNK
1982	0	UNK	0	0	100	UNK
1983	25	N/O	N/O	0	400	UNK
1984	N/O	N/O	N/O	0	200	UNK
1985	0	0	0	0	350	UNK
1986	0	UNK	UNK	UNK	450	UNK
1987	12	18	N/O	0	250	UNK
1988	UNK	10	0	0	1000	UNK
1989	9	1500	2	UNK	500	UNK
1990						
1991						
1992						
1993						
1994						
1995						

N/O = STREAM INSPECTED,NO FISH OBSERVED

UNK = STREAM NOT INSPECTED OR NOT INSPECTED FOR SPECIES INDICATED OR SPECIES PRESENT BUT NO ESTIMATE MADE

(Source:FHIIP, 1991)

Figure 5: Escapements of anadromous species to the Mid-Bulkley watershed

salmonid habitat of a given stable channel type (see table 3 below). This information is presented in a more detailed fashion in Reach and Section descriptions to follow.

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	Very High	Moderate	Moderate	Mod-Good	Poor	Excellent	F,C,PTR,AH,T,DO	Good	Moderate
	B	Very High	Poor	Mod-Good	Moderate	Poor	Good	CP,C,AAH,WQ,WL	Good	Moderate
2		Very High	Poor	Moderate	Good	Poor	Excellent	C,CP,WL,PTR,AAH,DO,T	Good	Moderate
3		Very High	Good	Good	Excellent	Good	Good	C,SC,CP,AAH	Good	High
4		Very High	Good	Mod-Good	Excellent	Excellent	Excellent	F,PTR	Good	High

Table 3: Primary and overall fish habitat value by reach and section, including limiting factors (see section 3.0 for key to codes)

There are no obstructions to fish movement in the mainstem. Log jams, particularly after flood years such as this spring, are often thought to be barriers to migrating spawners and even juveniles. This is usually untrue unless there is a marked increase in hydraulic head behind the jam (ie-water levels are much higher behind), as an indication of how impermeable it is. Basically, if water can freely get through, so can fish. To prove this theory, migrating chinooks were able to negotiate all of the large log jams in the Mid-Bulkley in mid to low-flow conditions (field observations of spawner carcasses). It is unknown to what extent these log jams may provide a barrier to **some** individuals, and thus lead to a decrease in productivity.

Land-Use and Upslope Impact Potential

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 4. More detailed discussion will follow in Reach and Section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	A, H, R	Low	No	Low
	B	A, H, R, P	Moderate	Yes	Moderate
2		A, H, R, F, P	Moderate	No	Low
3		A, H, R, F, P	Moderate	No	Low
4		A, R, F, P	Low	No	Low

Table 4: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section.

The valley bottom of the Bulkley River is the most focused area for land-use in the watershed. With the exception of mining, all forms of land-use found elsewhere in the watershed are found here. In order of magnitude, the land-uses are as follows:

- Agriculture: Most of the agriculture occurring on the Bulkley River floodplain is hay farming, as it is the most productive land in the watershed. Cattle and sheep grazing occur sporadically.
- Urbanization: Areas of concentrated residences and associated infrastructure are in Houston and Topley. In Houston this includes a paved road and parking lot network, a storm sewer system, flood dyking, buildings, industry, a municipal sewage treatment plant, and a high concentration of roofed buildings, all of which have effects on the hydrology, fluvial geomorphology, and water quality in the mainstem, and thus on fish habitat.
- Transportation Corridors: Both the highway and the railway are laid out along the Bulkley River floodplain, dissecting and blocking access to numerous floodplain features and often channelizing the river to prevent erosion.
- Powerline Corridor: There are four major powerline corridors which exist within the watershed, but most have been built in the uplands area. The Bulkley River is occasionally crossed by these corridors, in particular in reaches 1 and 2.
- Forestry: Only very small amounts of forest harvesting now take place in the Bulkley River floodplain. Most of this has been for Cottonwood, and has occurred in the vicinity of Houston (reach 1). The floodplain has a long past history of forest

harvesting by farmers in the winter months to supplement their incomes. This is indicated by the huge areas of Poplar forest which now cover the valley-bottom.

For a detailed history of land-use in the watershed, see section 1.1.5.

3.1.1 Reach 1

Reach 1 of the Bulkley River is defined as an irregularly meandering gravel-bed channel with occasional channel islands, diagonal/point/medial bar formation, and lateral downstream progression with occasional cutoffs. It Is 11.3 km long, and is split into two reaches (A and B) with higher and lower intensities of land-use, respectively. The reach ends at the confluence of Buck Creek. The Buck Creek sub-basin accounts for approximately 40% of the watershed area.

Land-uses in the reach include agricultural land, the highway and railway corridor including two bridges, a powerline corridor crossing at Houston, urbanization at Houston, and a cutblock harvested in 1994 in section B.

Fish species using this reach are chinook salmon (J/Sp), coho salmon (J/Sp), pink salmon (Sp), sockeye salmon (migrating Sp), steelhead (all), rainbow trout (A), cutthroat trout (A), bull trout (A), and Dolly Varden (A).

Section A

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: moderate
- Rearing: moderate to good

- Overwintering: poor
- Holding: excellent
- Access to adjacent sections: good

Limiting factors to habitat value are smothering by fines, poor cover in sections due to canopy removal and pool in-filling, infrequent stable pool tailouts and riffles, a poor frequency of alternative habitats, elevated temperatures due to canopy and pool depth loss, and poor levels of DO due to low gradients and flows. Indicators of recent disturbance are eroding banks, parallel debris, and extensive areas of unvegetated bar. There is a poor amount of LWD in the section, and the distribution is even. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is young deciduous forest.

Visible impacts are bank erosion and losses of riparian canopy and function at cleared land, and a loss of pool depth due to in-filling by fines. The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely peak flows and upstream sediment delivery causing aggradation, increased bankfull width and decreased depth, and a loss of LWD and LWD function. This reach in particular would be impacted by increased peak flows as it responds to Buck Creek, which doubles the ECA of the watershed up to the point of its confluence from 12% to 24%.

There is a **low** upslope impact potential due to poor connectivity.

Plates 1 and 2 show oblique photos of the confluence of the Bulkley and the Morice Rivers ("The Forks"), and a representative shot of Reach 1.

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a low upslope impact potential, and the use by nine target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and the need to stabilize

upstream sources of sediment and peak flows prior to instream and riparian restoration here.

Section B

This Riffle-Pool channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: poor
- Spawning: moderate to good
- Rearing: moderate
- Overwintering: poor
- Holding: good
- Access to adjacent sections: good

Limiting factors to habitat value are compaction of substrates by fine sediment, poor cover, poor access to alternative habitats, poor water quality due to municipal sewage effluent, and low water levels affecting flows, temperature, DO, and access in dry years. Indicators of recent disturbance are eroding banks, parallel LWD, and extensive areas of unvegetated bar. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is young deciduous forest mixed with areas of shrub-herb, grassland, and rip-rap/pavement.

Visible impacts are:

- a slump on the Michelle Bay FSR where the fine-textured fill has failed. This has lead to the delivery of a good deal of fine-textured clay material to the mainstem via an intermittent tributary. (see oblique photo plate 3).

- a mass movement at the powerline crossing over the Bulkley at Houston, where land-clearing on a steep slope has lead to sediment delivery into the channel (see photo plate 4 and photo mosaic plate 18.
- confinement of the river between the valley wall and the highway/railway corridor, which is causing increased flow velocities during peak flow conditions, a decrease in sinuosity due to a number of avulsions over the past 30 years (visible on small-scale stereo pairs), loss of access to an important groundwater fed off-channel (oxbow where Silverthorne Creek has been diverted behind Houston Forest Products), and increased bank erosion. This is occurring concurrently with increased peak flows from Buck Creek, and the channel is in disequilibrium with both of these impacts.
- there is a prevalent loss of riparian area which is also contributing to decreased bank instability at every outside corner where there was land clearing, as well as a particularly bad site at the Westland Helicopters property.

The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely upstream sediment delivery and increased peak flows from Buck Creek and the upstream reaches of the Bulkley.

There is a **high** upslope impact potential due to the activity observed.

Plates 3-6 show oblique photos of impacts in this section..

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a high upslope impact potential, and the use by nine target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and the need to stabilize upstream sources of sediment and peak flows prior to instream and riparian restoration here.

3.1.2 Reach 2

Reach 2 is defined as the regularly to tortuously meandering, gravel/sand-bed channel with irregular island frequency, all bar types but dominantly point and longitudinal, with lateral progression and cutoff activity. Sand bedforms predominate in this reach. It is 32.87 km in length and runs from the confluence of Buck Creek to an area of greater confinement near the confluence of McQuarrie Creek. There are frequent log jams and off-channel areas typical of a meandering valley flats area, in which wood is the principal channel-forming mechanism.

Land-use in this reach is dominantly hay cultivation with some minor areas of cattle grazing. The highway and railway corridors dissect the floodplain, but only presently act to confine lateral movement of the river and access to offchannel areas between Knockholt and the just prior to the extensive hay lands at North Bulkley. The powerline crosses the river once, and there are three significant bridge crossings at Houston, by the railway east of Houston, and by the McKilligan Road bridge at Knockholt. A small bridge crosses the river at the confluence of Aitken Creek. There are several first and second order streams feeding this reach. Of these, significant ones are McKilligan Creek and Summit Lake or Raspberry Creek, both of which have been significantly logged, having ECA's of 30%. Their small size does not contribute a great deal to the overall ECA of the Mid-Bulkley River, and as intermittent creeks are not of great value to the target species in this assessment. However, logging practices are known to be introducing sediments into McKilligan Creek, and thus into the Bulkey River (MIC Notes, 1997).

Fish species using this reach are chinook salmon (J/Sp), coho salmon (J/Sp), sockeye salmon (migrating Sp), steelhead (all), rainbow trout (A), cutthroat trout (A), bull trout (A), and Dolly Varden (A). As discussed in section 4.1, this reach is not very productive for salmonids because of a low gradient and near-standing water much of the year. Deep riffles and the tailouts of glides and pools are particularly important habitats. Also of note are areas where the valley wall intersects the channel. These areas will likely provide sites of upwelling groundwater, and do provide small natural

slides of larger substrates which are incorporated into riffle crests during high flows (field observations). Bank erosion of fine-textured banks on this floodplain does not often contribute large substrate to the channel (field observations).

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: poor
- Spawning: moderate to good
- Rearing: good
- Overwintering: poor
- Holding: excellent
- Access to adjacent sections: good

Limiting factors to habitat value are smothering by fine sediments, compaction of substrate by fines, poor cover in many sections due to bank slumping, low water levels in summer leading to water quality concerns, a poor frequency of channel features for spawning, poor access to alternative habitats in many areas due to highway/railway dissection and rip-rapping, low DO, and elevated summer temperatures expected. Indicators of recent disturbance are eroding banks, recently formed log jams, extensive areas of unvegetated bar, multiple channels, and extensive sediment wedges. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 26-50% of the wetted channel area (much of the channel area is glides). The riparian area is young deciduous forest with frequent and extensive areas of grassland and shrub-herb at cleared land.

Visible impacts are bank erosion and channelizing by the railway/highway corridor, which is also causing poor access to both fish and floodwaters to these areas. Related

to both of these is loss of and in the case of channelizing, permanent disconnection of the riparian canopy.

- Bank erosion is occurring consistently at cleared land on outside corners of meanders, and in straight sections. This is contributing a great deal of sediment to the channel, as witnessed by a decrease in pool depth, extent, and frequency, and an increase in bankfull width in the downstream direction.
- Channelizing by the highway and railway corridors is causing both an increase in water velocities downstream of the rip-rapping and subsequent increases in erosive power and unstable deposition, as well as acting to deny entry of peak flows to off-channel areas (other than through seepage) which are important sediment and water storage sites to buffer peak and base flows. The author believes that this is artificially increasing flood peaks and water velocities by decreasing the area of channel delivering the water, and removing the constant energy dissipation which occurs with lateral movement. Since the areas of channelizing occur over about a third to a half of the length of the reach, it is thought that this will have a significant effect as outlined above. Furthermore, the blocking of fish access to these off-channel areas constitutes a major loss of overwintering and rearing habitat, in terms of its value as a refuge from poor water quality in the mainstem, and the energy required to maintain a position in the river. This applies particularly to coho, chinook, and Dolly Varden juveniles (Lister and Finnigan, 1997). Many of these off-channel areas against the northern valley wall are fed by groundwater, and will be buffered from temperature extremes, and will provide good DO. It is not thought that any of these off-channels yield enough groundwater flow for spawning. A field survey of off-channel access in this reach and reaches 3 and 4 showed that more than half of them were not provided with any access, and that a further number of these had blocked or poorly placed (high and dry) culverts.

Given the importance of the near-bank habitat to rearing salmonids during regular flows, it can also be concluded that the impacts from riparian losses and

bank erosion are likely having a serious effect on juvenile salmonid populations. Impacts here appear to be somewhat greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely upstream sediment delivery from tributaries in reach 3 and 4, as well as from the Maxan watershed.

There is a **low** upslope impact potential due to poor connectivity to the channel and no anthropogenic activity observed..

Plates 7 to 11 show oblique photos of the impacts discussed above.

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a low upslope impact potential, and the use by eight target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, property and public protection issues surrounding the alteration of erosion and flood control measures, and the need to stabilize upstream sources of sediment and peak flows prior to instream and riparian restoration here.

3.1.3 Reach 3

Reach 3 is defined as the higher gradient topographically confined section of the Bulkley River between approximately North Bulkley and the end of the alluvial fan at Byman Creek. It is 9.5 km in length and receives water and sediment inputs from McQuarrie Creek and Byman Creek.

Land-use in this reach includes hay cultivation, and the railway/highway corridor, which channelizes almost all of the outside corners of meanders in this reach. There is some minor urbanization at the Uplands trailer park.

Fish species using this reach are chinook salmon (J/Sp), coho salmon (J/Sp), sockeye salmon (migrating Sp), steelhead (all), rainbow trout (A), cutthroat trout (A), bull trout (A), and Dolly Varden (A).

This Riffle-Pool channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: good
- Rearing: excellent
- Overwintering: good
- Holding: good
- Access to adjacent sections: good

Limiting factors to habitat value are compaction of substrate by fines, scouring at higher flows, poor cover, and access to alternative habitats (access to good groundwater-fed offhchannels and ditchlines is often cut off by the railway/highway corridor). Indicators of recent disturbance are eroding banks, recently formed log jams, and extensive areas of unvegetated bar. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is young mixed forest (deciduous dominant).

Visible impacts are channelizing by the railway/highway corridor, including loss of access to many groundwater-fed off-channels and ditchlines for salmonids, suspected increases in downstream lateral movements in response to the channelizing, and an increase in avulsions and a loss of sinuosity translating into a loss of fish habitat. Furthermore, a large log jam which occurred at plates 84 and 85 of the photo mosaic and posed a threat to the CN rail line during flooding was removed by the company, leaving a large sediment wedge vulnerable to erosion and degradation of fish habitat

downstream. As is common with log jams, the area below them is somewhat scoured out, and in this case, a large clean area of uncompacted spawning gravels had been created. The sudden erosion of the sediment wedge will destroy this prime habitat. On a larger scale, removal of log jams in a channel such as this removes a key element of water and sediment storage and energy dissipation, as well as regular lateral activity which creates good salmon habitat such as that noted above. An policy of log jam removal will lead to increased water velocities, and a loss of habitat as fines are flushed immediately out of the system, coating the substrate, and as lateral activity declines and the channel straightens. The latter leads to poor channel complexity and the formation of extensive riffles, a direct loss of fish habitat as the channel becomes incised and disconnected from the floodplain. As with downstream reaches, rip-rapping and riparian canopy removal from land clearing are leading to impacts on rearing and holding salmonids. The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. As with downstream reaches, rip-rapping and riparian canopy removal from land clearing are leading to impacts on rearing and holding salmonids. Therefore, cumulative impacts are suspected, namely upstream sediment delivery from tributaries in this reach, and reach 4.

There is a **low** upslope impact potential due to a lack of anthropogenic activity observed.

Plates 12 and 13 show photos related to the CN log jam.

Due to the nature and severity of impacts in this section, as indicated by a one-fold decrease in habitat value, a low upslope impact potential, and the use by eight target species, and the importance of this reach in the context of the river and the watershed, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, property and public protection issues surrounding the alteration of erosion and flood control measures and the need to stabilize upstream sources of sediment prior to instream and riparian restoration here.

3.1.4 Reach 4

Reach 4 is described as the unconfined regularly to tortuously meandering low gradient gravel-bed channel from the end of reach 3 to the confluence of Richfield Creek. It is very similar to reach 2 except that there is a lower intensity of agriculture and a more intact riparian area. Remnants of climax valley bottom riparian forest can be found here, and this reflects on greater bank stability, high quality stable off-channel areas, and better access to those areas. This reach is fed by the tributaries Richfield Creek and Johnny David Creek.

Land-use in this reach includes the railway corridor, which is blocking access to a number of offchannel areas (although off-channels are not particularly limited in this reach), hay farming, and cattle farming (range-use).

Fish species using this reach are chinook salmon (J/Sp), coho salmon (J/Sp), sockeye salmon (migrating Sp), steelhead (all), rainbow trout (A), cutthroat trout (A), bull trout (A), and Dolly Varden (A). Chinook spawner carcasses and redds were found in the vicinity of the railway bridge crossing (photo mosaic plate 116/117) during field checks.

This Riffle-Pool channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: moderate to good
- Rearing: excellent
- Overwintering: excellent
- Holding: excellent
- Access to adjacent sections: good

Limiting factors to habitat value are siltation and an infrequent amount of spawning habitat . Indicators of recent disturbance are eroding banks, extensive areas of unvegetated bar, and recently formed log jams. There is an abundant amount of LWD in the section, and the distribution is even. The extent of pool habitat is 50-75% of the wetted channel area. The riparian area is mixed mature forest intermixed with young deciduous forest and with areas of shrub-herb and grassland at cleared land.

Visible impacts are bank erosion and a loss of riparian at cleared land, and occasional channelizing and off-channel access cutoff by the railway. It is expected that some upstream sediment delivery is occurring from Johnny David Creek and Richfield Creek due to the fine texture of material deposited in alluvial fans, as well as from sediment sources upstream of this watershed, in the Maxan. This reach is thought to be a much closer approximation of a natural valley bottom reach than is reach 2.

There is a **low** upslope impact potential due to no anthropogenic activity observed.

Due to the nature and severity of impacts in this section, as indicated by a one-fold decrease in habitat value, a low upslope impact potential, and the use by eight target species, a **moderate priority** for detailed assessment and restoration is assigned.

3.2 Buck Creek Sub-basin

Sub-Basin Description

The Buck Creek sub-basin is located to the south of the Bulkley River mainstem and refers to the third-order basin area which is drained by Buck Creek and all of its tributaries (see Appendix 3, mapsheet 1). The mouth of Buck Creek is located at UTM 9.652100.6029200, and this defines the POI. The total watershed area is 56 333 hectares.

Table 5 below describes areas of mainstem Buck Creek and its tributaries which were assessed. The results for each of these tributaries will be described separately below.

Waterbody	Length Assessed	# of Reaches	UTM of Endpoint (Zone 9)	
Buck Creek	53.4	11	6003200	678560
Klo Creek	6.2	2	6011200	667300
Dungate Creek	12.5	4	6020075	663620

Table 5: Tributary information for the Buck Creek sub-basin

3.2.1 Buck Creek Mainstem

General Description

The Buck Creek mainstem was photographed and assessed from its confluence with the Bulkley River to the outlet of Goosly Lake, and from the inlet of Goosly lake south to UTM 9.6003200.678560. It was segregated into 11 reaches over 53.4 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. **Appendix 1, form 1, form #2** shows the distribution of known, suspected or historically present species by life stage and reach number. **Appendix 1, form 2, form #2** shows the results of habitat condition data by reach and section. **Appendix 1, form 3, form #3** shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Fish Species Distribution, Abundance, and Habitat Values

Buck Creek is thought to be one of the most significant "nursery" streams for salmonids in the watershed. It is utilized by chinook, coho, and pink salmon, rainbow and steelhead trout, Dolly Varden and bull trout, and numerous coarse fish species (FISS, 1995, FHIIP, 1991, Perlotto, pers. comm., J. Lough, pers. comm., Tredger, 1984, Bustard, 1989). Historically, coho escapements have been higher here than at

Richfield Creek (maximum=600, mean=7), (the only other tributary with escapement data), and chinook escapements are similar (maximum=50, mean=11)(FHIIP, 1991) (see figures 6 and 7 below). Point sampling has shown relatively high densities of steelhead/rainbow fry, and resident rainbow trout have historically inhabited the upper mainstem and Klo Creek in its headwaters (Bustard, 1989, MELP, 1974). This creek is thought to have an estimated standing steelhead crop of 72 020 fry and parr (accounting for the strength runs in different years), and maximum sampling densities for chinook and steelhead fry were found in this creek below the cascade barrier (see below) in the context of the Mid-Bulkley watershed.

ESCAPEMENT : BUCK CREEK

WATERSHED-CODE : 46-5600

YEAR	SOCKEYE	COHO	PINK	CHUM	CHINOOK	STEELHEAD
1953	0	300	0	0	0	UNK
1954	UNK	UNK	UNK	UNK	UNK	UNK
1955	0	60	0	0	0	UNK
1956	0	75	0	0	0	UNK
1957	0	75	0	0	0	UNK
1958	0	200	0	0	0	UNK
1959	0	200	0	0	0	UNK
1960	0	200	0	0	0	UNK
1961	UNK	UNK	UNK	UNK	UNK	UNK
1962	0	500	0	0	0	UNK
1963	0	400	0	0	0	UNK
1964	0	600	0	0	0	UNK
1965	0	200	0	0	0	UNK
1966	0	200	0	0	0	UNK
1967	0	200	100	0	0	UNK
1968	0	200	0	0	0	UNK
1969	0	300	N/O	0	0	UNK
1970	0	300	0	0	50	UNK
1971	0	300	0	0	N/O	UNK
1972	N/O	0	0	0	25	UNK
1973	0	N/O	N/O	0	N/O	UNK
1974	0	N/O	N/O	0	N/O	UNK
1975	0	150	N/O	0	N/O	UNK
1976	0	200	UNK	0	UNK	UNK
1977	0	250	N/O	0	N/O	UNK
1978	0	200	N/O	0	N/O	UNK
1979	0	0	0	0	0	UNK
1980	0	N/O	N/O	0	N/O	UNK
1981	N/O	0	0	0	0	UNK
1982	0	50	0	0	12	UNK
1983	0	N/O	0	0	N/O	UNK
1984	UNK	UNK	UNK	UNK	UNK	UNK
1985	UNK	UNK	UNK	UNK	25	UNK
1986	0	UNK	UNK	UNK	UNK	UNK
1987	0	0	0	0	N/O	UNK
1988	0	N/O	0	0	50	UNK
1989	0	N/O	N/O	0	N/O	UNK
1990						
1991						
1992						
1993						
1994						
1995						

N/O = STREAM INSPECTED, NO FISH OBSERVED

UNK = STREAM NOT INSPECTED OR NOT INSPECTED FOR SPECIES INDICATED OR SPECIES PRESENT BUT NO ESTIMATE MADE

(Source: FHIIP, 1991)

Figure 6: Escapement data for anadromous species (for the Buck Creek watershed).

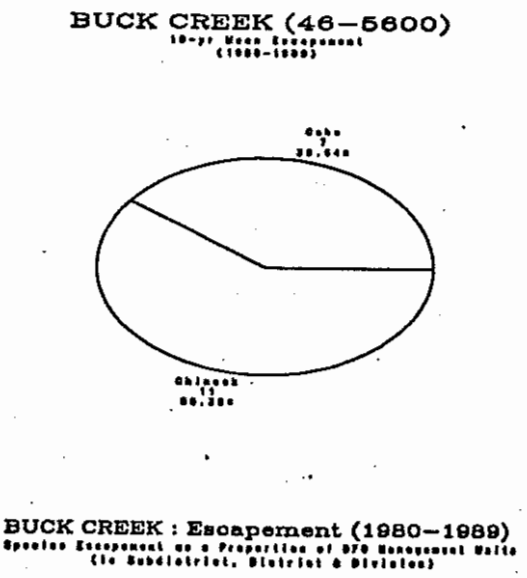


Figure 7: 10-year mean escapements for chinook and coho as a percentage of DFO target escapements (for the Buck Creek watershed).

Known and suspected distribution of fish species and critical habitats are as follows:

- pink salmon: Near mouth (FHIIP, 1991). Reach 1 and 2 (suspected).
- coho salmon: To the falls in Reach 8 (suspected), possibly only to the cascade in Reach 3 (FHIIP, 1991) in some years due to water levels. Observed rearing in Reach 6, historically may have been present to Goosly Lake and in Upper Buck Creek (MELP, 1986).
- chinook salmon: To the falls in Reach 8 (suspected), possibly only to cascade in Reach 3 (FHIIP, 1991) in some years due to water levels. Observed spawning in Reach 6 (MELP, 1986) and Reach 1-3 (FHIIP, 1991). Fry densities indicate that the Dungate confluence is a critical rearing habitat (in the context of this watershed) (Tredger, 1982). High densities rearing behind beaver dams in reach 5/6 (MIC Notes, 1997).
- steelhead: To the falls in Reach 8 (suspected), and to at least 10 km from mouth (cascade-reach 3) (FHIIP, 1991). Good steelhead fry, parr rearing, and spawning habitat up to 16 km from mouth (MELP, 1980). Observed spawning at Reach 6

(MELP, 1980). Buck Creek was stated as being the most significant tributary in Upper Bulkley for rearing area/habitat quality for steelhead (Tredger, 1982)

- rainbow: No data for distributions below Goosly Lake. Suspected to use mainstem in selected sections of Reach 9 and 10 for rearing and spawning (similar channel morphology, gradient to areas above Goosly Lake, no major obstructions).
- Dolly Varden/bull trout: Known to be present at mouth of Dungate Creek (Tredger, 1982). Observed holding in Reach 1 (Perlotto, pers. comm.). Suspected rearing in Reaches 3 and 8 (higher gradient canyon areas). No definite bull trout/Dolly Varden/hybrid identifications using standard method of Haas (1997).

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 6 below). This information is presented in a more detailed fashion in Reach and section descriptions to follow.

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	Very High	Poor-Mod	Poor-Mod	Moderate	Poor	Moderate	CP,C,AH,VR,I	Good	Moderate
	B	Very High	Poor	Poor	Poor	Poor	Poor	SC,C,WL,VR,AH,T,I,CP	Moderate	Low
	C	Very High	Poor-Mod	Moderate	Poor-Mod	Poor	Moderate	WL,C,PTR,VR,AH,I	Good	Moderate
2	A	Very High	Moderate	Moderate	Moderate	Moderate	Good	CP,AH,I, WL, SC, VR	Good	Moderate
	B	Very High	Moderate	Moderate	Mod-Good	Good	Mod-Good	F,C,PTR,T,WL	Good	Moderate
	C	Very High	Moderate	Moderate	Moderate	Moderate	Good	F,C,PTR,T,AAH	Good	Moderate
3	A	High	Good	Mod-Good	Good	Poor	Good	LS,SC,AH,I	Moderate	Moderate
	B	Low-Moderate	Moderate	Poor	Poor	Poor	Moderate	LS,SC,AH,WL,VR,I	Moderate	Low-Moderate
	C	High	Moderate	Poor-Mod	Moderate	Poor	Moderate	SC,PTR,VR,AH	Moderate	Moderate
4	A	Very High	Moderate	Moderate	Good	Mod-Good	Good	F,C,T,WL	Good	Moderate-High
	B	Very High	Good	Moderate	Mod-Good	Moderate	Good	F,C,AH,T	Good	Moderate-High
	C	Very High	Moderate	Good	Moderate	Moderate	Moderate	F,AH,DO,VR	Good	Moderate
5	A	Very High	Moderate	Poor-Mod	Good	Good	Moderate	F,WL,T,A	Moderate	Moderate
	B	Very High	Poor	Mod-Good	Moderate	Moderate	Mod-Good	SC,C,AH,WL	Good	Moderate
	C	Very High	Moderate	Mod-Good	Mod-	Mod-Good	Mod-Good	F,C,PTR,WL,AAH,I	Good	Moderate-High

					Good					
6	A	Very High	Moderate	Moderate	Moderate	Poor	Moderate	CP, SC, C,AH	Moderate	Moderate
	B	Very High	Good	Mod-Good	Mod-Good	Mod-Good	Good	SC,C,T,DO,AAH,A	Moderate	Moderate-High
	C	Very High	Moderate	Poor	Moderate	Poor	Good	F,DO,C,T,AAH,A	Moderate	Moderate
7		Very High	Moderate	Poor	Good	Moderate	Good	F,DO,C,T,A	Moderate	Moderate
8	A	High	Moderate	Good	Good	Good	Good	VR	Good	High
	B	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	PTR, AH	Moderate	Moderate
	C	Low	Low	Poor	Poor	Poor	Poor	VR,A	Poor	Low
9	A	Very High	Good	Good	Good	Good	Good	CP,AH,A	Moderate	High
	B	Very High	Good	Poor	Good	Moderate	Good	F,C,DO,T	Good	Moderate-High
10	A	Very High	Good	Good	Good	Mod-Good	Good	F,C,T	Good	High
	B	High	Poor	Poor	Excellent	Good	Good	PTR	Good	Moderate-High
11	A	High	Moderate	Poor	Moderate	Poor	Good	PTR,WQ,DO	Moderate	Moderate
	B	Very High	Good	Good	Excellent	Excellent	Excellent	F	Good	High-Very High

Table 6: Primary and overall fish habitat value by reach and section, including limiting factors for Buck Creek (see section 3.0 for key to codes)

There are known obstructions to fish movement at mid-Reach 3 (cascade previously thought to be in Reach 2 according to FHIIP, 1991) which is not thought to be a barrier at higher flow conditions, and at the end of Reach 8 (originally thought to be in Reach 3 according to FHIIP, 1991) which is suspected impassable to all species. It is also thought to mark the boundary between resident rainbow trout and anadromous steelhead. However, there may be some overlap in this distribution due to residents successfully migrating downstream.

Land-Use and Upslope Impact Potential

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 7. More detailed discussion will follow in Reach and Section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	None	Low	No	Low
	B	H, R, RR	Low	No	Low
	C	H, R	Moderate	Yes	High
2	A	P, I	Moderate	Yes	High

	B	A, H, R	Low	No	Low
	C	A, F	Moderate	Yes	Moderate
3	A	None	High	No	Low
	B	None	High	No	Low
	C	None	High	No	Low
4	A	A, F	High	Yes	High
	B	A, R, P	Moderate	No	Low
	C	A, F, H	Moderate	Yes	Moderate
5	A	A, F, H	Moderate	Yes	Moderate
	B	A, F, H, R	Moderate	No	Low
	C	A, F, H, R	Moderate	Yes	Moderate
6	A	A, F, H, R, FI	Moderate	Yes	Moderate
	B	A, F, H, R, FI	Low	No	Low
	C	A, F, H, R, FI	Low	No	Low
7		A, F, R, FI	Low	No	Low
8	A	F, FI, R	High	No	Low
	B	F, FI, R	High	No	Low
	C	F, FI, R	High	No	Low
9	A	F	Low	No	Low
	B	F	Low	No	Low
10	A	F	Low	No	Low
	B	F	Low	No	Low
11	A	F, I, R	Low	No	Low
	B	F, R	Moderate	Yes	Moderate

Table 7: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section.

Buck Creek has experienced a considerable history of land-use for agriculture, urbanization, forestry and mining. The valley bottom floodplain was cleared for agriculture and habitation at the beginning of the century and through to the present at both Buck Flats and at the mouth. Peak periods for urban development occurred in the late 1960's, when the town was incorporated, and subsequently when it was given municipal status. This was accompanied by an increase in paved area, road density, water use, urban runoff, drainage simplification, loss of riparian, and dyke building in reach 1. Forestry has been carried out in the upper reaches of the mainstem and above Goosly Lake since the late 1950's and increased considerably after the establishment of the Bulkley Valley Forest Industries Ltd. and the onset of industrial forestry in the early 1970's. Peak flows are expected to have increased, and baseflows diminished in Buck Creek given the ECA of the watershed. This will be further frustrated by the effects on hydrology of a large fire (the Swiss Fire) which

burned 8% of the total watershed area in 1983 (Wilford, 1984). This area was subsequently salvaged logged the following spring (D. Wilford, pers. comm.). Early mineral extraction took place on Bob Creek in 1914-1920, and later in Klo Creek in the late 1950's, early 1960's. Several quarries and a concrete manufacturer have operated on Buck Creek in the past two decades. Equity Silver Mine operated in the Upper Buck Creek basin (on Bessemer Creek) for 14 years from 1980 until 1994, and there have been significant Acid Mine Drainage (AMD) problems from this facility. The most serious event occurred when 108 metric tons of sulphuric acid was spilled into the creek, along with associated high concentrations of heavy metals, and continual problems with AMD exist today. Apparently, the delivery of high concentrations of metals and low pH waters (from AMD) to the Buck Creek mainstem are somewhat buffered by sedimentation and residence time in Goosly Lake (G. Ferris, pers. comm.). Thus, the bulk of the impact has been to Upper Buck Creek and Goosly Lake. There is one powerline crossing in reach 2 which was probably cut in approximately 1952. The railway and highway transportation corridors dissect Buck Creek in reach 1. The railway has existed since 1910, and the highway was constructed in the 1940's. See section 1 for a more detailed history of land-use.

3.2.1 Reach 1

Reach 1 encompasses the area from the mouth of Buck Creek to the upstream end of flood dyking at Houston. It is 2.7 km in length and includes three sections:

- Section A: the length of channel below the dual bank dyking
- Section B: the channelized section with dyking on both banks
- Section C: the section between the reach 1/2 break and the dual-bank dyking

Adjacent land-use includes the highway and railway corridor, parkland, urban dwellings, and flood dyking .

Fish species in this reach are chinook (J/Sp), coho (J/Sp), pink (Sp), steelhead (all), rainbow (all), Dolly Varden/bull trout (known A, suspected J). The life-history of the char population in Buck Creek is unknown, and therefore use of habitat is difficult to predict. Sockeye were thought to have historically used this reach for spawning.

Section A

This section of riffle-pool (RPgw) channel has a **very high** primary habitat value for target species in a stable state. The overall habitat rating is only **moderate**, however, and the channel is **aggrading** . This indicates a degree of impact. Habitat value for target species and general indicators of productivity is as follows:

- Complexity: poor to moderate
- Spawning: poor to moderate
- Rearing: moderate
- Holding: moderate
- Access to adjacent sections: good

Limiting factors include poor cover, a lack of velocity refugia for feeding/holding, substrate is compacted (field observation), and there may be anchor and frazl ice formation in cold temperatures. Indicators of recent disturbance include extensive areas of unvegetated bar, non-functional LWD (parallel to banks), and recent log jams (2 lateral log jams). Complexity and therefore general productivity is poor due to the poor functionality of LWD, and the homogenization of the channel by siltation and scouring. Historic air photo analysis since 1973 shows simplification of the meander pattern as one avulsion and another partial avulsion are occurring below the channelized section.

Visible impacts within the section are a loss of riparian function at dyked and cleared sections, bank erosion and avulsions, unstable deposition, and LWD impacts to function and distribution. The upslope impact potential for this section is low due to connectivity.

The nature of impacts is both cumulative and direct. The loss of riparian and associated functions due to land clearing for parkland, and residences is leading to a decrease in the ability of the bank to resist normal and shear stress imposed by higher water velocities/levels and undercutting. The bank failures and avulsions are external and internal sediment sources, respectively. This may be responsible for some of the aggradation occurring here. However, the channelized section has lead to channel straightening, and a lack of energy dissipation and depositional zones, and thus the downstream delivery of water, sediment and LWD has lead to log jams, aggradation, and lateral instability as the channel adjusts to an increase in these fluxes. Although all of the necessary variables indicating the probability of increased peak flows (or flashiness) have not been calculated, the ECA in the watershed is greater than 25%. This value has proven to be the indicative ECA for increased peak flows, especially as a function of rain-on-snow events (Slaney and Martin, 1997). There is also a significant area of higher elevation clearcuts, which will increase the synchronicity of snowmelt. Furthermore, urban developments and storm sewers have probably led to drainage simplification and a decrease in infiltration coupled with an increase in overland flow and faster basin response. This is another factor that will act to intensify runoff to the creek in storms and snowmelt, and decrease groundwater recharge and baseflows. An increase in peak flows, and a decrease in baseflows will exaggerate the impacts discussed above, which are also symptomatic of this problem.

Plates 14, 15, and 16 show oblique photos of the reach and impacts.

The decrease in habitat value by two ratings, the severity and nature of impacts, and the high value to target species of various life stages make this a **high priority** for detailed assessment and restoration. Barriers to restoration are the

adjacent private land ownership, the public safety and property protection issues surrounding an alteration of flood control measures, the lack of solid data on peak flow increases, and the need to restore upstream to decrease peak flows if they are a root cause of the impacts here.

Section B

This section of Riffle-Pool (RPcw) has a **very high** primary habitat value for target species in a stable state. However, the overall habitat value is **low**, and the channel is **degrading**. This indicates a degree of impact. The habitat value for specific life-stages and general indicators of productivity is as follows:

- Complexity: poor
- Spawning: poor
- Rearing: poor
- Overwintering: poor
- Holding: poor
- Access to adjacent sections: moderate

Limiting factors to habitat values are areas of scour, compaction of substrate, low water levels, a lack of velocity refugia, a lack of alternative habitats, increased temperatures, a probability of anchor and frazl ice formation in cold temperatures, and poor cover. Indicators of recent disturbance include extensive riffles and poor pool frequency in a channel type which should naturally be higher in pool rather than riffle features. There is virtually no LWD in the active channel width, and none of it is functional .

Visible impacts in the section include a permanent loss of some riparian functions due to dyking, and clearing of the riparian at the time of dyking leading to poor complexity of riparian cover and thus a poor diversity of nutrient and invertebrate inputs by the canopy. This translates further into poor channel complexity due to

a loss of LWD input as the primary channel-forming mechanism in an alluvial valley-bottom channel. Furthermore, when the dyking was carried out, aggrading substrate was also removed from the channel. This would have further decreased the jumps in hydraulic energy that facilitate fish passage and the effect that this sort of variability has in forming channel features. Again, the possibility of increased peak flows has to be considered. This would exaggerate the effects of the impacts above on simplifying and degrading the channel, and consequently increase the loss of fish habitat and the productivity of the reach. One of the final blows to this section may be the loss of holding habitat, presenting a possible barrier to upstream migration to more productive reaches. There is a **low** upslope impact potential in this reach due to a lack of upslope connectivity.

Plate 17 shows a representative photo of this section.

Due to the nature and severity of impacts on fish habitat, and the high value to target species, this section has a **high priority** for detailed assessment and restoration. Barriers to restoration include adjacent private land ownership, the public safety and property protection issues surrounding an alteration of flood control measures, the lack of solid data on peak flow increases, and the need to restore upstream to decrease peak flows if they are a root cause of the impacts here.

Section C

This Riffle-Pool (RPcw) channel has a **very high** primary habitat value to the target species in a stable state. However, the channel has a **moderate** habitat value overall, and is **aggrading**. This indicates a degree of impact. The habitat value for specific life-stages and general indicators of productivity is as follows:

- Complexity: poor to moderate
- Spawning: moderate

- Rearing: poor to moderate
- Overwintering: poor
- Holding: moderate
- Access to adjacent sections: good

Limiting factors to the value of this section to fish are low water levels, a lack of cover, a lack of stable pool tailouts, a lack of velocity refugia, poor access to alternative habitats, and possible frazl and anchor ice formation in cold temperatures. Indicators of recent channel disturbance are extensive areas of unvegetated bar, elevated mid-channel bars, and extensive riffle zones. A decrease in functional LWD is indicated by the "few" rating in the habitat condition assessment. Riparian impacts are insinuated by the dominant structural stage of the canopy. There are also some areas of grassland/shrub herb on the downstream right.

Visible impacts to the channel include dyking on the downstream right bank of the creek, bank erosion on the opposite bank downstream, loss of riparian canopy along the dyked section and permanent separation from the active channel, loss of floodplain access, loss of LWD function, and a rotational slump from the edge of an upslope road. The slump appears to have not failed into the channel significantly, but observations of the slump scarp showed signs of recent slippage. Some measures have been taken to drain subsurface water from the soil onto the face of the slump, and are of unknown age an effectiveness. An increase in toe erosion if the creek moves again to the downstream left may trigger a failure. Due to the size and possible impact that this slump could have if it failed, this section is assigned a **high** upslope impact potential. Most of the aggradation in the section is occurring at a sharp corner, dyked on one side, visible in Plate 9 of the Buck Creek photo mosaic. There is probably a sudden drop in hydraulic energy here as the creek dissipates it against the outside corner, knocking material out of suspension in the water column. Aggradation may also be due to bank erosion on the outside corner. Whatever the case, the square-corner design of

dyking here does not conform to natural patterns in stream geometry, and is having an impact on channel stability and habitat. Again, there is the possibility of increased peak flows, and upstream impacts may be frustrating the aggradation here as well.

Plate 19 shows a photo of the slump scarp described above.

Due to the nature and severity of impacts as indicated by the two-rating drop in habitat value, the intensive use by target species, and the high upslope impact potential, this section is given a **high priority** for detailed assessment and restoration. Barriers to restoration are adjacent private land ownership, the public safety and property protection issues surrounding an alteration of flood control measures, the lack of solid data on peak flow increases, the need to restore upstream to decrease peak flows if they are a root cause of the impacts here, and the need to stabilize the upslope problem prior to doing in-channel or riparian restoration.

3.2.1.2 Reach 2

Reach 2 describes the length of Buck Creek from the end of flood dyking to the mouth of the first major canyon on Buck Creek. It is confined in areas and is dominantly a Riffle-Pool channel type of slightly higher gradient than Reach 1. Reach 2 is 4.6 km in length and is broken into three sections:

- Section A: A confined section with larger substrate and greater upslope connectivity.
- Section B: A less-confined gravel-wood substrate section bordered by Dungate Creek upstream. Increased land-use and historic land-use issues in this section. Increase in bankfull width downstream of Dungate Creek.

- Section C: A partially confined gravel-wood substrate section upstream of Dungate Creek with moderate connection to upslope areas and lower levels of adjacent land-use.

Land-use in this reach includes a powerline corridor/crossing, two gravel quarries, the abandoned site of BV Concrete at the mouth of Dungate Creek, extensive cleared areas for hay farming and range-use, and upslope forestry south of the Dungate confluence (section C).

Target species and life-stages using this creek are chinook (J/Sp), coho (J/Sp), pink (Sp), steelhead (all) and rainbow trout (all). It is suspected that Dolly Varden/bull trout are present in this reach as well, although habitat use by life-stage is unknown since life history of Buck Creek population is also unknown (fluvial/adfluvial/stream resident). Known presence in the lower reaches of Dungate indicates at least occasional use of the mainstem.

Section A

This Riffle-Pool (RPcw) section has a **very high** primary habitat value for the target species in a stable state. However, the overall habitat value is only **moderate** and the channel is **degrading** . This indicates a degree of impact. The habitat value for specific life-stages and general productivity is as follows:

- Complexity: moderate
- Spawning: moderate
- Rearing: moderate
- Overwintering: moderate
- Holding: good
- Access to adjacent sections: good

Limiting factors to fish habitat value are a likely compaction of substrate, a lack of alternative habitats, the possibility of frazl ice formation in cold temperatures, low water levels, scouring, and the frequency of velocity refugia (more crucial at higher flows). Recent indicators of disturbance include extensive riffles, poor frequency and extent of pools, and parallel (non-functional) LWD. This is also indicated by the poor pool frequency (1-25% by area) and the poor frequency of LWD (few pieces). The lack of LWD (as the primary morphology control in this channel type) is responsible for poor complexity. The confined nature of the channel makes it laterally stable, and historic changes in channel stability were not noted over the past three decades.

Visible impacts in the channel are erosion, riparian loss and compaction at the powerline crossing, and mass movements from the upslope quarry on the downstream right, as well as the distinct absence and function of LWD in a reach with an abundance of fairly large deciduous and moderately large coniferous trees available for recruitment. The powerline crossing is a visible external sediment source due to the erosion of the fine-textured sandy access road on the steep slope to the downstream right, and may be a source of compaction both at the crossing, and downstream as the fines penetrate the cobble-gravel matrix. The quarry adjacent to the powerline crossing area (same side of creek) shows signs of mass movements into the sharp bend in the creek at plate 13 of the air photo mosaic. A survey of air photos in 1973 showed what appeared to be a bare slip face. A field check on this area shows an open grassy slope which is surrounded by poplar forest on both sides. Some of the adjacent trees appeared to indicate signs of recent slippage, but may be windthrow as well. There was also some hummocky terrain from the lip of the slope down to the creek on both sides of the grassy area, possibly creeping blocks. All signs seem to indicate recent mass movements, and this would be a probable consequence of clearing the forest to the edge of the canyon (which it was), and perhaps altering the water table during quarrying and the removal of overburden. Both of the above situations show that this section has a **high** upslope impact potential. The lack of LWD points to an increase in peak flows from upstream. All of the wood recruited by the channel has been

swept downstream by the higher discharges despite the likelihood that it was relatively large. This magnitude of discharge should not be occurring in a riffle-pool channel type, and it seems apparent that this is indeed a function of upstream and upslope, not urban, impacts to basin response. The decrease in pool habitat is in turn caused by a decrease in LWD, as well as the erosion of pool tailouts and subsequent loss of pool depth and increase in riffle extent (as pools become riffles).

Plates 20 to 22 show oblique photos of the upslope impacts and a representative photo of the section.

Due to the nature and severity of impacts, the intensive use by target species, and the high upslope impact potential, this section is designated as a **high priority** for detailed assessment and restoration. Barriers to restoration include adjacent private land, and the need to restore upstream and upslope areas prior to successful in-stream recovery to take place.

Section B

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to the target species in a stable state. However, overall habitat value is **moderate** and the channel is **aggrading**. It is likely that impacts have occurred. The habitat value for specific life-stages, and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: moderate
- Rearing: moderate to good
- Overwintering: good
- Holding: moderate to good
- Access: good

Limiting factors to the value and productivity of habitat in this section are an abundance of fine substrates, poor cover, poor frequency of stable pool tailouts/riffle crests, a possible temperature increase due to loss of canopy cover, and low water levels in sections at baseflows. Indicators of recent disturbance are extensive unvegetated bar, elevated mid-channel bars, eroding banks and poor pool frequency. Of note in this section is the extensive off-channel areas, which are of particular value for overwintering coho and chinook. There are also a few (not many) large, deep pools. Off-channel access and DO values during the winter would indicate more fully their values as overwintering habitat. The lack of large, clean substrate in this reach indicates that it may be limiting as overwintering and rearing habitat for steelhead and char. LWD is frequent but often dysfunctional, and pool areas are at the lower end of the scale (class 2). The shrub riparian type and structural stage are indicative of riparian impacts. This section is probably naturally laterally unstable, and air photo analysis since 1973 shows steady but not overly irregular lateral activity. Certain sections appear to be undergoing greater bank erosion due to a loss of bank strength from clearing of the riparian area for hay land and range-use by cattle. This area has a history of agricultural land-use dating back to the 1910-1920 period. The other significant land-use was Bulkley Valley Concrete which operated directly on the alluvial fan of Dungate Creek just North of the confluence. The riparian area was also cleared extensively at this site, but is now recovering. The company has not been operating since 1985. The Dungate fan is now used for cattle range land, and sections have been burned off for this purpose.

Visible impacts are bank erosion at cleared land, and an extensive area at the bottom of the section which has been blanketed by fine sediments. LWD is functional only at higher water levels, and much is parallel. Sediment sources include the eroding banks, and remnant siltation from the old BV Concrete site. The ability to store sediments, and dissipate energy at high flows is curtailed by the lack of LWD function. It is important to note the spatial distribution of fine

sediment deposits in this section. Of concern again is the exaggeration of these impacts by increased peak flows.

The upslope impact potential in this section is **low** due to poor connectivity with the channel.

Due to the nature and severity of impacts, shown by the two-fold drop in habitat value, and the importance of this section to target species, there is a **high priority** for detailed assessment and restoration. Barriers to restoration include adjacent private property and the need to restore upstream impacts and decrease peak flows before the integrity of in-stream works can be guaranteed.

Section C

This Riffle-Pool (RPgw) section has a **very high** primary habitat value to target species in a stable state. It has a **moderate** overall habitat value, and it is **aggrading**. This indicates a measure of impact. The habitat value for specific life-stages, and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: moderate
- Rearing: moderate
- Overwintering: moderate
- Holding: good
- Access to adjacent sections: good

Limiting factors to the value and productivity of habitats are an abundance of fine sediments in the lower end of the section, poor cover in sections, poor frequency of stable pool tailouts in the lower end of the section, probability of temperature increases due to low canopy cover in sections, and poor access to alternative habitats. Indicators of recent disturbance are extensive areas of unvegetated bar,

eroding banks, and isolated backchannels. Of particular interest is the large off-channel area at plate 24 of the photo mosaic which appears to be inaccessible, but is extensive, appears to be deep, and has good overhead and LWD cover. There are some larger substrate in this channel which could provide velocity refugia for rearing and overwintering. However, many seem to be high and dry for much of the year, as indicated by mid-stage water levels at the time of mosaic photography. Most of the habitat concerns in this section are concentrated at the lower end of the section where there is an area of range land, and a mass movement from an upslope cutblock. The section appears much more stable above this point. There has been some irregular lateral movement and a number of avulsions in the lower part of the section as well.

Visible land-use impacts occur at range-use land around the mouth of Dungate Creek where there is significant lateral movement and sediment deposition, and at a corner at which it is suspected that an upslope cutblock is either concentrating water over the edge of the canyon and increasing erosion of the clay slumps visible in plate 23, or there is an eroding gully above this areas from the edge of the cutblock. A distinct landslide scar was noted in a 1991 air photo of the area (30 BCB 91185 #95), and the slide appears to be occurring along a fire break. This activity , and a moderate connectivity between the upslope and the channel, give this section a **moderate** upslope impact potential. The lateral movements and avulsions in the lower part of the section are probably due to an increase in peak flows combined with land clearing and range use, which weakens the bank strength in a situation of increasing stress from water levels and velocities.

The nature and severity of impacts on habitat value in this section, combined with high use by target fish species, and a moderate upslope impact potential make this a **high priority** for detailed assessment and restoration. Barriers to restoration are adjacent private land concerns (only at bottom of section at Dungate confluence), and the need to stabilize upslope and upstream problems prior to in-stream or riparian restoration in this section.

3.2.1.3 Reach 3

Reach 3 defines the area of Buck Creek from reach 2 to the end of the long first canyon. It is a confined, higher gradient Cascade-Pool reach , with a short section of Step-Pool channel type. It is 1.3 km in length. There are frequent natural mass movements, and the dominant substrates are cobbles and boulders. LWD plays a less significant role in channel morphology here as clast size increases. Most of the surficial geology here is composed of colluvium, a large area of which is visible below the escarpment to the East of the creek on small-scale air photos, as indicated by drainage and vegetation pattern differences. The reach is broken up into three sections:

- Section A: The Cascade-Pool (CPcw) stretch which is slightly less confined and of lower gradient.
- Section B: The Step-Pool (SPbw) stretch with active natural mass movements and higher gradient
- Section C: similar to section A, but acts as a control point for debris above the narrowing canyon in section B.

There is no present land-use in this reach either adjacent to the creek or in the upslope area. There is a distinct possibility that this area was selectively logged in the late 1950's, when the Buck Creek Lumber Co. built a road up to the Buck Flats and Goosly Lake area. This road is still visible on small-scale air photos, and ran parallel to the canyon to the West.

Use of this reach by target species is relatively unknown, and the cascade in this canyon at section B is thought by some agencies to be a barrier to upstream migration for most species. The success in migrating through this barrier may vary annually with water levels, but the gradient (8%) and morphology of this section (there appears to be fairly frequent pools) indicates that it is probably passable for most fish most of the time. All species have been observed by

MELP, consultants, and local residents above this cascade. A letter from a local resident (MELP, 1986) states that there is one section of rapid incline on the creek (section B), but that it could be easily walked up the stream bed (indicating ease of passage). The species known to use the reach below this cascade are chinook (J/Sp), coho (J/Sp), steelhead (all), and rainbows (all). All of these species will use the rest of the reach in some capacity, as well as upstream habitat to the falls/canyon in Reach 8.

Section A

This Cascade-Pool (CPcw) channel has a **high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **degrading**, indicating that impacts to habitat have occurred. The habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: moderate to good
- Rearing: good
- Overwintering: poor
- Holding: good
- Access to adjacent sections: moderate

Limiting factors to the value of this habitat are large substrates inhibiting spawning (there are pockets of good gravels), scouring, poor alternative habitats, and the probability of frazl/anchor ice formation in the water column at low temperatures. An indicator of recent disturbance is the frequent areas of scour, and extensive riffles. Stone-lines on the cascade crests appear to be eroding fairly consistently at the upper end of the section, which is leading to loss of pool habitat and an increase in riffle area. These disturbances and impacts are indications of increased peak flows, and disequilibrium in the channel morphology as it adjusts to this situation.

The nature and severity of impacts, and the subsequent drop in habitat value by one rating, combined with high use by target species, and a low upslope impact potential make this section a **moderate** priority for detailed assessment and restoration. A barrier to restoration is the need to reduce peak flows in the headwater areas prior to downstream restoration to guarantee the structural integrity of works.

Section B

This section of Step-Pool (SPbw) has a **low to moderate** primary habitat value to the target species. It has an overall habitat value is **low to moderate** and the channel is **degrading** (minimally). This indicates some degree of impact. Habitat values for specific life-stages and general productivity are as follows:

- Complexity: moderate
- Spawning: poor
- Rearing: poor
- Overwintering: poor
- Holding: moderate
- Access to adjacent sections: moderate

Limiting factors for this section are poor spawning substrate (too large), scouring, no alternative habitats, low water levels during baseflows, infrequent velocity refuges (secondary pool habitat and large substrates out of turbulent area provide some VR), and a high probability of frazl and anchor ice formation in the water column at low temperatures.

Increased peak flows may be causing some minimal degradation here, as indicated by infrequent organized stone-line patterns. This may be a natural

phenomena, however, and a more detailed assessment of this reach is definitely required.

Due to the need for secure access to the extensive areas of higher value habitat upstream, this reach has a **moderate priority** for detailed assessment. It is as of yet unknown whether restoration is either feasible or appropriate.

Section C

This section of Cascade-Pool (CPcw) channel has a **high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **degrading**. The habitat values for specific life-stages and general indicators of productivity are:

- Complexity: moderate
- Spawning: poor to moderate
- Rearing: moderate
- Overwintering: poor
- Holding: moderate
- Access to adjacent sections: moderate

Limiting factors to the value of this section are scouring, poor frequency of stable pool tailouts for spawning, infrequent velocity refugia, and no alternative habitats. Indicators of recent disturbance are areas of scour, limited pool frequency and extent, parallel LWD, and a recently formed LWD jam. The downstream end of this section is thought to be an important sediment and debris catchment located at the point where the canyon walls narrow. As with section A, stone lines here have been eroded, and riffle area increased due to channel adjustments to increased peak flows. The damage here is more extensive than section A.

Due to the nature and severity of impacts, as witnessed by the drop in habitat value by one rating, and the use of this section by target species, it has been assigned a **moderate priority** for detailed assessment and restoration. A barrier to restoration is the need to reduce peak flow problems in the headwaters prior to doing instream/riparian restoration in this reach.

3.2.1.4 Reach 4

Reach 4 comprises the area of Buck Creek from the first canyon to the area above the first Buck Flats Road Bridge. It is moderately confined, low gradient, Riffle-Pool (RPgw) channel, with an irregular wandering channel pattern. It is 5.1 km in length, and receives drainage from Bob Creek, a small, steep second order tributary. The reach is split into three sections:

- Section A: The length of channel downstream of Bob Creek
- Section B: The length of channel from Bob Creek to the first Buck Flats Road bridge, in which there is increasing land use
- Section C: The length of stream from Buck Flats Bridge 1 to the reach 4/5 break

There is a distinct increase in bankfull width from the top to the bottom of this reach.

Adjacent and upslope land-uses include forestry and forest road-building, agriculture (hay farming and range-use), the Buck Flats Road crossing and powerline corridor, and residences. There is a history of mining on Bob Creek which extends as far back as 1914. The area above where Buck Flats Road crosses the creek has also experienced settlement and land-use since the early part of the century (approximately 1910). This includes agriculture, forestry (selective and clearcutting), and road building. Grazing was and is probably the most prevalent land use on the immediately adjacent lands to the creek.

Fish species using this reach are coho (J/Sp), chinook (J/Sp), steelhead (all), and rainbow (all). The chinook spawners may not be spawning in this reach (they have only been observed spawning in Reach 6), but will definitely be holding and migrating through this area in the August-September period. Furthermore, coho have not actually been visually observed spawning above the cascade in Reach 3. It is unlikely that juvenile coho would be able to pass the cascade in the upstream direction, so it is assumed that spawning occurs above the cascade and juveniles migrate downstream. There has also been occasional coho fry releases by DFO and the Toboggan Creek fish hatchery above the cascade, and the fish observed may have been hatchery fry (the record of observation was not life-stage specific) (B. Donas, pers. comm.).

Section A

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate to high** and the channel is **aggrading** . Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: moderate
- Rearing: good
- Overwintering: moderate to good
- Holding: good
- Access to adjacent sections: good

Limiting factors to habitat value are smothering by fine sediments, poor cover, possible increase in temperature due to land clearing of riparian canopy, and water levels at baseflows. Indicators of recent disturbance include multiple channels (braiding), eroding banks, and recently formed log jams. The riparian canopy is mature mixed forest, with open immature deciduous stands and

intermittently at range land. LWD is abundant but has a clumped distribution. Off-channel habitat is excellent in this section, and access also looks good. However, many of these areas are now within the active channel width due to increased peak flows and lateral activity, and may not provide refuge in high turbidity or frazl ice events.

Visible impacts within the section are riparian canopy clearing and riparian damage from range-use (loss of understory species), several mass movements (one from an upslope cutblock to the downstream right (top of plate 33), two from cleared land directly adjacent to the stream (plates 39-40)), bank erosion, and possible aggradation from upstream sediment delivery with localized areas of degradation, as indicated by elevated point and mid-channel bars. The frequency of mass movements caused by land-use gives this section a **high** upslope impact potential. There has also been fairly extensive channel pattern simplification here, as witnessed by a number of recent avulsions and lateral activity. These cumulative impacts are manifested as the limiting factors on habitat value above, the most significant probably being the external and internal sources of fine sediments from within the section and from upstream.

Given the nature and severity of impacts, the value to target species, and the high uplsope impact potential, this section is given a **high priority** for detailed assessment and restoration. Barriers to restoration are continued range-use by the grazing licensee (Crown land), and the need to reduce upstream sources of sediment and peak flows, and upslope impacts prior to instream and riparian restoration.

Section B

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate to high** and the channel is **aggrading** . Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: moderate
- Rearing: moderate to good
- Overwintering: moderate
- Holding: good
- Access to alternative sections: good

Limiting factors to habitat value are smothering by fine sediments, poor cover, possible elevated temperatures due to canopy removal, and poor alternative habitats. Indicators of recent disturbance are eroding banks, extensive areas of unvegetated bar, and recently formed log jams. There is an abundant frequency of LWD, but the distribution is fairly clumped (mostly in one large log jam).

Visible impacts are an old secondary road eroding into the creek near the Buck Flats Road bridge crossing, range-use impacts to riparian function, and a loss of riparian at cleared land. The latter two areas show occasional bank erosion, and the log jam below Buck Flats Bridge 1 forced bank erosion and lateral channel activity to the downstream left during the recent flood. The extent of sediment delivery in this case was probably exaggerated by the loss of riparian vegetation adjacent to Buck Flats road.

There is a **low** upslope impact potential due to a lack of mass movement activity observed.

Plates 23 and 24 show impacts and representative photos of this section.

Due to the nature and severity of impacts in this section, as indicated by a 1.5-fold decrease in habitat value, and the use by target species, a **moderate priority** for detailed assessment and restoration is assigned. Barriers to restoration include

continued range-use by the grazing licensee in possible areas for riparian treatments, and the need to stabilize upstream sources of sediment and peak flows prior to instream and riparian restoration here.

Section C

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **aggrading** . Impacts are suspected. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: good
- Rearing: moderate
- Overwintering: moderate
- Holding: moderate
- Access to adjacent sections: good

Limiting factors to habitat value are smothering by fine sediments, a lack of alternative habitats, possible water quality impacts (dissolved oxygen) during low flow and winter periods, and a poor frequency of velocity refugia. Pool depths and areas appear limited in parts of this section.. Indicators of recent disturbances are limited pool frequency and extent, extensive riffles, and parallel LWD. The dominant riparian zone is mixed young forest, with frequent cleared areas of grassland or shrub-herb types, and/or open stands of deciduous. Open stands and shrub-herb areas appear most frequently at range land.

Visible impacts to the channel include a clay slump above the Buck Flats Road into a ditchline (not visible on photo mosaic) just past the bridge crossing, and loss of riparian canopy at the bridge crossing and at range-use land. The impacts here appear to be disproportionately greater than the sum of those direct impacts

listed above. Therefore, cumulative impacts are suspected, namely peak flows and upstream sediment delivery causing a loss of pool depth, and loss of LWD function.. Banks in this section appear fairly stable, indicative of a change in bank texture relative to adjacent sections. The single slide above Buck Flats Road, and the moderate upslope connectivity give this section a **moderate** upslope impact potential.

The nature and severity of impacts in this section, as shown by a two-fold decrease in habitat value, combined with use by four target species with varying life stages, and a moderate upslope impact potential show that this section is a **high priority** for detailed assessment and restoration. Barriers to restoration include continued use of the riparian area by the grazing licensee, and the need to reduce upstream sediment delivery and peak flows prior to instream restoration in this section.

3.2.1.5 Reach 5

Reach 5 defines the area of Buck Creek from Reach 4 to the downstream end of the valley bottom burned in the Swiss Fire. It is 6.2 km in length. The reach is split into three sections:

- Section A: A highly and probably historically depositional area of the creek, described as an area of extreme lateral instability (3+ channels, log jams, numerous active and relic offchannels), followed by a rapidly confined, near-180 degree bend in the creek. This feature acts to store water, sediment and debris behind it, and **its function of buffering hydrologic and sediment fluxes from upstream is probably extremely important to the health of downstream reaches.**
- Section B: A higher gradient, degrading section with larger substrate
- Section C: A lower gradient aggrading section with more intensive land use

Adjacent and upslope land-uses within this reach are agriculture, residences, main and secondary roads and road crossings, and forestry. This area is the first part of what is locally known as Buck Flats, and it has a long history of land use, as outlined previously. Industrial forest harvesting has been carried out here since 1950, and this area (South to Goosly Lake and including Parrot Lakes) usually made up the largest portion (up to 90%) of the Annual Allowable Cut in the district. There was a significant increase in logging in this area in the 1970's, when the large BV Forest Industries complex was established, and the Pulp Harvesting Area (PHA) tenure was granted. The most recent area of logging has been carried out along the Poplar FSR, on the uplands to the west of this reach. Some cultivation, and dominantly grazing has been occurring here since approximately 1910, and most of the valley bottom, from here to reach 7 and also in reach 9, has been cleared extensively for this purpose.

Fish species using this reach are coho (J/Sp), chinook (J/Sp), steelhead (all), and rainbow (all). The chinook spawners may not be spawning in this reach (they have only been observed spawning in Reach 6), but will definitely be holding and migrating through this area in the August-September period. Furthermore, coho have not actually been visually observed spawning above the cascade in Reach 3. It is unlikely that juvenile coho would be able to pass the cascade in the upstream direction, so it is assumed that spawning occurs above the cascade and juveniles migrate downstream. There has also been occasional coho fry releases by DFO and the Toboggan Creek fish hatchery above the cascade, and the fish observed may have been hatchery fry (the record of observation was not life-stage specific) (B. Donas, pers. comm.).

Section A

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: poor-moderate
- Rearing: good
- Overwintering: good
- Holding: moderate
- Access to alternative sections: moderate

Limiting factors to habitat value are smothering by fine sediments, water levels at low flows, probable temperature increase due to riparian canopy removal, and possible seasonal access problems through the extensive log jam area in this section. Indicators of recent disturbance are recently formed log jams, multiple channels (braiding), and extensive sediment wedges (upstream of the topographic control). There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area consists of stands of mixed young forest intermixed with open shrub-herb clearings.

Visible impacts are a mass movement from cleared/range-use land into the channel (large earthflow (plate 53, appendix B), and loss of and/or simplification of the riparian canopy and its functions due to land clearing and range use. The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely peak flows and upstream sediment delivery causing a decrease in pool area and depth, a greater level of lateral activity and sediment/debris deposition above the topographic control , and a decrease in the function of LWD in other parts of the section.

There is a **moderate** upslope impact potential due to the activity observed..

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a moderate upslope impact potential, and the use by four target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, continued land use after restoration, and the need to stabilize upstream sources of sediment and peak flows prior to instream and riparian restoration here.

Section B

This Riffle-Pool (RPcw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **degrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: poor
- Spawning: moderate-good
- Rearing: moderate
- Overwintering: moderate
- Holding: moderate-good
- Access to alternative sections: good

Limiting factors to habitat value are scouring, poor cover, a lack of alternative habitats, and possibly poor water levels at low flows for rearing/overwintering. Indicators of recent disturbance are eroding banks, areas of scour, and poor pool frequency and extent. There is no visible LWD in the section. The extent of pool habitat is 0% of the wetted channel area. The riparian area is dominantly shrub-herb and grassland species, with some areas and isolated stands of mixed young forest.

Visible impacts are a loss and/or simplification of the riparian canopy and function, especially that of large LWD input, there is also occasional bank erosion

at cleared land, and scouring of the channel to bedrock (upper end). The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely peak flows and upstream sediment delivery causing homogenization of the channel due to a loss of pool habitat and LWD function.

There is a **low** upslope impact potential due to no activity being observed from areas of land-use, and only a moderate connectivity to the channel..

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a low upslope impact potential, and the use by four target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include a small area of adjacent private land ownership on the upper end of the section, and the need to stabilize upstream sources of sediment and peak flows prior to instream and riparian restoration here.

Section C

This Riffle-Pool (RPcw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate to high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: moderate -good
- Rearing: moderate-good
- Overwintering: moderate-good
- Holding: moderate-good
- Access to alternative sections: good

Limiting factors to habitat value are smothering by fine sediments, poor cover, limited numbers of stable pool tailouts for spawning, possible water levels too low for rearing and overwintering at baseflows, questionable access to alternative habitats, and the probability of frazl ice formation during low temperatures. Indicators of recent disturbance are eroding banks and recently formed log jams. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is dominantly mixed forest at a pole-sapling structural stage with frequent areas of shrub-herb and grassland, and sparse stands of mixed young forest.

Visible impacts are rip-rapping at two bridges (Buck Flats Road and a small secondary road) causing separation of the riparian area from the channel and possibly increased water velocities, the old bridge earthen bridge abutment at the Buck Flats Road bridge #2 wasting into the creek, a fine textured slump on a corner below grazing land, and bank erosion and losses/simplification of riparian canopy at cleared and range-use lands. The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely upstream sediment delivery causing a loss of pool depth and extent due to in-filling.

There is a **moderate** upslope impact potential due to observed activity and channel connectivity.

Plates 25 and 26 show representative photos of this reach, and impacts.

Due to the nature and severity of impacts in this section, as indicated by a 1.5-fold decrease in habitat value, a moderate upslope impact potential, and the use by four target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, continued land-use after restoration, and the need to stabilize upstream and

upslope sources of sediment and peak flows prior to instream and riparian restoration here.

3.2.1.6 Reach 6

Reach 6 comprises the area of Buck Creek which suffered riparian losses and damage in the Swiss Fire of 1983. This reach is an unconfined Riffle-Pool channel 5.5 km in length. It is split into three sections:

- Section A: This section showed more extensive depositional activity on point bars, and had a greater intensity of land-use
- Section B: This section is extensively beaver dammed, and had minimal turbulence.
- Section C: A higher gradient section similar to A, but with less land-use

Adjacent and upslope land-uses in this reach are roads (main and secondary), residences, forestry (salvage logging, clearcutting, silviculture), secondary bridge crossings, and agriculture (range-use, minimal cultivation).

Another source of impacts to Buck Creek is the Swiss Fire area. The fire burned 8% of the watershed area in 1983, including parts of the valley bottom. Field checks were done on tributaries draining the Swiss Fire area to ascertain whether there was a high degree of sediment transport and/or water delivery. Small-scale air photos were analysed for mass movements in the fire area, as was the work of LaRose and Rencoret (1996). Dave Wilford, the regional hydrologist at the Ministry of Forests, was consulted as to known effects of the fire on hydrology in the Buck watershed. It was found that although there was little evidence of mass movement activity, the unnamed tributaries to the creek appeared to have a very high bankfull width to wetted width and depth and were aggraded at and below the Buck Flats Road. This may indicate sediment delivery, and/or that culverts at the road crossing are undersized for the discharges. It certainly indicates that the

tributaries are "flashy", carrying large amounts of water in freshets and little water the rest of the year. Wilford stated in a report he did on the area (1984), that peak flows in Buck Creek were not expected to be impacted a great deal by increased rates of snowpack melt, and increases in the rate of delivery (to the creek) and the levels of soil moisture in the absence of transpiration by vegetation. This was based on an analysis of the elevation and aspect of the fire area. He also stated in this report that rates of sediment delivery should not have increased following the fire if salvage logging and road building was carried out properly, and because the fire break had been water-barred and revegetated. An interview with Mr. Wilford revealed that the salvage logging had not been carried out under ideal conditions. It had been done mostly in the spring, on saturated soils, and this might have increased both sediment and water delivery to the tributaries. Much of the riparian area was also burned, and the effects of this on bank erosion as a sediment must also be considered. Furthermore, cumulative impacts tend to propagate downstream, and the effects of any single impacts are exaggerated as one proceeds in that direction. It is strongly suspected that this fire plays a part in the cumulative impacts observed in Buck Creek.

Fish species using this reach are coho (J/Sp), chinook (J/Sp), steelhead (all), and rainbow (all). The chinook spawners may not be spawning in this reach (they have only been observed spawning here), but will definitely be holding and migrating through this area in the August-September period. High densities of chinook juveniles have been observed rearing behind the log jams in this reach (MIC Notes, 1997). Furthermore, coho have not actually been visually observed spawning above the cascade in Reach 3. It is unlikely that juvenile coho would be able to pass the cascade in the upstream direction, so it is assumed that spawning occurs above the cascade and juveniles migrate downstream. There has also been occasional coho fry releases by DFO and the Toboggan Creek fish hatchery above the cascade, and the fish observed may have been hatchery fry (the record of observation was not life-stage specific) (B. Donas, pers. comm.). Steelhead redds have also been observed in this reach by MELP staff (MELP, 1980).

Section A

This Riffle-Pool (RPcw channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **degrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: moderate
- Rearing: moderate
- Overwintering: poor
- Holding: moderate
- Access to alternative sections: moderate

Limiting factors to habitat value are extensive areas of scour, poor cover, a poor frequency of alternative habitats (overgrown off-channel, but one unnamed tributary may provide an alternative), and compaction. Indicators of recent disturbance are eroding banks and extensive areas of scour. There is a poor amount of LWD in the section, and the distribution is even. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is dominantly shrub-herb with conifers in the understory, and with intermixed areas of grassland from grazing. The width of riparian canopy is mostly quite thin along the stream.

Visible impacts are a large clay slump (possibly related to land-use), extensive areas of bank erosion at cleared and range-use land and at a rip-rapped section of Buck Flats Road which is directly in the floodplain, loss of riparian canopy and function in many sections due to the Swiss Fire, and sediment delivery from two tributaries draining the fire area (possibly exaggerated by undersized culverts on Buck Flats Road). Degradation here appears to be greater than above the most

upstream tributary draining the fire area, indicating an increase in water delivery to the channel. The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely peak flows and upstream sediment delivery causing degradation of the channel and disconnection from the floodplain (as indicated by abundant boulder substrate in a low gradient channel, and overgrown relic off-channel areas with fairly even-aged vegetation, respectively). There may be seasonal access problems due to occasional beaver dams.

There is a **moderate** upslope impact potential due to the one clay slump observed, and moderate connectivity.

Plates 27 and 28 show impacts to this section and an aerial view of the Swiss Fire area. above Buck Creek.

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a moderate upslope impact potential, and the use by four target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, continued land-use in the riparian area after restoration, and the need to stabilize upstream and upslope sources of sediment and peak flows prior to instream and riparian restoration here.

Section B

This Riffle-Pool (RPcw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate to good** and the channel is **degrading**. The degradation is intermixed with areas of aggradation, and beaver dams appear to be adding an element of stability to the section. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate-good
- Spawning: moderate-good
- Rearing: moderate to good
- Overwintering: moderate to good
- Holding: good
- Access to alternative sections: moderate

Limiting factors to habitat value are scouring in sections, poor cover, a probable increase in water temperature due to riparian canopy removal, possible water quality (dissolved oxygen) concerns during the winter, poor access to alternative habitats, and seasonal access problems through beaver dams. Indicators of recent disturbance are eroding banks and areas of scour. There is a poor amount of LWD in the section, and the distribution is even. The extent of pool habitat is 1-25% of the wetted channel area, most of the section being extensive areas of glide. The riparian area is shrub-herb and grassland, with occasional conifers in the understory, and an area of young mixed forest.

Visible impacts are eroding banks and loss of off-channel access due to loss of riparian canopy and cumulative impacts. Loss of riparian canopy and function, as well as simplification thereof occurs at range-land, residences, and burned-over areas. Increased sediment and water delivery may occur at the upstream tributary draining the Swiss Fire area. The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely peak flows and upstream sediment delivery causing degradation of pool tailouts and the creation of long glides, as well as channel incision and isolation of the floodplain. Most of the off channel in this reach was not even accessed by floodwaters this spring, indicating a definite separation from the channel. Beaver dams appear to be buffering some of the effects of peak flows, acting to catch some bedload, and creating some minor lateral complexity, giving this reach a higher habitat value than it would otherwise have.

There is a **low** upslope impact potential due to no activity observed and low connectivity..

Due to the nature and severity of impacts in this section, as indicated by a 1.5 - fold decrease in habitat value, a low upslope impact potential, and the use by four target species, a **moderate priority** for detailed assessment and restoration is assigned. Barriers to restoration include, continued land-use after restoration, and the need to stabilize upstream sources of sediment and peak flows prior to instream and riparian restoration here.

Section C

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: poor
- Rearing: moderate to good
- Overwintering: poor
- Holding: good
- Access to alternative sections: moderate

Limiting factors to habitat value are smothering by fines (dominant substrate), likelihood of poor water quality (DO, temperature), poor cover, poor access to alternative habitats, and seasonally poor access through beaver dams. Indicators of recent disturbance are eroding banks and extensive unvegetated bars. There is a low amount of LWD in the section, and the distribution is even. The extent of

pool habitat is 51-75% of the wetted channel area. The riparian area is shrub-herb and grassland.

Visible impacts are bank erosion and loss of/simplification of the riparian canopy and function. due to range use and fire impacts. There may be seasonal access problems through beaver dams here.

There is a **low** upslope impact potential due to low connectivity.

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a low upslope impact potential, and the use by four target species (but likely only for rearing), a **moderate priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and continued land-use after restoration.

3.2.1.7 Reach 7

Reach 7 comprises the regularly meandering, low gradient, unconfined channel from the end of Reach 6 to the mouth of the second canyon above Buck Flats. It is 6.3 km in length, and is treated as all one section.

Land use in this Reach includes grazing lands and some small private cutblocks. It is likely that this reach too has a long history of land-use for agriculture, and may have been cleared many years ago for this purpose.

Fish species in this reach are chinook (J/Sp), coho (J/Sp), steelhead (all), rainbow (all). The lower gradients and poor in-stream cover, with likely higher temperatures make this a poor reach for steelhead, and they will likely use it only for migrating and holding. chinook and coho, as well as rainbows, which are less sensitive to temperature increases probably use this reach for rearing and possibly spawning. There appear to be some good gravels but fine sediment deposits visible on bars show that smothering by fines may inhibit egg survival. This may

be an especially important reach during freshets and other high turbidity events, with abundant alternative habitats and better complexity than adjacent reaches

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate to good
- Spawning: moderate to good
- Rearing: good
- Overwintering: moderate
- Holding: good
- Access to alternative sections: good

Limiting factors to habitat value are smothering by fine sediments, poor cover in many sections, elevated temperatures and decreased dissolved oxygen due to autochthonous growth, and seasonally poor access due to beaver dams. Indicators of recent disturbance are extensive areas of unvegetated bar, bank erosion, and multiple channels. There is a poor amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 51-75% of the wetted channel area. The riparian area is shrub-herb and grassland, with some areas of mature conifers.

Visible impacts are bank erosion and siltation, with bank erosion occurring most frequently and extensively at cleared/ range-use land. Loss of and simplification of the riparian area has occurred leading to a loss of many of the riparian functions. The extent of bank erosion in this reach is very severe, and this may be a major sediment source to downstream areas.

There is a **low** upslope impact potential due to low connectivity.

Due to the nature and severity of impacts in this section, as indicated by a one-fold decrease in habitat value, a low upslope impact potential, and the use by 4 target species, a **moderate priority** for detailed assessment and restoration is assigned. A moderate , rather than a low, priority is assigned because of the extent of bank erosion and the possible downstream impact from this. Barriers to restoration include adjacent private land ownership, continued land-use after restoration, and the need to stabilize upstream sources of sediment and peak flows prior to instream and riparian restoration here.

3.2.1.8 Reach 8

Reach 8 is the confined, sinuous, dominantly Cascade-Pool channel in the second canyon on Buck Creek. It is 4 km in length, and is split into three sections:

- Section A: A less confined section, with more deposition and some off-channel areas
- Section B: Greater bedrock control of the channel, this is a transitional channel for sediment transport
- Section C: Step-Pool (SPr) channel, set of four impassable falls

There is no adjacent land-use in this reach. Historic land-use patterns are unknown.

Species in this reach, as indicated by the lack of downstream barriers, channel type, gradient, and MELP file information (Bustard, 1989, MELP, 1986), are coho (J/Sp), chinook (J/Sp), steelhead (all), and rainbow (all). It is possible, given downstream (Reach 1/2) observations, and the ability to migrate long distances (Haas, 1997), that this reach may support a population of Dolly Varden and/or bull trout. However, since this is not a glacier or summer snowpack-fed system, water temperatures for these species are probably limiting. The falls at the end of

this reach is thought to be impassable to all species, and to be a definitive marker for the split between the steelhead and rainbow trout populations in the watershed. There may be some blurring of boundaries by the successful downstream migrations of rainbows.

Section A

This Cascade-Pool (CPcw) channel has a **high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is **degrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: good
- Rearing: good
- Overwintering: good
- Holding: good
- Access to alternative sections: good

Limiting factors to habitat value are the frequency of in-channel velocity refuges. An indicators of recent disturbance is parallel LWD and areas of scour. There is a poor amount of LWD in the section (despite the healthy riparian area), and the distribution is clumped. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is mature coniferous forest. This intact riparian area could serve as a template for other areas in the watershed

Visible impacts are the loss of stone-lines and the loss of pool habitat due to peak flows.

There is a **low** upslope impact potential due to a lack of activity observed, and no upslope land-use.

Due to the nature and severity of impacts in this section, as indicated by no decrease in habitat value, a low upslope impact potential, and the use by four target species, a **low priority** for detailed assessment and restoration is assigned.

Section B

This Cascade-Pool (CPb) channel has a **moderate** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **stable**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: moderate
- Rearing: moderate
- Overwintering: moderate
- Holding: moderate
- Access to alternative sections: moderate

Limiting factors to habitat value are stable pool tailouts and large substrate for spawning, a poor frequency of velocity refugia, and no alternative habitats. Indicators of recent disturbance are areas of scouring. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is mature coniferous forest.

There are no visible impacts.

There is a **low** upslope impact potential due to no adjacent land-use concerns.

Due to the nature and severity of impacts in this section, as indicated by no decrease in habitat value, a low upslope impact potential, and the use by four target species, a **low priority** for detailed assessment and restoration is assigned.

Section C

This Step-Pool (SPr) channel has a **low** primary habitat value to target species in a stable state. The overall habitat value is **low** and the channel is **low**. There is no land-use concern here, and no visible impacts.

This section has a **low priority** for detailed assessment and restoration

3.2.1.9 Reach 9

Reach 9 is a regularly to tortuously meandering Riffle-Pool channel in a broad, unconfined flats section of Buck Creek. It is 10.2 km in length, and is split into two sections:

- Section A: Short higher gradient confined section with forestry-related land-use
- Section B: Long meandering, very low gradient section with range land for cattle as the primary land-use

Fish species using this reach are rainbow trout (all). Note that this reach contains a degree of habitat variability at the boundary between the two sections which could serve to support multiple life-stages.

Section A

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is

stable. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: good
- Rearing: good
- Overwintering: good
- Holding: good
- Access to alternative sections: moderate

Limiting factors to habitat value are possible compaction , a lack of alternative habitats, and poor access to the downstream reach. There are no indicators of recent disturbance. There is a poor amount of LWD in the section, and the distribution is even. The extent of pool habitat is 51-75% of the wetted channel area. The riparian area is young coniferous forest.

Visible impacts are a distinct lack of LWD in a channel with a fairly healthy riparian area. Increased peak flows are thought to be the cause of this phenomenon. Some compaction of gravels is also suspected, due to the high proportion of fines in the substrate in the upstream section. The clearcut area above this section should be examined more carefully to see if there is any delivery of sediment to the channel.

There is a **low** upslope impact potential due to no activity observed.

Due to the nature and severity of impacts in this section, as indicated by no decrease in habitat value (the decrease was due to poor access to the downstream section, a function of the falls not land-use), a low upslope impact potential, and the use by one target species, a **low priority** for detailed assessment and restoration is assigned.

Section B

This Riffle-Pool channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate to high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: poor
- Rearing: good
- Overwintering: moderate
- Holding: good
- Access to alternative sections: good

Limiting factors to habitat value are smothering by fines, poor complexity of cover types, a likely low level of DO due to the fairly infrequent occurrence of flowing water in the section, and increased temperatures. Indicators of recent disturbance are eroding banks, recently formed log jams, and extensive areas of unvegetated bar. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 76-100% of the wetted channel area. The riparian area is young coniferous forest in approximately equal proportions with shrub-herb and grassland areas. It is thought that wetness may control the numbers and distribution of conifers in this section, and there is also evidence of extensive range-use by cattle (numerous cattle-tracks).

Visible impacts are aggradation and eroding banks due to adjustments to higher peak flows and inputs of sediment from Klo Creek. There appears to be an increasing but small loss in sinuosity as one progresses towards the Reach 9/10 break due to avulsions and other lateral activity. Cutoff activity is high here, as evidenced by a number of newly formed oxbows. It is unknown whether this level of lateral activity is regular or irregular. A longer temporal range of air

photos would have to be acquired to determine if more lateral activity occurred after the Paul Fire of 1961, or the extensive clearcutting in the Klo Creek watershed in 1992 (possible vectors to peak flows in Buck Creek).

There is a **low** upslope impact potential due to poor connectivity.

Due to the nature and severity of impacts in this section, as indicated by a 1.5-fold decrease in habitat value due to cumulative impacts, a low upslope impact potential, and the use by one target species, a **low priority** for detailed assessment and restoration is assigned. It is thought that restoration will occur naturally and rapidly here following a decrease in peak flows.

3.2.1.10 Reach 10

Reach 10 comprises the area of Buck Creek from Reach 9 to the outlet of Goosly Lake. It is an irregularly sinuous Riffle-Pool channel through a flats area. It is split into two sections of equal gradient:

- Section A: The area of channel below Klo Creek. It is of a distinctly different sediment and hydraulic character than the upstream section, with a much greater bankfull width and a much higher proportion of gravel/cobble substrate.
- Section B: A high-fines channel and wetland complex at the outlet of Goosly Lake.

There is no land-use adjacent to this reach. There is a great deal of forestry in the upslope area, but there is very low connectivity between the channel and the upslope.

Rainbow trout are thought to use this reach for all life stages.

Section A

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: good
- Rearing: good
- Overwintering: moderate to good
- Holding: good
- Access to alternative sections: good

Limiting factors to habitat value are smothering by fines, scouring in some areas, poor cover due to an increased bankfull width, and a possible temperature elevation. Indicators of recent disturbance are extensive areas of unvegetated bars, bank erosion, and recently formed log jams. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 51-75% of the wetted channel area. The riparian area is dominantly shrub-herb in the immediate floodplain area, and young coniferous forest in the seasonally wetted floodplain. The width of the shrub band is variable and is sometimes nil.

Visible impacts are an increased bankfull width, numerous overgrown offchannel areas, signs of channel incision and what appears from visible bar deposits to be a high proportion of fines in the substrate. The channel incision in an aggrading reach seems strange, but it is thought that this section must experience conditions as both an erosional and a depositional channel, as a function of water velocities. Critical water velocities at which this status changes are probably during the spring freshet and subsequent high water events. The root cause of these impacts is probably increased peak flows from Klo Creek and the Goosly Lake/Upper

Buck Creek areas, in which there is a significant area of high elevation clearcuts. Whether ECA's at this elevation exceed safety margins (25-30% of watershed area) for runoff increasing peak flows during critical periods of snowmelt The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above.

There is a **low** upslope impact potential due to poor connectivity with the channel.

Due to the nature and severity of impacts in this section, as indicated by a one-fold decrease in habitat value, a low upslope impact potential, and the use by one target species, a **low priority** for detailed assessment and restoration is assigned.

Section B

This Pond-Lake (L) channel has a **high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is **stable**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: poor
- Spawning: poor
- Rearing: excellent (at downstream end)
- Overwintering: good
- Holding: good
- Access to alternative sections: good

Limiting factors to habitat value are stable pool tailouts with good coarse substrate. There are no indicators of recent disturbance. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of

pool habitat is 76-100% of the wetted channel area. The riparian area is shrub-herb and mature coniferous.

There are no visible impacts.

Plate 29 shows some of the extensive logging above Goosly Lake to the East.

Due to the nature and severity of impacts in this section, as indicated by no decrease in habitat value, a low upslope impact potential, and the use by one target species, a **low priority** for detailed assessment and restoration is assigned.

3.2.1.11 Reach 11 (Upper Buck Creek)

This Reach encompasses the area from the inlet of Goosly Lake to the confluence of two unnamed tributaries at the end of the study area in this watershed. Beyond this point, the forest harvesting in the upslope decreases significantly, there is no road adjacent to the creek, and the creek becomes predominately a wetland. This reach is 6.2 km long, and is split into two sections:

- Section A: A predominately wetland section which receives the waters of Bessemer Creek. This creek is the receiving environment for discharges from a tailings pond at the Equity Silver Mine site, a decommissioned mine.
- Section B: A moderately confined Riffle-Pool channel which is paralleled by FSR-2417 road

Land-use in this area has been dominantly forestry. Records of openings go back as early as 1965, but logging was selective or small clearcuts until the early 1970's when a large portion of the Western slope of this Reach was clearcut. This activity continued into the 1980's, to 1989. There is record of a wildfire in 1920 as well which was less than 100 hectares in size. There are 13 small first and second order intermittent (mostly) tributaries which run through cutblocks of

varying age (<30 years old) into this reach, including Bessemer Creek. This area is planned to have a high future level of logging (MIC Notes, 1997). The Equity Mine operated for 14 years from 1980 until 1994, when it was decommissioned. There has been a significant Acid Mine Drainage (AMD) problem from this facility, and it has had impacts on Upper Buck Creek. However, the impacts associated with large-scale underground mining are beyond the scope and assessment methods of WRP, and they will not be discussed in detail in this report.

Target species use in this Reach is by rainbow trout, which use section A for limited rearing and migration to the lake and to section B for spawning, rearing, and overwintering (Bustard, 1989). The numbers of spawners and juveniles using the upper section will increase due to the replacement of a culvert obstruction with a bridge in the summer/fall of 1997.

Section A

This Lake-Pond channel has a **high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **stable**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: poor
- Rearing: moderate
- Overwintering: poor
- Holding: good
- Access to alternative sections: good

Limiting factors to habitat value are a lack of stable pool tailouts and substrate for spawning, and poor water quality (both DO and mine effluent concerns).

Indicators of recent disturbance are sediment wedges. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 76-100% of the wetted channel area. The riparian area is grassland and shrub-herb, with some stands of mature conifers.

Visible impacts are a change in water colour below the Bessemer Creek confluence, likely indicating concentrations of ferric metals, and sediment wedges at the upper end of the section. The sediment source is expected to be the adjacent road and ditchlines, combined with possible sediment delivery by unnamed tributaries.

There is a **low** upslope impact potential due to poor connectivity.

Due to the nature and severity of impacts in this section, as indicated by a one-fold decrease in habitat value (probably caused mostly by mining problems), a low upslope impact potential, and the use by one target species, a **low priority** for detailed assessment and restoration is assigned.

Section B

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **high to very high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: good
- Rearing: excellent
- Overwintering: excellent
- Holding: excellent
- Access to alternative sections: good

Limiting factors to habitat value are smothering by fines. Indicators of recent disturbance are extensive unvegetated bars, multiple channels, and eroding banks. There is an abundant amount of LWD in the section, and the distribution is even. The extent of pool habitat is 51-75% of the wetted channel area. The riparian area is mature coniferous forest.

Visible impacts are failing ditchlines and some slope erosion into ditchlines from the FSR. A survey of the unnamed tributaries crossing the FSR into Buck show that they are carrying alot of bedload for their size and gradient, and this indicates that there may be erosion from upslope cutblocks into these creeks. Furthermore, the culverts at these road crossings are probably undersized, since there are areas of erosion upstream and downstream of the culvert. This will be another source of sediment to Upper Buck Creek. This is particularly true for the unnamed creek which enters the upstream end of the study area from the west. The extent of clearcutting here indicates that this basin may be one of the source areas for higher peak flows in the watershed, although this may be buffered by Goosly Lake.

There is a **moderate** upslope impact potential due to activity observed along ditchlines and the FSR.

Plates 30 to 33 show photos of representative areas in the reach and impacts.

Due to the nature and severity of impacts in this section, its possible effects on downstream sections, a moderate upslope impact potential, and the use by one target species (for which this a critical multiple life-stage habitat), a **high priority** for detailed assessment and restoration is assigned.

3.2.2 Klo Creek

General Description

Klo Creek was photographed and assessed from its mouth at Buck Creek to UTM 9.6011200.667300. It was segregated into 2 reaches over 6.2 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #15 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 9 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 10 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Fish Species Distribution, Abundance, and Habitat Values

Klo Creek is known to be inhabited by rainbow trout in its upper reaches, upstream of the Equity Mine Road Bridge, as well as in Buck Creek at the Buck/Klo confluence (MELP, 1974, Bustard, 1989). Due to their known presence in these areas and the gradient and morphology of Klo Creek in the study area, it is strongly suspected that it is used by rainbow trout for multiple life stages. It provides good rearing and holding habitats, as well as an abundance of good spawning gravels.

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 8 below). This information is presented in a more detailed fashion in Reach and Section descriptions to follow.

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1		Very High	Moderate	Moderate	Good	Moderate	Good	F,C,WL,T	Good	Moderate-High
2	A	Very High	Moderate	Moderate	Good	Poor	Good	F,WL,T,AH	Good	Moderate

	B	Very High	Moderate	Moderate	Good	Poor	Good	SC,CP,WL,T,AH	Good	Moderate
	C	Very High	Moderate	Moderate	Good	Poor	Good	F,WL,T,AH	Good	Moderate

Table 8: Primary and overall fish habitat value by reach and section, including limiting factors for Klo Creek(see section 3.0 for key to codes)

There are no known obstructions to fish movement in the study area, and no obstructions between the end of the study area and the area of known rainbow presence in the upper reaches (MELP, 1974).

Land-Use and Upslope Impact Potential

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 9. More detailed discussion will follow in reach and section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1		F	Moderate	No	Low
2	A	F	High	Yes	High
	B	F	High	No	Moderate
	C	F	High	No	Moderate

Table 9: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by reach and section for Klo Creek.

Klo Creek has experienced several types of land-use: forestry, mining, and road building. Some mineral showings were worked in Klo Creek through exploration for large tonnage low grade ore bodies in and around 1970 and possibly earlier. This activity was not disruptive to the landscape, but may have affected water quality. A large open pit quarry operation also exists in the headwaters of Klo Creek, at the site of the Paul Fire (oblique photo plate 38). Forestry has occurred only recently in the Klo Creek basin, and large areas have been cut very quickly. The majority of the ECA was logged in 1992-94. This sort of rapid harvesting will play an important role in the generation of increased peak flows which are thought to be occurring in Buck Creek. Furthermore, the Equity Mine

Road was built in the late 1970's. and a bridge crossing was built over Klo Creek. The headwaters area was visited as part of field checks, and the bridge crossing appeared to be having no significant effect on the channel. The channel appeared to be quite stable through the meadows above the bridge as well, and appeared unchanged from that described in (MELP, 1974).

3.2.2.1 Reach 1

Reach 1 describes the length of Klo Creek from the confluence at Buck Creek to where the channel becomes confined by steep canyon walls. It is 2.4 km long, and shows extreme lateral activity and is actively undercutting its banks to the downstream right (North). There are a number of avulsions and large log jams. In (MELP, 1974), fish and wildlife branch staff report that "...at about two miles from the confluence with Buck Creek, Klo Creek enters a meadow. It meanders with slow flow. There are many logs in the creek and deep holes". Nothing of this sort exists at the lower end of Klo Creek today, and it is unknown whether the MELP staff might have missed the confluence of Buck Creek, and be describing the meadow at Reach 8 and 9 there. Analysis of a 1986 small-scale (1:50 000) air photo (BC86072 # 42) shows that, prior to any harvesting within the study area that a similar channel configuration, bankfull width, and substrate existed, with no meadows with meandering channels and slow flows. It would certainly be unusual for the channel to experience such a rapid change. Since the only major disturbance prior to clearcutting in 1992 was the Paul Fire (1961), and no such changes were noted in 1974 (13 years following the fire), it can be assumed that if these changes took place between 1974 and 1986, there might have been a natural disturbance of some sort.

There are two clearcuts on the adjacent upslope area in this reach. This is the only land-use.

The only target species which uses this reach is rainbow trout, as described above.

This Riffle-Pool channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate to high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: moderate
- Rearing: good
- Overwintering: moderate
- Holding: good
- Access to alternative sections: good

Limiting factors to habitat value are smothering by fines, poor cover due to increased bankfull width, low water levels due to sub-surface flows, and possible increased temperatures. Indicators of recent disturbance are long riffle sections, multiple channels, and extensive areas of unvegetated bars. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is mixed mature forest, combined with dominantly young coniferous forest on the North bank (the bank being actively undercut), and some areas of shrub-herb on bars that are revegetating.

Visible impacts are a high bankfull relative to wetted width ratio (even at mid-flows), extensive and frequent log jams (mostly of fresh blowdown), with numerous avulsions and relic channels, and aggrading material with a high percentage of fines (visible on the tops of bars and in areas where lateral turbulence caused deposition). The erosion of the North bank is extensive throughout this reach and this is recruiting a great deal of LWD to the channel.. There was extensive high elevation logging in all tributaries of Klo Creek (most of the clearcuts here are in the 1000 to 1400 m range, the upper range of the Sub-Boreal Spruce forest, and the critical elevation for increased peak flow generation during snowmelt (Wilford, 1984)). The Paul Fire was also entirely above the 1000 m elevation mark. The decrease in sinuosity, the

increase in sediment delivery, and the loss of LWD function, and possibly changes in channel planform causing erosion of the North bank are most likely a function of increased peak flow generation.

There is a **low** upslope impact potential due to a lack of activity observed.

Due to the nature and severity of impacts in this section, as indicated by a 1.5-fold decrease in habitat value, a low upslope impact potential, the likelihood of increased peak flow impacts on the whole sub-basin from this tributary, and the use by one target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include the need to stabilize upstream sources of sediment and peak flows prior to instream and riparian restoration here, and high levels of future logging planned (as indicated by proposed cutblocks by HFP and Northwood on their 5-year Development Plans).

3.2.2.2 Reach 2

This reach is defined by the highly confined channel between the end of Reach 1 and the end of the study area (which is adjacent to the last upslope cutblock on the mainstem in the valley bottom). It is split into three sections:

- Section A: An extensive area of riffle habitat, low water levels, and minimal pool habitat. Depositional, aggrading.
- Section B: Greater confinement, very little bar formation, minimal amounts of functional LWD. Erosional, degrading.
- Section C: Similar to section A, there is a large debris catchment at a set of sharp corners at the bottom of the section.

There are three large cutblocks in the upslope area of this reach, along with associated road building and silviculture.

It is suspected that rainbow trout are the only target species using this reach, as outlined in the tributary description above.

Section A

This Riffle-Pool (RPcw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: moderate
- Rearing: good
- Overwintering: poor
- Holding: good
- Access to alternative sections: good

Limiting factors to habitat value are smothering by fine sediments, low water levels most of the year, possible elevated temperatures due to the increased bankfull width, and a paucity of alternative habitats. Indicators of recent disturbance are extensive areas of unvegetated bar, poor frequency and extent of pools, and multiple channels. There is a poor amount of LWD in the section, and the distribution is even. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is mixed mature forest.

Visible impacts are the same as for Reach 1, with the addition of a gully failure noted from a cutblock to the downstream right (opening #10) into the channel. There is also the possibility that drainage patterns are being affected by the tertiary road patterns and soil compaction in the cutblocks, and this may be diverting drainage over the face of the numerous bedrock outcrops on the creek. This cannot be conclusively stated at this level of assessment, however.

There is a **high** upslope impact potential due to the presence of large areas of fine textured soils and the activity observed.

Plate 37 shows a representative photo of Reach 2, combined with the gully failure scar noted from opening #10 (marked by the line of yellow deciduous crowns).

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a high upslope impact potential, the disproportionate effect of this tributary on the rest of Buck Creek, and the importance of restoring it, and the use by one target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include plans for high levels of future logging, and the need to stabilize upstream sources of sediment and peak flows prior to instream and riparian restoration here.

Section B

This Riffle-Pool channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **degrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: moderate
- Rearing: good
- Overwintering: poor
- Holding: good
- Access to adjacent sections: good

Limiting factors to habitat value are scouring, compaction low water levels most of the year, increased temperature due to increased bankfull width, and a lack of

alternative habitats. Indicators of recent disturbance are extensive riffles and parallel LWD. There is a poor amount of LWD in the section, and the distribution is even. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is mature mixed forest.

Visible impacts are poor LWD function and a loss of pool habitat due to the scouring down of riffle crests at pool tailouts.

There is a **moderate** upslope impact potential due to high connectivity and the presence of uplsope forestry.

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a moderate upslope impact potential, the disproportionate impact of this tributary on the rest of the sub-basin and the need to restore it, and the use by one target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include plans for high levels of future forestry, and the need to stabilize upstream sources of sediment and peak flows prior to instream and riparian restoration here.

3.2.3 Dungate Creek

General Description

Dungate Creek was photographed and assessed from its mouth at Buck Creek (UTM 9.6026350.654250) to the downstream end of the meadows on the uplands area. It was segregated into 4 reaches over 12.5 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #12 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 11 shows the results of habitat condition data by reach and section.

Appendix 1, form 3, form # 4 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Fish Species Distribution, Abundance, and Habitat Values

Dungate Creek is known to be inhabited by chinook salmon (J/Sp suspected), coho (J suspected/Sp suspected due to use of the Buck mainstem to this point), steelhead (J/A suspected in Reach 1, Sp suspected), rainbow trout (J/A, Sp suspected), and Dolly Varden (J/A suspected, Sp suspected). It is assumed that, except where mentioned, this distribution extends to the second falls in reach 2B. It may extend only to the first falls in years with extreme low water. Late fall spawners are probably able to access it. This tributary could be especially important to steelhead, as the abundant canopy cover and topographic shading will preserve lower summer temperatures in the mainstem, and water levels are expected to be quite constant during baseflows due to the fairly intact riparian area and the large wetland area at the top of the creek. Tredger (1982) estimated a steelhead standing crop of 8550 fry and parr (to account for the strength of different runs). Chinook fry densities indicate that the Dungate confluence is a critical rearing habitat (in the context of this watershed) (Tredger, 1982).

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 10 below). This information is presented in a more detailed fashion in Reach and Section descriptions to follow

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	Very High	Poor-Mod	Moderate	Mod-Good	Mod-Good	Good	F,C,WL,A	Moderate	Moderate
	B	Very High	Moderate	Good	Good	Unknown	Good	F	Good	High
2	A	Very High	Good	Good	Good	Good	Excellent	F,AH,A	Moderate	High
	B	High	Good	Excellent	Excellent	Poor	Good	F, AH, A	Poor	Moderate-High

Table 10: Primary and overall fish habitat value by reach and section, including limiting factors for Dungate Creek (see section 3.0 for key to codes)

There are four permanent natural obstructions to fish movement in Reach 2. These are a set of (suspected) passable falls in Reach 2A, and a set of three impassable falls in Reach 2B. Extensive beaver dams at the mouth may be a barrier to upstream migration during low flows in the summer.

Land-Use and Upslope Impact Potential

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 11. More detailed discussion will follow in Reach and Section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	A, F, H, R	Low	No	Low
	B	A, F, H, R	High	Yes	High
2	A	A, F, R	High	Yes	High
	B	A, F, R	High	Yes	High

Table 11: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section for Dungate Creek.

There has been extensive history of land-use in the basin of this tributary. Dungate Creek, by virtue of its proximity to Houston, experienced land clearing for agriculture and homesteads as early as 1914. This activity occurred along the north ridge of the creek above reaches 1 and 2. Range-use for cattle has been occurring on the upslope and the valley bottom of the area for that long as well. One of these early settlers was also

one of Houston's earliest logging contractors. His name was Olaf Hanson, and the area above reach 2 known as Hanson's Meadows bears his name. Hanson hewed wood for railway ties, and the upland forests of Dungate Creek bare the marks of his mighty work ethic. There are many patches of young forest which are known logged but have an unknown age on Forest Cover Maps. One would reckon that these were cut sometime between 1914 and 1940, when the railroad tie business was booming. In the 1960's, the alluvial fan and adjacent lands were bought up and developed by one Harry Hagman for a large concrete plant (BV Concrete). The fan was cleared to the streambank on both Dungate Creek and Buck Creek, and this operation caused a great deal of aggradation and siltation both here and downstream (visible clearly on 1973 1:10 000 stereo pairs). Local residents who fished Buck Creek below the highway crossing during the time of the plant's operation noted that there was a sharp decline in fish populations until the plant was closed (G. Ferris, pers. comm.). Hagman was also the largest logging contractor in the area, and played a key role in founding the BV Forest Industries complex that began the era of industrial clearcut harvesting here. Thus, Hagman also allowed or created access to the south slope of the river bench, and several large clearcuts were harvested in the 1975-77 period. These cutblocks are now the source of numerous mass movements, into both Dungate Creek and Buck Creek. The development of the Equity Mine Road in the mid- to late 1970's also opened up much of the lands to the east of Buck Creek. There was fairly steady harvesting in the upper reaches of Dungate Creek from about 1976 to 1983. Of particular note is a large area of an unnamed tributary (UTM 9.6025800.657500) that was clearcut in 1976. Outliers from this pattern are a block as early as 1958, and one in the headwaters as late as 1993. The Equity Mine Road and the powerline corridor running beside it is another significant land-use. Of particular note is the fact that the road was built on very fine-textured fill, similar in construction to the North Road FSR. This has repercussions to the sediment load carried by Dungate Creek as the road erodes, which has been occurring since its inception (FHIIP, 1991). For a more detailed history of land-use in the Mid-Bulkley watershed, see section 1.1.5.

3.2.3.1 Reach 1

Reach 1 of Dungate Creek describes less confined portion of the creek as it runs through the short alluvial fan to Buck Creek. The upper end is marked by an increase in confinement, gradient, and substrate size as the creek enters the canyon that connects it to the upland meadows at the end of the study area. The reach is 1 km long and is split into two sections:

- Section A: Unconfined gravel substrate channel with land clearing for range use and a homestead on both sides and multiple channel threads.
- Section B: More confined cobble substrate channel with more intact riparian area

Land-use in this reach includes upslope forestry and associated road networks, an uplsope farm road, range-use for cattle, an old road crossing, and cleared land for a residence.

Fish species using this reach are chinook salmon (J/Sp suspected), coho (J suspected/Sp suspected due to use of the Buck mainstem to this point), steelhead (J/A suspected, Sp suspected), rainbow trout (J/A, Sp suspected), and Dolly Varden (J/A suspected, Sp suspected). The extensive beaver dams in the first section may be a seasonal access problem, but also provide cooler, deeper low-gradient rearing habitat which is more than likely breached with every freshet.

Section A

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: poor to moderate
- Spawning: moderate
- Rearing: moderate to good

- Overwintering: moderate to good
- Holding: good
- Access to adjacent sections: moderate

Limiting factors to habitat value are smothering by fines, poor cover, possible seasonal low water problems due to aggradation, and possible seasonal access problems through beaver dams. Indicators of recent disturbance are extensive areas of unvegetated bar, multiple channels, and eroding banks. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is shrub-herb.

Visible impacts are heavy aggradation and sedimentation from the old BV Concrete operation, clearing of the fan for range-use (burned) causing more lateral instability and erosion of banks, and eroding culverts and banks at the residence. The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely upstream sediment delivery from mass movements at cutblocks and grazing lands, as well as erosion of fine-textured fill from the Equity Mine Road.

There is a **low** upslope impact potential due to poor connectivity to the upslope (double-floodplain=no upslope).

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a low upslope impact potential, and the use by five target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and the need to stabilize upstream sources of sediment prior to instream and riparian restoration here.

Section B

This Riffle-Pool (RPcw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: good
- Rearing: good
- Overwintering: unknown (due to canopy closure)
- Holding: good
- Access to adjacent sections: good

Limiting factors to habitat value are smothering by fines. Indicators of recent disturbance are extensive areas of unvegetated bar. There is an abundant amount of LWD in the section, and the distribution is even. The extent of pool habitat is unknown. The riparian area is mixed young forest.

Visible impacts are mass movements from a) an upslope farm road (2) which have existed since pre-1973 and post-1986, respectively (this information was obtained from small-scale stereo pairs) and b) an upslope cutblock, as well as range-use impacts to the riparian understory in the valley bottom. The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely upstream sediment delivery from the Equity Mine Road and mass movements.

There is a **high** upslope impact potential due to activity observed.

Plate 34 shows an oblique photo of the large slide from the upslope farm road.

Due to the nature and severity of impacts in this section, as indicated by a one-fold decrease in habitat value, a high upslope impact potential, and the use by five target

species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and the need to stabilize upstream sources of sediment and peak flows prior to instream and riparian restoration here.

3.2.3.2 Reach 2

Reach 2 defines the stretch of Dungate Creek from the downstream end of the canyon to the downstream end of a less confined and incised section of the same canyon. The reach is 5 km in length and is split into three sections:

- Section A: To the first falls. Riffle-Pool channel.
- Section B: Cascade-Pool Channel. To the end of the three impassable falls.
- Section C: Riffle-Pool channel. To the end of the reach.

This reach has the most intense concentration of land-use in the basin. The north and south upslope areas have been extensively harvested. There is a high density road network here as well (farm, forestry and Equity Mine roads). The large cleared and grazed area (Hanson's Meadows) is also within this reach, having been cleared and grazed since the early part of the century.

Fish species using this reach are chinook salmon (J/Sp suspected), coho (J suspected/Sp suspected due to use of the Buck mainstem to this point), steelhead (J/A suspected, Sp suspected), rainbow trout (J/A, Sp suspected), and Dolly Varden (J/A suspected, Sp suspected). Their distribution is thought to occur up to the impassable falls in section B.

Fish habitat and habitat values will only be described to section B in this creek. Beyond this point, only impacts thought to be a sediment source to fish habitat downstream will be noted.

Section A

This Riffle-Pool (RPcw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is **stable**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: good
- Rearing: good
- Overwintering: good
- Holding: excellent
- Access to adjacent sections: moderate

Limiting factors to habitat value are smothering by fines, poor alternative habitats, and questionable access through the first falls. Indicators of recent disturbance are recently formed log jams. There is an abundant amount of LWD in the section, and the distribution is even. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is mature mixed forest.

There are no visible impacts. Sedimentation is expected, but this section may transport fine-textured suspended sediments downstream as well.

There is a high upslope impact potential due to high connectivity..

Due to the nature and severity of impacts in this section, as indicated by no decrease in habitat value, a high upslope impact potential, and the use by five target species, a **low priority** for detailed assessment and restoration is assigned.

Section B

This Cascade-Pool (CPcw) channel has a **high** primary habitat value to target species in a stable state. The overall habitat value is **moderate to high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: excellent
- Rearing: excellent
- Overwintering: poor
- Holding: good
- Access to adjacent sections: poor

Limiting factors to habitat value are siltation, poor alternative habitats, and access problems between both adjacent sections. Indicators of recent disturbance are extensive areas of unvegetated bar, recently formed log jams, multiple channels. There is an abundant amount of LWD in the section, and the distribution is even. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is mature mixed forest.

Visible impacts are mass movements from range-use and land-clearing, a cutblock (opening #34) (1+ loaded gullies) on the south slope into the creek, and from an upslope logging road into an unnamed tributary (UTM 9.6025800.657500). The soils on the valley walls are marked on Forest Cover maps as environmentally sensitive. Aggradation and increased bankfull width is noted downstream of the confluence of this tributary with Dungate.

There is a **high** upslope impact potential due to activity observed.

Plate 36 shows an aerial photo of the slide into the unnamed tributary, and plate 35 shows a photo of the first impassable falls.

Due to the nature and severity of impacts in this section, as indicated by a 1.5-fold decrease in habitat value (partially imposed by natural barriers), a high upslope impact potential and the disproportionate impact the upslope is having on downstream reaches, and the possible use by five target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include some adjacent private land ownership.

Section C

Visible impacts are erosion of the Equity Mine Road fill slope, and a mass movement spotted from the south slope cutblock (opening #34).

There is a **high** upslope impact potential due to activity observed.

Due to the nature and severity of impacts in this section, as indicated by a high upslope impact potential, a **moderate priority** for detailed assessment and restoration is assigned.

3.2.3.3 Reach 3

This reach runs from the end of Reach 2 to the beginning of another more incised section of canyon. For a short stretch, Dungate Creek has a floodplain, and meanders in a less confined setting. This reach is 3.7 km long.

Forestry and the Equity Mine Road are the only land-uses in this reach.

Section A

Visible impacts are sediment from the Equity Mine Road and the Dungate FSR ditches (at its crossing of the creek).

There is a **moderate** upslope impact potential due to activity observed.

Due to the nature and severity of impacts in this section, as indicated by a moderate upslope impact potential, a **low priority** for detailed assessment and restoration is assigned.

Section B

Visible impacts are eroding banks at a road crossing where a bridge was pulled, and erosion from the Equity Mine Road. Frequent sediment wedges behind log jams are evidence of this occurring.

There is a **low** upslope impact potential due to no activty observed and moderate connectivity.

Due to the nature and severity of impacts in this section, and a low upslope impact potential, a **low priority** for detailed assessment and restoration is assigned.

3.2.3.4 Reach 4

This reach runs in another incised canyon section of Dungate Creek from the end of Reach 3 to the meadows at the end of the study area. The upslope is composed of steep gullied terrain.

There are several large cutblocks in this reach which were cut in 1960 and 1983.

This reach shows no impacts from logging activities. However, canopy closure was high, and the more recent 1983 cutblock is located in unstable terrain. This area should be assessed on the ground to determine if impacts are occurring.

3.3 Aitken Creek Sub-Basin

Sub-Basin Description

Aitken Creek is a second-order basin located to the East and North of Houston. Its mouth is at UTM 9.6037200.660450 at the Bulkley River, Reach 2. It drains an area 11947.3 hectares in size and it has an intermediate bifurcation ratio. Aitken Creek is a lake-headed system comprised of Old Man Lake, Lars Lake, Swans Lake, and two unnamed lakes. It has a dammed outflow from the most northerly lake, and flows through a wetland complex before becoming a distinct channel. Typical of tributaries in this watershed, the alluvial fan has been cleared for range agriculture and is laterally very active, a steep canyon with falls follows with infrequent adjacent land-use, and headed by a low gradient meandering channel through mature mixed forest and a meadows area which has been logged extensively. Intermittent first-order tributaries deliver water and sediment to the larger channel from upslope areas during snowmelt and rain-event periods.

Aitken Creek was photographed and assessed from its confluence with the Bulkley to the outflow of the dam at the unnamed lake (UTM 9.6032060.666985). It was segregated into 3 reaches over 10.1 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #14 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 13 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 9 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Fish Species Distribution, Abundance, and Habitat Values

Aitken Creek is known to be inhabited by rainbow trout in reaches 2 and 3 (DFO, 1997). Given the general distribution of target species using the Bulkley River, the water levels present in the creek at baseflows (stage at the time of aerial photography), access to mid-

Reach 2 and the gradient in Reaches 1 and 2, it is suspected that coho (J/Sp), steelhead (all) and cutthroat trout (all) are present in the lower reaches (FHIIP, 1991). A double set of high, impassable falls (MELP, 1977) obstructs up and downstream migration of headwater and valley bottom fish populations.

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 12 below). This information is presented in a more detailed fashion in Reach and Section descriptions to fo

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1		Very High	Poor	Good	Moderate	Poor	Moderate	F,C,VR,WL,AH	Moderate	Moderate
2		Moderate-High	Good	Poor	Mod-Good	Poor-Mod	Poor	LS,SC,AH,A,I	Poor	Moderate
3	A	Very High	Good	Good	Moderate	Moderate	Good	F,C,T,DO,AAH	Moderate	Moderate-High
	B	Moderate-High	Poor	Poor	Moderate	Poor	Good	F,C,DO,AAH,A	Poor	Low-Moderate

Table 12: Primary and overall fish habitat value by reach and section, including limiting factors for Aitken Creek (see section 3.0 for key to codes)

The other possible obstruction to fish movement is the dam at the outflow of the first unnamed lake. Pictures taken of the dam indicate that there is a gabioned weir which is probably passable at good flows. This may change during summer. This outflow was historically dammed by beavers (MELP, 1977). Due to this fact, the rainbow population in this creek may not be adfluvial (juveniles and spawners in creek, adults in lake).

Land-Use and Upslope Impact Potential

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 13. More detailed discussion will follow in Reach and Section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1		A	Moderate	Yes	Moderate

2		A,F	High	Yes	Moderate
3	A	A,F	Low	No	Low
	B	A,F	Low	No	Low

Table 13: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section for Aitken Creek.

As outlined in section 4.3, land-uses in the tributary basin have been agriculture (for cattle and sheep grazing and for hay on top of the plateau), and SBFEP logging. The age of cutblocks varies from 1961 to 1987, with the majority occurring from 1976 to 1983. One cutblock from 1976 (opening #19) is particularly large, and cuts across and on both sides of the creek. Distinct channel changes were noted on air photos from before and after this period of logging. For a more detailed history of land-use in the Mid-Bulkley watershed, see section 1.1.5.

3.3.1 Reach 1

Reach 1 of Aitken Creek defines the unconfined irregularly wandering gravel-bed channel on the valley-bottom alluvial fan. It is 1.8 km long and shows a great deal of regular and irregular lateral movement. Although bar vegetation shows the channel to have a regular annual quantity of deposition, it has been noted from 1:10 000 stereo pairs that the channel has migrated across the floodplain to at least three different locations in the past 50-75 years. This is the approximate age of general land clearing and habitation in this area, and it is suspected that this has contributed to the movements. It is suspected that log jams and beaver dams at the top of where the Bulkley floodplain intersects Aitken Creek's basin have been the vector to recruitment of new (or perhaps relic) channels.

Land-use in this reach is range agriculture, with one road crossing (visible in plate 1), and one cutblock (age unknown, no opening #) in the upslope area to the west.

Fish species using this reach are suspected to be coho (J/Sp), steelhead (all), rainbow (all), and cutthroat (all), as described in section 4.3.

This Riffle-Pool channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: poor
- Spawning: good
- Rearing: moderate
- Overwintering: poor
- Holding: moderate
- Access to adjacent sections: moderate

Limiting factors to habitat value are smothering by fines, limited cover, a lack of velocity refugia, low water levels at base flows, and a lack of alternative habitats. Indicators of recent disturbance are extensive areas of unvegetated bar, poor pool frequency and extent, and multiple channels. There is a poor amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is young mixed forest intermixed with shrub-herb and grassland areas. There is likely seasonally poor access through the large beaver dam visible at the top of plate 1.

Visible impacts are bank instability and lost riparian function, and a loss of pool habitat. There is also substrate compaction and erosion at the road crossing. From small-scale air photos, it also appears that there may have been a gully failure from the uplsope cutblock, but this could not be conclusively determined and requires a field check. The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely peak flows and upstream sediment delivery causing scouring and increased

lateral movement during flood years, and aggradation with smaller snowmelt peaks and rain events. This is indicated by a very low pool frequency, elevated bars, and the sub-basin ECA of 30% (see section 1.1.5.4, table 1).

There is a **moderate** upslope impact potential due to activity observed and moderate connectivity to the channel.

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a moderate upslope impact potential, and the use by possibly four target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and the need to stabilize upstream sources of sediment and peak flows prior to instream and riparian restoration here.

3.3.2 Reach 2

Reach 2 is defined by the confined cascade-pool channel that runs through the higher gradient canyon area of the Aitken Creek sub-basin. It is 2.1 km in length and contains two sets of impassable falls.

The only upslope land-use in this reach is forest harvesting. There are two cutblocks, one of 1975 vintage, and the other was harvested in 1987. The latter was cleared on a sloping section down right to the lip of the canyon above a very unstable and active scarp (see plate 13). It is suspected to be concentrating drainage over the edge of this scarp, although this feature existed prior to the development.

Target species using this reach are suspected to be steelhead (all), rainbow (all), and cutthroat (all) below the falls. rainbow (J, possibly adults) are known to be present above the falls.

This Cascade-Pool (CPcw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is

degrading. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: poor
- Rearing: moderate to good
- Overwintering: poor to moderate
- Holding: poor
- Access to adjacent sections: poor

Limiting factors to habitat value are large substrates (to spawners), scouring, poor alternative habitats, poor access, and the probability of anchor and frazl ice formation at low temperatures. Indicators of recent disturbance are recently formed log jams and scouring. There is a poor amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is mature mixed forest.

Visible impacts are a loss of or movement downstream of stone lines on cascade crests and localized aggradation of debris at catchment areas indicate the influence of increased peak flows. A lack of any significant aggradation of finer material, given the large source thereof in reach 3 may further show the influence of increased peak flows.

There is a **moderate** upslope impact potential due to high connectivity, upslope land-use (a cutblock -opening #56) and a high connectivity to the stream, but no activity observed.

Due to the nature and severity of impacts in this section, as indicated by a one-fold decrease in habitat value (basically due to poor access through the falls and the beaver dam downstream, an inherent degradation of habitat quality), a moderate upslope impact potential, and the use by possibly four target species, a **moderate priority** for

detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and the need to stabilize upstream sources of sediment and peak flows prior to instream and riparian restoration here.

3.3.3 Reach 3

Reach 3 of Aitken Creek defines the low-gradient unconfined Riffle-Pool channel on the plateau area of the basin between the upstream end of the canyon and the outlet of the first unnamed lake in the system. The outlet is dammed by a small earthen dam with a gabioned low gradient spillway which may facilitate fish passage. The dam was created for the purposes of creating and maintaining duck habitat in the lake system behind it by Ducks Unlimited (D. Meredith, pers. comm.). The reach is split into two sections:

- Section A: Riffle-Pool channel , heavy clearcut activity, several road crossings, aggrading.
- Section B: Ponded wetland, cultivation and some clearcut areas. Stable.

Extensive SBFEP clearcutting has been carried out in this reach which has cleared significant areas of the valley-bottom floodplain to the stream-edge. This has caused bank instability and erosion, and damage to the water and sediment storage functions of the riparian forest, which plays a major role in mitigating peak flows. Most of the clearcutting was carried out in the 1970's (1977 and 1979) in this area, and in 1983 in the upslope areas. There were distinct channel changes noted between pre- and post-logging channel conditions (1977 1:10 000 air photo, 1991 1:10 000 air photo and photo mosaics from this study), namely an increase in bankfull width, aggradation, and bank erosion. The channel prior to harvesting would be described as being lower gradient, having greater sinuosity, greater wetted width, and very few exposed bars. It was much more similar to section B than it presently is.

rainbow trout are the only known target species present in this reach. As described in section 4.3, it is unknown whether this was or is an adfluvial population, and whether the spillway of the dam is easily passable or not. It appeared to be from file pictures viewed by the author at MELP Regional Headquarters, Water Management Branch..

Section A

This Riffle-Pool channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate to high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: good
- Rearing: moderate
- Overwintering: moderate
- Holding: good
- Access to adjacent sections: moderate

Limiting factors to habitat value are smothering by fines, poor cover in sections, possible water quality (DO, temperature) problems due to increased insolation and growth of the periphyton and algal population, and access to alternative habitats. Indicators of recent disturbance are extensive unvegetated bars, eroding banks, and recently formed log jams. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is dominantly shrub-herb with areas of mixed mature forest in the lower end of the section and sporadic stands throughout the rest of the reach.

Visible impacts are loss of riparian area causing increased bank erosion, and loss of riparian function. Logging practices at the time of harvesting were likely to fall and

yard into the stream, perhaps using the stream for skidding. This may be attributed to the amount of LWD in log jams, and if not than possibly from slash and blowdown which was recruited in lateral channel activity. There are a large number of isolated or aggraded off channels as well, thought to be a result of aggradation from eroding banks. The increase in bankfull width, and decrease in wetted width may also be due to damming of the lake outlet, which would have provided more flow to the creek during low flows and perhaps from catastrophic discharges during high water levels when dam integrity may be an issue.

There is a **low** upslope impact potential due to poor connectivity to the channel.

Due to the nature and severity of impacts in this section, as indicated by a 1.5-fold decrease in habitat value, a low upslope impact potential, the disproportionate impact that this section may have on downstream reaches, and the use by one target species, a **high priority** for detailed assessment and restoration is assigned. A barrier to restoration include adjacent private land ownership.

Section B

This Pond-Lake channel has a **high to very high** primary habitat value to target species in a stable state. The overall habitat value is **low to moderate** and the channel is **stable**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: poor
- Spawning: poor
- Rearing: moderate
- Overwintering: poor
- Holding: good
- Access to adjacent sections: poor

Limiting factors to habitat value are water quality (DO), access to alternative habitats, fine sediments, and access to adjacent sections. There are no indicators of recent disturbance. There is a poor amount of LWD in the section, and the distribution is even. The extent of pool habitat is 76-100% of the wetted channel area. The riparian area is shrub-herb.

Visible impacts are a lack of LWD in the section, and the appearance of significant growth and oxygen deprivation in much of the channel and side channels (surface sheen, translucent green water). Both of these symptoms may be due to the flow control imposed by the dam. Certainly a lack of LWD would be expected when upstream sources and pathways have been blocked.

There is a **low** upslope impact potential due to poor connectivity to the channel.

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a low upslope impact potential, and the use by one target species, a **moderate priority** for detailed assessment and restoration is assigned. A barrier to restoration is adjacent private land ownership.

3.4 Barren Creek Sub-Basin

Sub-Basin Description

The Barren Creek sub-basin is a second-order watershed which drains an area 2606 hectares in size. The mouth of Barren Creek (the POI) is located at 9.6037600.660850 at its confluence with the Bulkley River, Reach 2. It is located north and east of Houston, BC on the north side of the Bulkley River. The real confluence of the creek is at an oxbow in the Bulkley River floodplain, but the creek has filled this oxbow with alluvium, and the channel (now semi-confined) empties through a culvert under the railway and into the Bulkley.

Barren Creek was photographed and assessed from its confluence with the Bulkley River to the end of the most upstream land-use (an upslope cutblock). It was segregated into 3 reaches over 5.15 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #13 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 12 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 1 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Fish Species Distribution, Abundance, and Habitat Values

Barren Creek is known to be inhabited by chinook salmon (J), coho salmon (J), and rainbow trout (J) to the outlet of the highway culvert. The following species and life-stages are suspected due to habitat preferences, channel type, gradient, and an absence of barriers to the end of Reach 2A, where there is a culvert obstruction at the North Road FSR: coho (Sp), steelhead (all to the end of reach 1, adults not in reach 2), rainbow (adults, spawners), and cutthroat (all). Fish habitat above the culvert is not limiting, and access is good for 2 km to the point of an impassable falls just above the Reach 2/3 break.

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 14 below). This information is presented in a more detailed fashion in Reach and Section descriptions to follow.

Reach	Section	1° Habitat alue	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat alue
1		Very High	Poor	Poor	Moderate	Moderate	Moderate	F,C,WL,DO,AAH,A	Moderate	Moderate
2	A	Very High	Mod-Good	Good	Excellent	Unknown	Good	F,C,A	Poor	High
	B	Very High	Good	Good	Excellent	Unknown	Good	F,C,A	Poor	High

Table 14: Primary and overall fish habitat value by reach and section, including limiting factors for Barren Creek (see section 3.0 for key to codes)

There are further obstructions to fish movement at the railway crossing culvert at the mouth. These two culverts are small-diameter concrete culverts which were obviously installed as a double unit to facilitate the passage of water, but not the passage of fish. One culvert is now completely blocked. This means that a culvert which already has poor roughness (and thus high water velocities) is now even more of a problem at high flows because it is passing the discharges of water which two culverts were originally designed to do. Therefore, this culvert is probably a barrier at high flows. The fine-textured alluvium dumped into the oxbow by the creek has also blocked fish passage to the high value overwintering and rearing habitat available there.

Land-Use and Upslope Impact Potential

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 15. More detailed discussion will follow in Reach and Section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1		N/A	N/A	N/A	Low
2	A	A, H, P, R	Moderate	Yes	Moderate
	B	A, P	Moderate	Yes	Moderate

Table 15: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section for Barren Creek.

Land-uses in Barren Creek are typical of tributaries on this side of the Bulkley River. The valley bottom is used extensively for range-use, and has a long history of land-use for various types of agriculture at various times (see section 1.1.5). The predominately poplar forest indicates land-clearing for homesteads, cattle, and possibly for winter logging as well. It is suspected due to patterns of possible relic channels visible on 1:10

000 stereo pairs and the sudden shift in direction of the creek, that it was diverted at some point where it bends and parallels the highway for no apparent topographic reason. This could have been carried out by a resident to divert floodwaters away from their poorly located home, or it could have been done during the building of the highway or the secondary road directly north of the highway. It is suspected that this may have triggered both the slide at the beginning of Reach 2, and the aggradation of fine material so evident in the oxbow. Range-use continues up to the North Road FSR Crossing. At this point, the culvert under the road is causing an obstruction to fish migration. Beyond this, the undersized culvert has lead to upstream erosion of a large area at the powerline crossing, which may be another considerable source of fines. Beyond this, Reach 2 is host to a cattle grazing license-holder on Crown land. This land-use continues to the Reach 2/3 break, along with two upslope cutblocks harvested in the late 1980's in Reach 2 and 3 respectively. For a more detailed history of land-use in the watershed, see section 1.1.5.

3.4.1 Reach 1

Reach 1 of Barren Creek defines the unconfined channel which flows from the highway crossing to its confluence with the Bulkley River through the west arm of an oxbow. It is highly aggraded with fine-textured sandy alluvium which seems to match the sandy esker deposit soils at the slump in Reach 2. This reach is 400 m in length.

Land-uses in this reach are the railway corridor and the highway corridor, both of which cross the creek, and heavy use by cattle for range use. A particularly big internal sediment source is the cattle crossing just north of the railway. These fine-textured soils have only just been recolonized by vegetation, and cattle grazing throughout this area will continue to remobilize sediment to the Bulkley through loss of understory root mass, the only source of stability here.

Fish species known or suspected to use this reach are coho, chinook, steelhead, rainbows and cutthroat. However, use of the reach below the highway will probably be restricted to migration, as habitat is highly degraded.

This Riffle-Pool channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate (poor below highway)** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: poor
- Spawning: moderate
- Rearing: moderate
- Overwintering: moderate
- Holding: moderate
- Access to adjacent sections: moderate

Limiting factors to habitat value are smothering by fines, poor cover, poor water levels at baseflows, likely poor water quality (DO), poor access to alternative habitats, and poor access to the reach through the railway culvert(s). Indicators of recent disturbance are extensive areas of unvegetated bar, extensive sediment wedges, and multiple channels. There is an abundant amount of LWD in the section, and the distribution is even. The extent of pool habitat is unknown. The riparian area is young deciduous forest intermixed with shrub-herb.

Visible impacts are loss of and damage to the riparian area by cattle grazing, extensive aggradation of fines from internal and external sediment sources, multiple channel threads through the fine-textured substrate, loss of access to the oxbow due to aggradation, and poor access through the railway culverts. The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely upstream sediment delivery from a large slump and significant bank erosion in Reach 2, and possibly, if the creek was diverted, internal sediment from the initial erosion of the channel bed. The sandy glacial deposit in the esker (long sinuous hill formed by a receding glacier) could very well be the source of the alluvium in the oxbow.

There is a **low** upslope impact potential due to no upslope area (double floodplain).

Plates 58 to 60 show oblique photos of this reach and impacts to it.

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a low upslope impact potential, and the use and suspected use by five target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and the need to stabilize upstream sources of sediment prior to instream and riparian restoration here.

3.4.2 Reach 2

This reach is defined by the moderately confined Riffle-Pool channel which runs through the narrow alluvial fan of Barren Creek, as it emerges from the upstream canyon at the end of the reach. The reach is 3.3 km long and is split into two sections:

- Section A: Riffle-Pool (RPgw) channel below the culvert barrier at the North Road FSR.
- Section B: Riffle-Pool (RPcw) channel above the North Road crossing.

Land-use in this reach includes range-use, land-clearing for a homestead, two roads (one parallels the creek in photo mosaic plates 4-6, the other is the North Road FSR crossing), two powerline corridors, and a quarry.

Fish species using this reach are known or suspected to be coho (J/Sp), steelhead (all), rainbows (all), and cutthroat (all) to the end of section A at the culvert obstruction.

Section A

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate to good
- Spawning: good
- Rearing: excellent
- Overwintering: unknown (due to canopy closure adjacent to channel)
- Holding: good
- Access to adjacent sections: poor

Limiting factors to habitat value are smothering by fines, poor cover in sections, and poor access to section B and to the Bulkley River. Indicators of recent disturbance are extensive unvegetated bars, and eroding banks. There is an abundant amount of LWD in the section, and the distribution is even. The extent of pool habitat is unknown. The riparian area is dominantly young deciduous forest with sections of initial grassland stages.

Visible impacts are poor culvert access at the FSR and some erosion of fine-textured fill into the channel, impacts to or loss of riparian function and bank erosion at land-clearing and range-use, and the large sandy slump in the bottom of the section which is likely contributing fines to Reach 1.

There is a **moderate** upslope impact potential due to moderate connectivity and activity observed..

Plates 61 to 62 show oblique photos of this section and impacts observed..

Due to the nature and severity of impacts in this section, as indicated by a one-fold decrease in habitat value, a moderate upslope impact potential, the location of a major

correctable obstruction, its disproportionate effect on the reach below it, and the use by a suspected four target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and the need to stabilize upstream sources of sediment prior to instream and riparian restoration here.

Section B

This Riffle-Pool (RPcw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: good
- Rearing: excellent
- Overwintering: unknown
- Holding: good
- Access to adjacent sections: poor

Limiting factors to habitat value are smothering by fines, poor cover in sections, and poor access to adjacent sections due to the culvert and falls obstructions. Indicators of recent disturbance are extensive areas of unvegetated bar, and bank erosion. There is an abundant amount of LWD in the section, and the distribution is even. The extent of pool habitat is unknown. The riparian area is mature mixed forest, which shows poor understory species in sections due to grazing by cattle.

Visible impacts are erosion at the powerline corridor/FSR culvert due to a loss of riparian root-mass and a large back-eddy scour pool that forms behind the undersized culvert in high water events, a possible slump above an ATV trail/cattle track (visible

in plate 14 of the photo mosaic)(slump has unknown connectivity to the channel due to canopy closure), and range impacts on riparian function.

There is a **moderate** upslope impact potential due to moderate connectivity and activity observed..

Due to the nature and severity of impacts in this section, as indicated by a one-fold decrease in habitat value, a moderate upslope impact potential, the sediment source from erosion above the FSR culvert, and the use by no target species due to access problems, a **moderate priority** for detailed assessment and restoration is assigned.

3.4.3 Reach 3

Reach 3 defines the length of creek running through a confined canyon area to the upstream end of an upslope cutblock (opening number #53) which was the last visible land-use on the creek. An impassable falls to fish migration occurs at the Reach 2/3 break, and fish habitat is not described above this point.

There are no visible impacts in this reach.

There is a **low** upslope impact potential due to a lack of activity observed from land-use.

Plate 63 shows a photo of the impassable falls at the Reach 2/3 break.

Due to the nature and severity of impacts in this section as indicated by a low upslope impact potential, and the use by no target species, a **low priority** for detailed assessment and restoration is assigned.

3.5 McQuarrie Creek Sub-Basin

Sub-Basin Description

The McQuarrie Creek sub-basin is a third-order watershed which drains from the uplands north of the Bulkley River and East of Houston. It is a lake-headed system composed of McQuarrie Lake, Farewell Lake, and Hidden Lake, which is intermittently connected to the headwaters of the Deep Creek watershed through a series of wetlands. The watershed is 11583 hectares in area. and has an intermediate bifurcation ratio. The mouth of McQuarrie Creek (the POI) is located at UTM 9.6043400.664400 at the Bulkley River, Reach 3.

McQuarrie Creek was photographed and assessed from its mouth to the crossing of the North Road FSR. It was segregated into 3 reaches over 12.65 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #6 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 6 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 8 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Fish Species Distribution, Abundance, and Habitat Values

McQuarrie Creek is known to be inhabited by chinook salmon, coho salmon, steelhead, and rainbow trout (FHIIP, 1991, FISS, 1995, MELP, 1982). Their distribution is as follows:

- chinook: Known to be present in this creek (FISS, 1995). Distribution is thought to be from the mouth to the cascade in reach 2B due to good access, gradient, habitat quality, and usual distribution of this species in watersheds (mainstem and valley-bottom users).

- coho: Juveniles and spawners known to be present in reaches 1 to 2B (FHIIP, 1991). Suspected to be present above the cascade barrier to the end of Reach 3 due to upstream habitat quality, gradient, lack of additional barriers in this section. The culvert at the North Road FSR (end of Reach 3) is thought to be a barrier to upstream migration (Tredger, 1982, field observations). Land-use and habitat quality above the barrier appears to be ideal to the lakes (upstream canyon area may have a falls, but this could not be ascertained from small-scale stereo-pairs).
- steelhead: Juveniles, adults and spawners known to inhabit this stream from the mouth to the end of Reach 3 at the FSR culvert barrier (Tredger, 1982, FHIIP, 1991).
- rainbows: Known to be present in McQuarrie Lake. Suspected to be present in the entire mainstem due to habitat quality, gradient, no land-use and associated impacts upstream of the culvert barrier, and the likely good access downstream through this culvert. What appeared to be adult rainbow trout were observed feeding just below the culvert outlet at its large scoured plunge pool. Good canopy closure present over part of the pool was providing overhead cover at a low-energy site with a suspected abundant invertebrate drift. This large pool may be providing good overwintering habitat, and if the culvert were to be replaced, it should be designed to maintain this feature.

The only data available on abundance are from Tredger (1982) who reports an estimated steelhead standing crop of 13460 fry and parr (accounting for the strength of different run-years).

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 16 below). This information is presented in a more detailed fashion in Reach and Section descriptions to follow.

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	Very High	Poor	Mod-Good	Poor	Poor	Poor	PTR,C,VR,SC,WL,AH	Moderate	Low-Moderate

	B	Very High	Moderate	Mod-Good	Mod-Good	Poor	Moderate	PTR,WL,F,AH,VR	Good	Moderate
2	A	Very High	Good	Mod-Good	Good	Poor	Good	LS,F,AH,I	Good	Moderate-High
	B	Low-Moderate	Moderate	Poor	Moderate	Poor	Moderate	LS,SC,VR,AH,I	Moderate	Low-Moderate
	C	High	Good	Excellent	Good	Good	Good	F, AH	Good	High
3	A	Very High	Good	Good	Good	Moderate	Good	F,AH,WL	Moderate	High

Table 16: Primary and overall fish habitat value by reach and section, including limiting factors for McQuarrie Creek (see section 3.0 for key to codes)

As mentioned above, there are two obstructions to fish movement at a cascade in Reach 2B (suspected passable to most species at all but the lowest and highest flows), and the culvert at the North Road FSR . It is also expected that the channelized and homogenized section of Reach 1 poses a barrier at extreme flow conditions as well. The cascade in Reach 2 is suspected to be passable because it generally compares with the cascade in Reach 3 of Buck Creek, which is known to be passable at good flows to chinook and coho. The cascade here is shorter and appears to be less severe.

Land-Use and Upslope Impact Potential

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 17. More detailed discussion will follow in Reach and Section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	N/A	N/A	N/A	Low
	B	A,H,F	Moderate	Yes	Moderate
2	A	A	High	Yes	High
	B	A	High	No	Moderate
	C	None	High	No	Low
3	A	R	High	Yes	High

Table 17: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section for McQuarrie Creek.

Most land-use in the McQuarrie Creek watershed is focused in Reaches 1 and 2. The alluvial fan is heavily used in particular, for residential purposes, range-use, hay cultivation, a powerline right-of-way, the highway crossing and the railway crossing. At this point, the creek has been channelized on both sides for flood control. In the upslope, there is a network of secondary roads and/or ATV tracks from which numerous mass movements appear to originate, and a cutblock. It appears that soils on the steep valley sides in reach 2 are very unstable, as indicated by both natural and anthropogenic mass movements. Information relating to the age of various land-uses here is scarce. The cutblock age from observing rates of regeneration in 1977 and 1991 1:10 000 stereo pairs is circa 1975 . The North Road FSR is the only land-use in the upper reach. It parallels the west side of the creek on the lip of the valley for 2 km until crossing the creek at the end of Reach 3. There are a two mass movements which originate from the road. One appears to be caused by a diversion of drainage causing a rotational slump (partially visible in plate 31of the photo mosaic), and the other appears to occur from a small unnamed first order tributary gully which has failed below the road crossing. Aggradation from the latter is though to be visible at the bottom of plate 27 of the photo mosaic in the channel. For a more general history of land-use in the watershed, see section 1.1.5.

3.5.1 Reach 1

This reach comprises the originally unconfined Riffle-Pool channel which runs through the alluvial fan of McQuarrie Creek below the confined canyon. It is 1.65 km in length, and experiences intensive land-use as outlined in section 4.5 above. It is split into two reaches:

- Section A: Channelized on both sides, degrading.
- Section B: Channelized on one side, aggrading.

This reach is extremely high value habitat for a number of reasons. First, it has known presence of chinook, coho, and steelhead. These three species are the top

priority target species due to declining numbers, traditional cultural value, and economic value (J. Lough, pers. comm.., P. LeMieux, pers. comm.). Secondly, access through this reach is essential, as there is a great deal of high value habitat which remains lightly impacted by land-use upstream. Thirdly, the second point is particularly important in the scope of the watershed because this is one of the few tributaries which has little impact by land-uses in the mid- to headwaters area, and does not have an impassable natural barrier between the valley bottom and the headwaters, thus making it an important and potentially highly productive nursery tributary for wild anadromous salmonids. chinook use of this reach is thought to be limited to spawning and overwintering.

Section A

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **low to moderate** and the channel is **degrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: poor
- Spawning: moderate to good
- Rearing: poor
- Overwintering: poor
- Holding: poor
- Access to adjacent sections: moderate

Limiting factors to habitat value are a lack of stable pool tailouts for spawning, poor cover, poor velocity refuges, scouring, low water levels much of the year, and no access to alternative habitats (in this case of channelizing, highway ditches may qualify as good alternative habitats for coho and chinook). Indicators of recent disturbance are extensive riffles, poor pool frequency and extent, and multiple channels. There is no LWD in the section. The extent of pool habitat is 0% of the wetted channel area. The riparian area is shrub-herb.

Visible impacts are channelizing on both banks causing a loss of the natural stream pattern , a loss of energy dissipation, and a loss of LWD leading to sever impacts on habitat quality and productivity. Furthermore, the channel is scoured and because of a lack of energy dissipation or sediment storage capacity, is delivering large volumes of sediment to Reach 3 of the Bulkley. This section may be an obstruction at seasonal high and low flows due to a lack of depth variability and holding habitat.

There is a **low** upslope impact potential due to poor connectivity to the channel.

Due to the nature and severity of impacts in this section, as indicated by a 2.5-fold decrease in habitat value, a low upslope impact potential, and the use or suspected use by four target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and perceptions of property protection and public safety which originally lead to the channelizing.

Section B

This Riffle-Pool channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: moderate
- Rearing: moderate to good
- Overwintering: poor
- Holding: moderate
- Access to adjacent sections: good

Limiting factors to habitat value are an infrequent number of stable pool tailouts for spawning, seasonally low water levels, smothering by fines, poor alternative habitats, and infrequent velocity refuges. Indicators of recent disturbance are extensive unvegetated bars, recently formed log jams, and eroding banks. There is an abundant amount of LWD in the section, and the distribution is mostly clumped. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is deciduous pole-sapling and shrub-herb. There are several areas with exposed mineral soil and no riparian vegetation due to dyking and land-use.

Visible impacts are dyking on the east bank causing increased lateral instability on the right bank and leading to bank erosion, an aggradation in the bottom of this section prior to the constricted downstream section, range-use and hay farming causing impacts to or loss of the riparian area, and mass movements which are possibly frustrated by cattle passage and grazing on sensitive soils.

There are a number of spring-fed ponds adjacent to this section on the floodplain that are not accessible due to dyking. These ponds would serve as excellent overwintering, rearing and spawning habitats if developed, and probably even now act as a stable source of flow to this creek during baseflow periods.

There is a **moderate** upslope impact potential due to moderate connectivity and activity observed.

Plate 55 shows a representative photo of Reach 1.

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a moderate upslope impact potential, and the use and suspected use by four target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and perceptions of property protection and public safety which originally lead to the channelizing.

3.5.2 Reach 2

Reach 2 describes the higher gradient, confined channel with steep valley sides and occasional bedrock outcrops. It is 8 km in length and is split into three sections:

- Section A: Riffle-Pool (RPcw) channel with occasional larger colluvium. Some mass movements of fine-textured soils and range-use and roads on the lip and slopes of the valley.
- Section B: Cascade-Pool (CPcw with short section of CPb) channel with possible minor barrier to fish movement (see plate 15 of the photo mosaic). No land-use in this section.
- Section C: Cascade-Pool (CPcw with sections of RPcw) channel receiving upstream sediment input from natural and anthropogenic slides. No land-use in this section.

Fish species known or suspected to inhabit this reach are chinook (to the cascade in section B), coho, steelhead and rainbow trout.

Section A

This Riffle-Pool (RPcw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate to high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: moderate to good
- Rearing: good
- Overwintering: poor
- Holding: good
- Access to adjacent sections: good

Limiting factors to habitat value are areas of large substrates to spawners, possible smothering by fines, a lack of alternative habitats, and the probability of frazl and anchor ice formation during low temperatures. Indicators of recent disturbance are recently formed log jams. There is an abundant amount of LWD in the section, and the distribution is even. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is mixed young forest.

Visible impacts are mass movements originating from an upslope road and land clearing of sensitive soils. This is causing sedimentation and aggradation in this section, and likely to downstream sections.

There is a **high** upslope impact potential due to high connectivity and activity observed.

Due to the nature and severity of impacts in this section, as indicated by a 1.5-fold decrease in habitat value, a high upslope impact potential, and the use or suspected use by four target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include some adjacent private land ownership.

Section B

This Cascade-Pool (CPcw with sections of CPb) channel has a **moderate to high** primary habitat value to target species in a stable state. The overall habitat value is **low to moderate** and the channel is **stable**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: poor
- Rearing: moderate
- Overwintering: poor

- Holding: moderate
- Access to adjacent sections: moderate

Limiting factors to habitat value are large substrates to spawners, scouring, infrequent velocity refuges in sections, poor alternative habitats, and the probability of frazl and anchor ice formation in low temperatures. Indicators of recent disturbance are scouring. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is mature coniferous forest.

There are no visible impacts in this section. Of note is a large groundwater-fed sidechannel which is slightly raised above the stream-bed and does not appear accessible to fish (see plate #15 of the photo mosaic).

There is a **low** upslope impact potential due to no activity due to land-use observed.

Due to the nature and severity of impacts in this section, as indicated by a 1-fold decrease in habitat value (due to access concerns), a low upslope impact potential, and the use or suspected use by three to four target species (above/below cascade), a **low priority** for detailed assessment and restoration is assigned.

Section C

This Cascade-Pool (CPcw with sections of RPcw) channel has a **high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is **stable**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: excellent
- Rearing: good

- Overwintering: good
- Holding: good
- Access to adjacent sections: good

Limiting factors to habitat value are possible siltation, and poor alternative habitats. Indicators of recent disturbance are extensive areas of unvegetated bar. There is an abundant amount of LWD in the section, and the distribution is even. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is mature coniferous.

Visible impacts are some minor amounts of aggradation, expected to originate from upstream mass movements from the North Road FSR.

There is a **low** upslope impact potential due to a lack of land-use in this section.

Due to the nature and severity of impacts in this section, as indicated by no decrease in habitat value, a low upslope impact potential, and the use or suspected use by four target species, a **low priority** for detailed assessment and restoration is assigned.

3.5.3 Reach 3

Reach 3 of McQuarrie Creek defines the upslope and channel area from the end of Reach 2 to the North Road FSR crossing. It is a less confined, lower gradient Riffle-Pool channel which is paralleled for most of its length by the FSR. It is 3 km long and its most downstream point acts as a significant debris catchment at a constriction in the canyon.

The only known land-use in the section is the FSR.

Steelhead are the only known fish species using this reach (FHIIP, 1991). It is assumed that all freshwater life-stages of steelhead are included in this. Suspected species are coho salmon (J/Sp), and rainbow trout (all), as outlined in section 5.5.

This Riffle-Pool channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: good
- Rearing: good
- Overwintering: moderate
- Holding: good
- Access to adjacent sections: moderate

Limiting factors to habitat value are siltation, a lack of alternative habitats, and possible low water problems at baseflows. Indicators of recent disturbance are multiple channels, elevated mid-channel bars, and extensive unvegetated bars. There is an abundant amount of LWD in the section, and the distribution is even (some log jams). The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is young coniferous forest.

Visible impacts are two mass movements and some erosion that appears to be originating from the North Road, aggradation which is likely related to this activity, and the culvert barrier at the road crossing. It is suspected that the culvert is poorly placed due to the amount of bedload that is piling up behind it. The culvert was probably originally well-placed, but appears to have undercut itself so that the channel bed and thus the water level is dropping below it from scouring a large outlet pool. There are many natural mass movements in this reach as well, revealing fine-textured erodible soils on the valley walls.

There is a **high** upslope impact potential due to high connectivity and activity observed.

Plates 56 and 57 show the North Road culvert and the aggradation occurring above it.

Due to the nature and severity of impacts in this section, as indicated by a one-fold decrease in habitat value, a high upslope impact potential, the severity of the impacts that the barrier may pose on the overall productivity of this creek, and the use and suspected use by three target species, a **high priority** for detailed assessment and restoration is assigned.

3.6 Byman Creek Sub-Basin

Sub-Basin Description

Byman Creek is a third-order watershed that drains the height of land east of Houston and north of the Bulkley River. The mouth (the POI) is located at UTM 9.604360.665600 at the Bulkley River, Reach 3. The watershed is 11435.2 hectares in area and has a relatively high bifurcation ratio. It is wetland-headed.

Byman Creek was photographed and assessed from its mouth to the North Road FSR. It was segregated into three reaches over 12.3 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #7 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 10 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 7 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Fish Species Distribution, Abundance, and Habitat Values

Byman Creek is known to be inhabited by the target species coho salmon (J/Sp suspected), chinook salmon (J/Sp suspected), steelhead (J/A), and rainbow trout (J/A) in Reach 1 to the highway (FISS, 1995, FHIIP, 1991, Tredger, 1982, SKR Consultants, 1997). Steelhead and rainbow are known to inhabit the lower reaches, which is more than likely to the cascade/falls in reach 2A. Tredger (1982) reports a standing steelhead crop (the lowest of those streams surveyed in this study in the Mid-Bulkley) of 1890 fry and parr. It is thought that water temperatures would be too warm for steelhead spawning, as they spawn in the early summer and their eggs incubate throughout the period of warmer temperatures. Water levels at summer flows would also be inhibitive. All species are thought to have historically inhabited the lower reaches of this creek up to this barrier due to gradient, channel type, and a lack of natural barriers. It is unlikely that this creek supports a productive salmonid population above the highway crossing due to widespread habitat degradation by range-farming, land-clearing, and bank erosion.

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 18 below). This information is presented in a more detailed fashion in Reach and Section descriptions to follow.

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	Very High	Poor	Moderate	Poor	Poor	Moderate	F,C,T,WL,AH,VR,A	Moderate	Low
	B	Very High	Poor	Poor-Mod	Poor-Mod	Poor	Poor-Mod	F,C,T,WL,AH,VR,A	Moderate	Low-Moderate
	C	Very High	Moderate	Mod-Good	Mod-Good	Poor	Moderate	F,WL,C,AH	Good	Moderate
2	A	Moderate	Good	Moderate	Excellent	Poor	Good	LS,F,SC,AH,I	Moderate	Moderate-High

Table 18: Primary and overall fish habitat value by reach and section, including limiting factors for Byman Creek (see section 3.0 for key to codes)

There are 14 obstructions to fish movement in this creek. There are 11 waterfalls (plates 42, 43, 44, 53, 54 of the photo mosaic), one cascade and/or falls which may be passable at some flows (plate 28 of the photo mosaic- there are some difficulties with photo

interpretation here as to passability), the highway culvert, which is suspected to be impassable at extremes in flow, and finally, the straight stretch of stream below the highway was found to be almost dry in the low flow period of field checks this year due to aggradation and sub-surface flows. Since this was not a hot, dry summer, it is almost certain that this is a barrier in most years during the August-September period. The stream bed is known to have been dry frequently during baseflow periods (FHIIP, 1991).

Due to obstructions, fish habitat will only be described up to Reach 2A.

Land-Use and Upslope Impact Potential

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 19. More detailed discussion will follow in Reach and Section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	R,A,H	Moderate	Yes	Moderate
	B	A,H	Moderate	No	Low
	C	A,R	High	Yes	High
2	A	A,R	High	No	Moderate

Table 19: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section for Byman Creek.

Land-use in the Byman Creek watershed includes agriculture (hay and cattle farming), and forestry. Agriculture which occurs on the alluvial fan of Byman Creek is especially problematic because of its highly unstable nature, and the extent of land clearing that has taken place. The entire fan has been completely cleared except for occasional areas of a narrow riparian canopy which has survived the lateral movements of the creek, and some initial deciduous shrub. The riparian understory is extensively grazed by cattle as well, and this has magnified effects on riparian functions and bank instability. Furthermore, it is suspected due to the sudden bend in the creek below the highway, what appears to be a relic channel next to an old homestead (observed on air photos and on the ground), and a

number of other relic channels of varying age that proceed on a more natural line to the Bulkley River further east of the present mouth (observed on air photos), that the creek was diverted at some point. The forestry in the watershed has mostly been salvage logging after the Row fire of 1982, which burned a significant area of the watershed (ECA=25%). The large ECA and the channel conditions to be described below indicate that there are increased peak flow problems in this watershed. Furthermore, there is a great deal of sediment which is being generated by extensive gully failures and slumps in the fire area below the areas of salvage logging. Whether this is natural (ie-is occurring due to the loss of vegetation from the fire), or is due to salvage logging practices such as longer skidding distances and road blading instead of building is uncertain. For a more detailed history of land-use in the Mid-Bulkley watershed, see section 1.1.5.

3.6.1 Reach 1

This reach is defined as the unconfined, regularly wandering riffle-pool channel followed by the straight (and suspected diverted) section of the creek which proceeds to intersect Perow Creek and the Bulkley River. It is 1.65 km in length and is split into three sections:

- Section A: The possibly diverted, mostly straight section of creek below the highway.
- Section B: Regularly wandering riffle-pool channel on the alluvial fan feature. Area of greatest agricultural impacts to the riparian canopy and bank stability.
- Section C: Similar to section B, but with less intense impacts from agriculture.

Land-use in this reach also includes the railway crossing, which is rip-rapped on both sides, hay farming below the railway crossing, the highway crossing, and a farm/homestead.

Fish species using this reach are chinook, coho, steelhead , and rainbows, as described in section 4.6 above.

Section A

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **low** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: poor
- Spawning: moderate
- Rearing: poor
- Overwintering: poor
- Holding: moderate
- Access to adjacent sections: poor

Limiting factors to habitat value are smothering by fine sediments, poor cover in sections, elevated temperatures, low water levels much of the year, alternative habitats are poor above the Perow confluence, few velocity refuges, and poor access through the straight section and possibly the highway culvert. Indicators of recent disturbance are . There is a low amount of LWD in the section, and the distribution is even. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is young deciduous forest with intermittent areas of shrub-herb and grassland.

Visible impacts are a loss of complexity, sinuosity, and LWD above the confluence of Perow Creek causing a loss of holding and rearing habitats. This is thought to be caused by aggradation of pool habitat, which is also having a major effect on water levels in the creek. There is a loss of riparian canopy and related functions due to land clearing in sections. The railway crossing has channelized the creek with rip-rap leading to a possible increase in water velocities and unstable deposition downstream.

The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely peak flows and upstream sediment delivery. Increased peak flows are certainly plausible for reasons outlined above, and this may affect the geomorphic status of the creek at different discharges, leading to scouring down of riffle crests followed by blanketing aggradation below some critical stream power. This would have maximum impact on habitat complexity and holding/rearing habitat. A further impact to habitat quality is the loss of access to an off-channel area through a culvert (visible in plate 5 of the photo mosaic), which also leads to lower water levels in this feature.

There is a **low** upslope impact potential due to poor connectivity.

Plates 51 and 52 show oblique photos of the two culvert problems listed above..

Due to the nature and severity of impacts in this section, as indicated by a three-fold decrease in habitat value, a low upslope impact potential, and the use by four target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and the need to stabilize upstream sources of sediment and peak flows prior to instream and riparian restoration here.

Section B

This Riffle-Pool (RPcw)channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **low to moderate** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: poor
- Spawning: poor to moderate
- Rearing: poor to moderate

- Overwintering: poor
- Holding: poor to moderate
- Access to adjacent sections: moderate

Limiting factors to habitat value are siltation, poor cover, temperature increase due to canopy removal, poor water levels most of the year, poor alternative habitats, infrequent velocity refuges, and poor access at times from section A to section B. Indicators of recent disturbance are multiple channels, extensive areas of unvegetated bar, parallel LWD, and eroding banks. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is dominantly deciduous forest at the pole-sapling successional stage, with extensive areas of grassland and shrub-herb.

Visible impacts are bank erosion and loss of or damage to the riparian canopy function due to clearing of the fan for range-use, grazing, and the clearing of the powerline right-of-way. The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely peak flows and upstream sediment delivery from the fire area magnifying the homogenization of habitat and the extremes in water levels..

There is a **low** upslope impact potential due to moderate connectivity, but no activity due to land-use observed.

Plate 53 shows a representative photo of this section, Reach 1 at baseflow conditions.

Due to the nature and severity of impacts in this section, as indicated by a 2.5-fold decrease in habitat value, a low upslope impact potential, and the use and/or suspected use by four target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and the need to stabilize upstream sources of sediment and peak flows prior to instream and riparian restoration here.

Section C

This Riffle-Pool (RPcw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: moderate to good
- Rearing: poor to moderate
- Overwintering: poor
- Holding: moderate
- Access to adjacent sections: good

Limiting factors to habitat value are poor water levels, smothering by fines, poor cover, and a lack of alternative habitats. Indicators of recent disturbance are multiple channels, eroding banks, and recently formed log jams. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is mixed young forest.

Visible impacts are bank erosion and loss of or damage to riparian canopy function from range-use. There is also a possible slump and loaded gully which originate from an upslope secondary road (visible on 1:10 000 stereo pairs- bottom of slump visible on plate 18 of photo mosaic). The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely peak flows and upstream sediment delivery from the upstream fire area.

There is a **high** upslope impact potential due to activity observed and moderate connectivity.

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a high upslope impact potential, and the use or suspected use by four target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and the need to stabilize upstream sources of sediment and peak flows prior to instream and riparian restoration here.

3.6.2 Reach 2

Reach 2 describes the highly confined channel, bedded with larger clasts, (frequently colluvium), and which is frequently bedrock-controlled that runs from the end of Reach 1 to the downstream end of the Row fire area. It is 6 km long, and is split into four sections:

- Section A: Cobble-pool (CPb) channel with some range-use
- Section B: Riffle-Pool (RPcw) channel
- Section C: Step-Pool (SPr) channel, several large falls
- Section D: Riffle-Pool (RPcw) channel

The only land-use in this reach is grazing by cattle in section A.

Target species using this reach are thought to be steelhead and rainbows presently. coho are suspected to use this reach. Distribution is thought to be to the falls in mid section A. Reasons are outlined in section 4.6 above.

Results will only be described in detail for the first section of this reach due to the falls obstruction. Other results are summarized in Appendix 3, form 2 (#10) and form 3 (#7).

Section A

This Cascade-Pool (CPb) channel has a **moderate** primary habitat value to target species in a stable state. The overall habitat value is **moderate to high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: moderate
- Rearing: excellent
- Overwintering: poor
- Holding: good
- Access to adjacent sections: moderate

Limiting factors to habitat value are frequent areas of large substrates to spawners, siltation, periods of scouring at high flows, a lack of alternative habitats, and the probability of frazl and anchor ice formation at very low temperatures. Indicators of recent disturbance are recently formed log jams. There is an unknown amount of LWD in the section due to canopy closure. The extent of pool habitat is 1 to 25% of the wetted channel area. The riparian area is mixed young forest with sections of grassland and shrub-herb.

Visible impacts are some bank erosion and riparian loss and/or damage due to range-use (much less so than previous sections). The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely peak flows and upstream sediment delivery from the Perow fire area.

There is a **moderate** upslope impact potential due to high connectivity but no activity observed.

Due to the nature and severity of impacts in this section, as indicated by an increase in habitat value, a moderate upslope impact potential, and the use or suspected use by three target species, a **low priority** for detailed assessment and restoration is assigned.

3.6.3 Reach 3

Reach 3 describes the confined canyon area which was burned over by the Perow fire. It is 2.3 km in length and consists of three sections:

- Section A: Debris catchment for sediment and blowdown from fire area.
- Section B: Degrading section, bulk of fire impacts here. Extreme terrain instability (seven gully failures over 700 m).
- Section C: Intact riparian, several large falls. Ends at North Road crossing.

Due to the impassable barriers to fish movement downstream, and the low probability of a resident population upstream (no upstream lake), fish habitat and impacts will not be summarized in detail here. See Appendix 3, form 2 (#10) and form 3 (#7) for a summary of the habitat condition and preliminary habitat assessments.

3.7 Johnny David Creek Sub-Basin

Sub-Basin Description

The Johnny David Creek Sub-Basin is a second-order watershed which drains the height of land east of Houston and north of the Bulkley River. It is 4571 hectares in area and has a low bifurcation ratio. The mouth (the POI) is located at UTM 9.6043500.670300 at the Bulkley River, Reach 4.

Johnny David Creek was photographed and assessed from its mouth to the end of valley bottom land-use at 5.1 km upstream. It was segregated into 2 reaches over 5.1 km, and

then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, and 4 show the positions of reach breaks and known obstructions. There was no solid fish presence data for this creek, so there was no mapping of the suspected fish distributions. Appendix 1, form 1, form #1 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 1 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 11 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Fish Species Distribution, Abundance, and Habitat Values

Johnny David Creek is thought to be inhabited by similar species to Richfield Creek (MIC Notes, 1997). These would be chinook salmon (J/Sp), coho salmon (J/Sp), and steelhead (all). A rancher who lived adjacent to the creek, and has since the 1950's has noted steelhead adults (holding below the highway) and rainbow/steelhead juveniles, rainbow trout adults, cutthroat trout (J/A) and Dolly Varden (J/A). He has never witnessed any spawning fish in the creek. It is thought that water temperatures would be too warm for steelhead spawning, as they spawn in the early summer and their eggs incubate throughout the period of warmer temperatures.

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 20 below). This information is presented in a more detailed fashion in Reach and Section descriptions to follow.

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1		Very High	Mod-Good	Moderate	Good	Poor	Moderate	DO,WL	Moderate	Moderate
2	A	Very High	Mod-Good	Poor	Moderate	Poor	Good	WQ, WL, DO	Moderate	Moderate
	B	Very High	Good	Good	Good	Moderate	Good	WQ, AH	Good	High

Table 20: Primary and overall fish habitat value by reach and section, including limiting factors for Johnny David Creek (see section 3.0 for key to codes)

There are no natural obstructions to fish movement in the study area. The culvert at the highway crossing may be a barrier at extremes in flow.

Land-Use and Upslope Impact Potential

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 21. More detailed discussion will follow in Reach and Section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1		A	Low	No	Low
2	A	A	Moderate	Yes	Moderate
	B	A	Moderate	Yes	Moderate

Table 21: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section Johnny David Creek.

There are several land-uses in the study area of Johnny David Creek. The typical agricultural uses exist here, with hay farming on the Bulkley floodplain and range farming north of the highway. Range use is intense here, and there have been severe impacts to the riparian understory, but a great deal of land-clearing has not actually occurred recently. The valley bottom forest is mostly alder and poplar, which indicates that land-clearing has taken place at some time in the past, probably by the initial land-owner. The highway crossing and powerline corridors also run through the valley bottom and across the creek. In the uplands, and centered around the North Road FSR,

there has been some extensive clearcutting and the Perow fire also burned part of the headwaters of this creek. A qualitative field survey of the area showed that sediment delivery into the mainstem of Johnny David was not a concern in the area, nor was road erosion from the North Road which parallels the creek for a stretch. However, some significant aggradation was noted on the most westerly unnamed creek in the headwaters. This creek is intermittent, but there had been a torrent of material into the channel below the FSR crossing. Since the channel bedload varied significantly on both sides of the road fill, and since there were significant signs of erosion, and much of the material matched the size of the fill., it was assumed that erosion of the fill slope was causing the aggradation. A further check on the area revealed that an old tertiary road that led from the FSR down to the creek was focusing water and leading to erosion of the road bed (see plates 49 and 50 for oblique photos of these impacts. This point source impact was thought to be a sediment source to the downstream reaches. This impact should fall within the Roads/Hillslopes/Gullies portion of the WRP. For a more detailed history of land-use in the Mid-Bulkley watershed, see section 1.1.5.

3.7.1 Reach 1

Reach 1 of Johnny David Creek is an irregularly meandering unconfined Riffle-Pool channel which runs from the mouth of the creek through its alluvial fan to an increasingly confined valley upstream. It is 1.9 km in length.

Land-use to the highway is for hay land, and intensive cattle grazing takes place above the highway. The highway and powerline corridors cross the creek in this reach.

Fish species thought to inhabit the reach are coho salmon (J/Sp), chinook salmon (J/Sp), steelhead (all), rainbow trout (J/A), cutthroat trout (J/A), and Dolly Varden (J/A) (MIC Notes, 1997, Local Rancher, pers. comm.).

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate to high** and the

channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: moderate
- Rearing: good
- Overwintering: moderate
- Holding: good
- Access to adjacent sections: good

Limiting factors to habitat value are smothering by fines, poor cover in sections, low water levels for rearing at baseflows, possible temperature increase from a decrease in canopy closure, and water quality problems from upstream cattle grazing. Indicators of recent disturbance are eroding banks, multiple channels, and extensive areas of unvegetated bar. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is young mixed forest (dominantly deciduous) with many sections of shrub-herb.

Visible impacts are a loss of and/or damage to riparian function causing bank erosion and aggradation in the creek combined with habitat degradation. The powerline right-of-way is causing similar effects, especially considering it is also being grazed and trampled by cattle. The culvert at the highway crossing is also a problem to fish access, as outline above. The mouth of the creek shows a great deal of aggradation of fine material.

There is a **low** upslope impact potential due to the double floodplain of the Bulkley and this creek (ie-no upslope area)

Plates 46 to 48 show oblique photos of impacts to the creek and give representative illustrations of the habitat.

Due to the nature and severity of impacts in this section, as indicated by a 1.5-fold decrease in habitat value, a low upslope impact potential, and the suspected use by six target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and the need to stabilize upstream sources of sediment prior to instream and riparian restoration here.

3.7.2 Reach 2

This moderately confined Riffle-Pool channel runs through an area of steeper valley sides from the end of Reach 1 to the end of land-use in the valley bottom at 5.1 km upstream. It is split into two sections, governed by the extent of impacts from cattle grazing. The reach is 3.2 km in length.

Range-use is the only land-use in this reach. Forestry land-use impacts occurring upstream are outlined in section 3.7 above.

Fish species thought to be using this reach are coho salmon (J/Sp), chinook salmon (J/Sp), steelhead (all), rainbow trout (J/A), cutthroat trout (J/A), and Dolly Varden (J/A) (MIC Notes, 1997, Local Rancher, pers. comm.).

Section A

This Riffle-Pool (RPcw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate to good
- Spawning: poor
- Rearing: moderate
- Overwintering: poor

- Holding: good
- Access to adjacent sections: moderate

Limiting factors to habitat value are water quality due to cattle use, water levels at mid to low flows, and Dissolved Oxygen. Indicators of recent disturbance are eroding banks and extensive areas of unvegetated bar. There is a poor amount of LWD in the section, and the distribution is even. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is mixed young forest with sections of shrub-herb and grassland.

Visible impacts are creep on cleared slopes indicating the potential for more serious mass movements, heavy range use causing a loss of bank stability, and damage to/loss of riparian canopy function, water quality concerns from cattle being in the channel and/or runoff from valley slopes, and several cattle/ATV crossing which are point sources of sediment.

There is a **moderate** upslope impact potential due to creep observed and moderate connectivity to the channel.

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a moderate upslope impact potential, and the suspected use by six target species, a high **priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership.

Section B

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good

- Spawning: good
- Rearing: good
- Overwintering: moderate
- Holding: good
- Access to adjacent sections: good

Limiting factors to habitat value are water quality impacts from cattle using the channel or upslope runoff, and poor alternative habitats. Indicators of recent disturbance are extensive areas of unvegetated bar, eroding banks, and multiple channels. There is an abundant amount of LWD in the section, and the distribution is even. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is mixed young forest.

Visible impacts are creep on cleared slopes above the creek, and a reduced level of range-use with similar but correspondingly decreased impacts(see section A) .

There is a **moderate** upslope impact potential due to the creep activity observed, and moderate connectivity to the channel.

Due to the nature and severity of impacts in this section, as indicated by a one-fold decrease in habitat value, a moderate upslope impact potential, and the suspected use by six target species, a **moderate priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership.

3.8 Richfield Creek Sub-Basin

The Richfield Creek Sub-Basin drains the Nechako Plateau west of Topley and north of the Bulkley River. It marks the north western boundary of the Mid-Bulkley watershed, and includes the highest point in the watershed, Tachek Mountain (1656m). The sub-basin area is 21634.8 hectares and the watershed has a low bifurcation ratio. The mouth of Richfield Creek (the POI) is located at UTM 9.6043000.672100.

Table 22 below shows the tributaries assessed in the Richfield sub-basin:

Waterbody	Length Assessed	# Reaches	UTM of Endpoint (Zone 9)	
Richfield Creek	6.4 km	4	6049590	674875
Robert Hatch Creek	4.8 km	1	6047800	669825

The results for each of these tributaries will be described separately below.

3.8.1 Richfield Creek

General Description

Richfield Creek was photographed and assessed from Its mouth at the Bulkley River , Reach 4 to the bridge at the Granisle Highway, 6.4 km upstream. This was the last known point of land-use. It was segregated into 4 reaches, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #4 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 4 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 5 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Fish Species Distribution, Abundance, and Habitat Values

Richfield Creek is known to be inhabited by the target species coho salmon, chinook salmon, steelhead, rainbow trout, cutthroat trout and Dolly Varden (FISS, 1995, FHIIP, 1991, Tredger, 1982, and A. McCracken, pers. comm.). This tributary is thought to be a critical habitat for coho, steelhead and chinook within the Mid-Bulkley, as indicated by past productivity, sampling densities of fry, and the stable flow rates and cooler temperatures provided by the large wetland at the mouth of Robert Hatch Creek (MIC Notes, 1997, Tredger, 1982). Tredger (1982) reports an

estimated standing steelhead crop of 19380 fry and parr (accounting for the strength of different runs) for this creek. This yield is thought to be overestimated due to the length of stream available for recruitment (see distribution comments below), but still is important in earmarking this creek as a nursery stream. Maximum coho and chinook escapements recorded from this creek are 300 and 100, respectively (FHIIP, 1991). The stream has been characterized as having a mean range of coho escapements from 25-100 (MELP, unknown date). A 36-year record of escapements for coho and chinook is presented below:

ESCAPEMENT : RICHFIELD CREEK

WATERSHED-CODE : 46-6400

YEAR	SOCKEYE	COHO	PINK	CHUM	CHINOOK	STEELHEAD
1953	0	100	0	0	N/O	UNK
1954	0	UNK	0	0	0	UNK
1955	0	15	0	0	25	UNK
1956	0	75	0	0	N/O	UNK
1957	0	N/O	0	0	N/O	UNK
1958	0	75	0	0	N/O	UNK
1959	0	N/O	0	0	N/O	UNK
1960	0	75	0	0	0	UNK
1961	UNK	UNK	UNK	UNK	UNK	UNK
1962	0	50	0	0	0	UNK
1963	0	300	0	0	30	UNK
1964	0	50	0	0	100	UNK
1965	N/O	0	0	0	N/O	UNK
1966	0	100	0	0	0	UNK
1967	0	N/O	0	0	0	UNK
1968	N/O	0	0	0	0	UNK
1969	0	100	0	0	0	UNK
1970	UNK	UNK	UNK	UNK	UNK	UNK
1971	0	N/O	0	0	0	UNK
1972	0	150	0	0	0	UNK
1973	0	UNK	0	0	0	UNK
1974	0	N/O	0	0	0	UNK
1975	0	UNK	0	0	0	UNK
1976	0	25	0	0	0	UNK
1977	0	200	0	0	0	UNK
1978	0	250	0	0	0	UNK
1979	N/O	N/O	0	0	0	UNK
1980	N/O	N/O	0	0	0	UNK
1981	0	UNK	0	0	0	UNK
1982	UNK	UNK	UNK	UNK	UNK	UNK
1983	0	0	UNK	0	UNK	UNK
1984	0	0	0	0	0	UNK
1985	0	0	0	0	0	UNK
1986	0	UNK	0	0	0	UNK
1987	0	UNK	0	0	0	UNK
1988	0	0	0	0	0	UNK
1989	UNK	UNK	UNK	UNK	UNK	UNK
1990						
1991						
1992						
1993						
1994						
1995						

N/O = STREAM INSPECTED,NO FISH OBSERVED

UNK = STREAM NOT INSPECTED OR NOT INSPECTED FOR SPECIES INDICATED OR SPECIES PRESENT BUT NO ESTIMATE MADE

(Source: FHIIP, 1991)

Figure 8: 36-year record of escapements Richfield Creek

Spawning, rearing, overwintering and holding habitat value was assessed for reaches 1 and 2A using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 23 below). This information is presented in a more detailed fashion in Reach and Section descriptions to

follow. The results of the FHAP for the reaches upstream of reach 2A can be found in Appendix 3.

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	Very High	Moderate	Good	Mod-Good	Mod-Good	Moderate	C,VR,T,WQ	Good	Moderate-High
	B	Very High	Poor	Moderate	Moderate	Poor	Poor	PTR,C,SC,WL,AH,VR	Moderate	Low-Moderate
	C	Very High	Moderate	Mod-Good	Moderate	Poor	Good	F,C,DO,AH	Good	Moderate
2	A	High	Excellent	Good-Exct	Good-Exct	Good	Excellent	AH,A,WQ	Moderate	High

Table 23: Primary and overall fish habitat value by reach and section, including limiting factors for Richfield Creek (see section 3.0 for key to codes)

There are three obstructions to fish movement at waterfalls in Reach 2 and 3. The most downstream falls was confirmed in field checks to be a barrier to upstream migration for all species at all flows, contrary to information reported by FHIIP, 1991. This was a determined as a function of vertical sections, a lack of resting points, and height (18.2 metres).

The target species listed above are known to occur only in the lower reaches of Richfield Creek, with the exception of rainbow trout which are found above Findlay Falls (Tredger, 1982). The creek between the falls barriers may support a productive population of resident fish, based on habitat quality and assuming access to lakes on Holmes Creek, but this data has not been gathered. The lower reaches are assumed to be defined by the mouth to the first falls in Reach 2A (see oblique photo plate 42), below which there are no barriers. Contrary to the work of Tredger, 1982, Findlay Falls, located at the Reach3/4 break is not the first impassable falls, as outlined above.

Land-Use and Upslope Impact Potential

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 24. More detailed discussion will follow in Reach and Section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	N/A	N/A	N/A	Low
	B	A, H	Low	No	Low
	C	A	Moderate	Yes	Moderate
2	A	A	High	No	Moderate

Table 24: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section for Richfield Creek.

Land-use is limited mostly to the valley bottom of this creek. However, it has undergone a fair amount of development in this area. Below the highway, the floodplain has been used for hay farming and urban development. There is a suburb of Topley directly adjacent to the creek. Water withdrawals for private wells, urban runoff, and loss of riparian function are the main impacts from this land-use. The highway and railway corridors both cross the creek here. There is extensive range-use above homesteads in Reach 1 and 2 north of the highway. One rancher has fenced off creek access and created two watering holes which cattle are restricted to for watering. It is assumed that water is pumped into these earthen troughs from the creek. However, there is still free-range cattle-use going on in the upper section of Reach 1 and Reach 2. There is very limited land-use above this area on Richfield Creek. There is some very limited forest harvesting going on above Redtop Creek and Holmes Creek. A field survey of tributaries running out of these areas showed that there was no impact observable impacts from forestry , aside from the erosion of a fire-break into an intermittent first-order tributary of Redtop Creek (occurring in opening # 37) (see oblique photo plates 42 and 43). This is not expected to be causing a significant impact to Richfield as of yet, because the tributary flows into a large wetland area, which will act as a sediment sink. The Granisle Highway bridge did not appear to be confining the creek or causing any access problems. The powerline crossing just upstream of here was also not impacting the creek. For a more detailed history of land-use in the Mid-Bulkley watershed, see section 1.1.5.

3.8.1.1 Reach 1

This reach extends from the mouth of Richfield Creek to a point of consistently increased confinement and gradient upstream. The reach is 1 km in length and is split into three sections:

- Section A: Prior to Topley residences, dominantly gravel substrate.
- Section B: Residences to confluence of Robert Hatch, dominantly cobble substrate.
- Section C: Robert Hatch confluence to large slump-site at reach break, dominantly gravel substrate.

Section A

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate to high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: good
- Rearing: moderate to good
- Overwintering: moderate to good
- Holding: moderate
- Access to adjacent sections: good

Limiting factors to habitat value are poor cover in many sections, infrequent velocity refuges, temperature increases due to riparian canopy losses, and water quality concerns from upstream cattle grazing. Indicators of recent disturbance are extensive areas of unvegetated bar, multiple channels, and eroding banks. There is a

poor amount of LWD in the section, and the distribution is even. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is dominantly shrub-herb and grassland species.

Visible impacts are loss of/damage to riparian functions at hay land and residences leading to lateral instability and bank erosion at several sites, and channelizing at the Railway Crossing leading to increased water velocities and consequently is thought to have caused an avulsion downstream. The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely upstream sediment delivery magnifying the aggradation and related habitat impacts outlined above.

There is a **low** upslope impact potential due to poor connectivity (double floodplain=no upslope).

Due to the nature and severity of impacts in this section, as indicated by a 1.5-fold decrease in habitat value, a low upslope impact potential, and the use or suspected use by five target species, a **moderate priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and the need to stabilize upstream sources of sediment prior to instream and riparian restoration here

Section B

This Riffle-Pool (RPcw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **low to moderate** and the channel is **degrading (aggrading upstream of highway crossing)**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: poor
- Spawning: moderate
- Rearing: moderate

- Overwintering: poor
- Holding: poor
- Access to adjacent sections: moderate

Limiting factors to habitat value are infrequent stable pool tailouts for spawning, poor cover, scouring, low water levels seasonally, a lack of alternative habitats, and infrequent velocity refuges. Indicators of recent disturbance are eroding banks, multiple channels, and limited pool frequency and extent. There is a poor amount of LWD in the section, and the distribution is even. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is young deciduous forest with frequent areas of shrub-herb and grassland species.

Visible impacts are channelizing at the highway crossing causing a loss of complexity, and scouring, as well as possible seasonal access problems due to a lack of depth variability at low flows and a lack of velocity refuges at high flows. There is also a significant amount of bank erosion due to cleared land at residences and the powerline crossing. The section is aggrading above the highway crossing. The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts from upstream sediment delivery are expected.

There is a **low** upslope impact potential due to poor connectivity to the channel.

Plate 39 shows a representative photo of this section of Reach 1.

Due to the nature and severity of impacts in this section, as indicated by a 2.5-fold decrease in habitat value, a low upslope impact potential, and the use or suspected use by six target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and the need to stabilize upstream sources of sediment prior to instream and riparian restoration here.

Section C

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate
- Spawning: moderate to good
- Rearing: moderate
- Overwintering: poor
- Holding: good
- Access to adjacent sections: good

Limiting factors to habitat value are smothering by fines, poor cover and complexity of cover, low dissolved oxygen due to eutrophication, and poor alternative habitats. Indicators of recent disturbance are eroding banks, multiple channels, and extensive areas of unvegetated bar. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is deciduous forest in the pole-sapling successional stage.

Visible impacts are a large rotational slump at the reach 1/2 break which has likely been caused by land-clearing (poplar forest here) at some point earlier in the century, and may be frustrated by cattle use. There is also frequent bank erosion due to cattle trampling and riparian loss/damage, and definite water quality impacts as witnessed by abundant algal growth on substrate, and overgrowth in standing water (observed in field surveys).

There is a **high** upslope impact potential due to moderate connectivity, and the size and impact of the large slump observed..

Plate 40 shows an oblique photo of the slump site.

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a high upslope impact potential, and the use or suspected use by target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership, and the need to stabilize the upslope source of sediment prior to any in-stream work.

3.8.1.2 Reach 2

This reach describes the first half of the canyon between the Nechako Plateau and the Bulkley valley bottom. It is less confined and less deeply incised into the bedrock. It runs from the end of Reach 1 to the second falls (plate 20 of the photo mosaic). It is 3.5 km in length and is split into three sections:

- Section A: Cascade-Pool (CPcw) channel with falls at end of section.
- Section B: Cascade-Pool (CPb) channel with upstream colluvial inputs and a large log jam.
- Section C: Cascade-Pool (CPb) channel with increased confinement and incision

Fish habitat and habitat impacts will only be described for section A due to the impassable falls located at its upstream end. Information on upstream habitat condition and a preliminary habitat assessment for other sections are found in appendix 3.

The only land-use in this reach is less intensive cattle grazing of the riparian understory. Water quality impacts were greatly decreased in this reach as noted in field checks.

Target species thought to be using this reach to the falls are coho (J/Sp), chinook (J/Sp), steelhead (all), cutthroat trout (all) and Dolly Varden (all). Section A of this reach is an especially important island of high value habitat, which could be very productive provided that good access to the area is secured and maintained.

Section A

This Cascade-Pool (CPcw) channel has a **high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is stable. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: excellent
- Spawning: good to excellent
- Rearing: good to excellent
- Overwintering: good
- Holding: excellent
- Access to adjacent sections: moderate

Limiting factors to habitat value are poor off-channel alternative habitats, poor access upstream, and possible water quality impacts from cattle manure runoff. There are no indicators of recent disturbance. There is an abundant amount of LWD in the section, and the distribution is even. The extent of pool habitat is 26-50% of the wetted channel area. The riparian area is mixed young forest with areas of mature coniferous.

Visible impacts are some minor range-use impacts on the riparian understory. Much of the directly adjacent riparian is alder/willow, and in a few areas near the Reach1/2 break there is significant grazing of the understory. This riparian provides good cover, but is not the natural climax forest, especially in a more laterally stable area such as this.

There is a **moderate** upslope impact potential due to high connectivity but no activity observed.

Plate 41 shows a representative shot of this section of the reach.

Due to the nature and severity of impacts in this section, as indicated by no decrease in habitat value, a moderate upslope impact potential, and the use or suspected use by six target species, a **low priority** for detailed assessment and restoration is assigned.

3.8.2 Robert Hatch Creek

General Description

Robert Hatch Creek was photographed and assessed from its mouth at a large wetland area adjacent to Richfield Creek, to the end of its alluvial fan, which also marked the end of cleared land and range-use. It is composed of 1 reach which is 4.8 km long, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #5 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form #5 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form #6 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Fish Species Distribution, Abundance, and Habitat Values

Robert Hatch Creek is not known to be inhabited by any fish. This is a high priority data gap to fill. However, the accessibility from Richfield Creek, the lack of permanent natural barriers in the area studied, and the gradient imply that this creek may have the same species present as Richfield Creek (MIC Notes, 1997). The value

of habitat here suggests that it would be used mostly by juveniles, and the wetland at its mouth could provide significant rearing and overwintering values provided water quality was good. The species thought to inhabit this tributary are chinook (J), coho (J/Sp suspected), steelhead (J), and cutthroat trout (all historically) (A. McCracken, pers. comm.). It is thought that water temperatures would be too warm for steelhead spawning, as they spawn in the early summer and their eggs incubate throughout the period of warmer temperatures.

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 25 below). This information is presented in a more detailed fashion in Reach and Section descriptions to follow.

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	Very High	Mod-Good	Moderate	Moderate	Poor	Good	F,WL,DO,WQ,A	Moderate	Moderate
	B	Very High	Good	Unknown	Good	Poor	Good	DO,WL,WQ	Good	Moderate-High

Table 25: Primary and overall fish habitat value by reach and section, including limiting factors for Robert Hatch Creek (see section 3.0 for key to codes)

There are no permanent natural obstructions to fish movement in the area of this creek studied. The large fan at the mouth of the creek appears to be a seasonal barrier, but a field survey would be required to confirm this. There could be a barrier upstream of the study area in the long canyon connecting the Nechako Plateau to the valley bottom.

Land-Use and Upslope Impact Potential

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 26. More detailed discussion will follow in Reach and Section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	A	Low	No	Low
	B	A	Low	No	Low

Table 26: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section for Robert Hatch Creek.

The only land-use on Robert Hatch Creek in the study area is cattle grazing with associated land-clearing and ATV/cattle stream crossings. There is some minor upslope forestry. A qualitative field survey of the headwaters revealed a fire break on a clearcut which had been bladed right in the creek bed of Robert Hatch. This had exposed quite a bit of mineral soil, and the site obviously erodes every spring and during heavy rain events (see oblique photo plate 44). The site is eroding into a large wetland behind a beaver dam, however, and is not thought to be a big sediment source to the creek. It is certainly a chronic problem that should eventually be corrected in the scope of the WRP Roads/Hillslopes/Gullies restoration. For a more detailed history of land-use in the Mid-Bulkley watershed, see section 1.1.5.

3.8.2.1 Reach 1

Reach 1 is split into two sections over the 4.8 km:

- Section A: High intensity of land-clearing and range-use with accordingly decreased canopy cover and bank stability. Heavy aggradation.
- Section B: Greater canopy cover with fewer signs of range impacts.

Section A

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is

aggrading. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate to good
- Spawning: moderate
- Rearing: moderate
- Overwintering: poor
- Holding: good
- Access to adjacent sections: moderate

Limiting factors to habitat value are smothering by fines, low water levels much of the year due to aggradation, water quality concerns due to range-use, and possibly limited access at the gravel fan as outlined above. Indicators of recent disturbance are eroding banks, multiple channels, and extensive areas of unvegetated bar. There is an amount of LWD in the section, and the distribution is even. The extent of pool habitat is 51-75% of the wetted channel area. The riparian area is young mixed forest with extensive areas of shrub-herb and grassland..

Visible impacts are range-use and land-clearing causing loss of/damage to the riparian function, bank instability and erosion, and aggradation of the channel. There are several point sources of sediment at ATV/cattle crossings. The extent of this erosion is indicated at the heavily aggraded fines/gravel fan at the mouth. However, there has not yet been a significant loss of pool habitat, and the extent of riparian vestiges suggests that there may be enough stability to support stable cutbanks in some areas. Field surveys may reveal that this is a very important tributary for rearing juveniles.

There is a **low** upslope impact potential due to poor connectivity.

Due to the nature and severity of impacts in this section, as indicated by a two-fold decrease in habitat value, a low upslope impact potential, and the use by an unknown number of target species, a **high priority** for detailed assessment and restoration is assigned. Barriers to restoration include adjacent private land ownership.

Section B

This Riffle-Pool (RPgw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate to high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: unknown
- Rearing: good
- Overwintering: poor
- Holding: good
- Access to adjacent sections: good

Limiting factors to habitat value are poor DO during winter and a poor probability of open water, low water levels seasonally, and water quality (high nutrients) concerns due to cattle use. Indicators of recent disturbance are eroding banks, recently formed log jams, and extensive areas of unvegetated bar. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 51-75% of the wetted channel area (judging only by sections where the stream was visible through the canopy. The riparian area is young deciduous forest with sections of shrub-herb and grassland.

Visible impacts are identical to section A, but of a lesser magnitude, due to less intense grazing and land-clearing activity.

There is a **low** upslope impact potential due to poor connectivity.

Due to the nature and severity of impacts in this section, as indicated by a 1.5-fold decrease in habitat value, a low upslope impact potential, and the use by an unknown number of target species, a **high priority** for detailed assessment and restoration is assigned. Upstream areas should also be surveyed for fish species use.

3.9 Emerson Creek Sub-Basin

General Description

Emerson Creek is a moderately steep, incised, cold stream draining the east slope of the Telkwa mountain range into the Bulkley River north of the Morice River confluence. The watershed is 6289 hectares in area and has a medium to high bifurcation ratio. It was photographed and assessed from its mouth at UTM 9.6035783.641953 to the upstream end of the most upstream cutblock (openings #6 and 24). It was segregated into 3 reaches over 13.1 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #8 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 7 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 12 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Fish Species Distribution, Abundance, and Habitat Values

Emerson Creek is not known to be inhabited by any fish species. This is a significant data gap. It has been assessed as having a high potential for steelhead, Dolly Varden, and bull trout due to its colder year-round temperatures and generally higher gradient (MIC

Notes, 1997). Mid-Bulkley Fish Fence staff who have walked the lower reach of this creek report that it was being used by pink spawners, although no spawning was taking place (P. Perlotto, pers. comm.). Given the gradient and habitat quality, and assuming use by species which are known to prefer lower water temperatures for spawning, it is suspected that the following species use the creek up to the cascade/falls in reach 2: pink salmon (holding and possibly spawning), steelhead (all), rainbow (all), Dolly Varden (all), and bull trout (all).

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 27 below). This information is presented in a more detailed fashion in Reach and Section descriptions to follow.

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	Very High	mod-good	good	mod-good	mod-good	mod-good	T, F, I, VR	good	moderate to high
	B	Very High	good	good	good	mod-good	good	T, F, I	good	high

Table 27: Primary and overall fish habitat value by reach and section, including limiting factors for Emerson Creek (see section 3.0 for key to codes)

There is a cascade/falls obstruction at the beginning of reach 2 which is documented as being impassable to fish (MELP, 1977). Fish habitat will only be described to the end of reach 1 for this reason.

Land-Use and Upslope Impact Potential

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 28. More detailed discussion will follow in Reach and Section descriptions.

Reach	Section	Upslope Land Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	R	Moderate	Yes	Moderate
	B	None	Moderate	No	Low
2		F	High	Yes	High
3		F,R	Moderate	No	Low

Table 28: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section for Emerson Creek.

Emerson Creek sustains a moderate level of forestry and road building. Cutblocks in the upslope area range from 1964 to 1991. There is a fairly low road density within the area. The Telkwa FSR and the railway corridor cross the creek in the valley bottom at the same spot, and have channelized the creek here.

3.9.1 Reach 1

Reach 1 is described as a higher gradient (1.3%) Riffle-Pool channel with abundant large and small cobbles. There are a few areas with large sediment wedges, suspected to be mostly due to a large slide in reach 2, and one (possibly two) in this reach. It is 4 km in length, and is split into two sections:

- Section A: More clumped distribution of LWD, less complexity, large sediment wedges and channelized at one area by the road/railway.
- Section B: Evenly distributed LWD with greater complexity, no adjacent land-use.

Fish species thought to be using this reach are outlined in section 4.9 above.

Section A

This Riffle-Pool (RPcw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **moderate to high** and the

channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: moderate to good
- Spawning: good
- Rearing: moderate to good
- Overwintering: moderate to good
- Holding: moderate to good
- Access to adjacent sections: good

Limiting factors to habitat value are siltation, low water temperatures, and the probability of frazl and/or anchor ice in low temperatures. Indicators of recent disturbance are extensive areas of unvegetated bar, and sediment wedges. There is a poor amount of LWD in the section, and the distribution is even. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is mature coniferous forest. There appears to be an excellent off-channel area visible on plate #7 of the photo mosaic.

Visible impacts are one, possibly two slides from the Telkwa FSR as it parallels the creek to the south, and channelizing of the creek by the railway/road with aggradation upstream of this, and little channel complexity below for a stretch. The impacts here appear to be disproportionately greater than the sum of those direct impacts listed above. Therefore, cumulative impacts are suspected, namely upstream sediment delivery from a large slide in reach 2.

There is a **moderate** upslope impact potential due to activity observed

Due to the nature and severity of impacts in this section, as indicated by a 1.5-fold decrease in habitat value, a moderate upslope impact potential, and the use by a suspected three target species, a **high priority** for detailed assessment and restoration

is assigned. A barrier to restoration is the need to stabilize upstream sources of sediments prior to restoration here.

Section B

This Riffle-Pool (RPcw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: good
- Rearing: good
- Overwintering: moderate to good
- Holding: good
- Access to adjacent sections: good

Limiting factors to habitat value are siltation, low water temperatures, and the probability of frazl/anchor ice formation in low temperatures. There are no indicators of recent disturbance. There is an abundant amount of LWD in the section, and the distribution is even. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is mature coniferous forest.

There are no visible impacts noted here. It is expected that compaction of substrate may be occurring due to a large slide in reach 2.

There is a **low** upslope impact potential due to moderate connectivity and no anthropogenic activity observed..

Due to the nature and severity of impacts in this section, as indicated by a one-fold decrease in habitat value (due to naturally low temperatures), a low upslope impact

potential, and the use by a suspected three target species, a **low priority** for detailed assessment and restoration is assigned.

See appendix 1 for information on the assessment of reaches 2 and 3. Results will not be summarized here due to a lack of upstream use by target species.

3.10 Dockrill Creek Sub-Basin

General Description

Dockrill Creek is a moderately steep, incised, third-order glacier fed creek which drains the Telkwa mountain range to its confluence at the Bulkley River north of the Morice River confluence. The drainage area for this creek is 8596.6 hectares with a mid to high bifurcation ratio. Dockrill Creek was photographed and assessed from its mouth at UTM 9.6036776.640775 to the upstream end of cutblocks 6 and 24. The latter was the most upstream land-use on the creek. It was segregated into 2 reaches over 9.6 km, and then into sections where needed. These sections were mostly dictated by variations in land-use or channel morphology. Appendix 3, mapsheets 2, 3 and 4 show the positions of reach breaks, fish distributions, and known obstructions. Appendix 1, form 1, form #9 shows the distribution of known, suspected or historically present species by life stage and reach number. Appendix 1, form 2, form # 8 shows the results of habitat condition data by reach and section. Appendix 1, form 3, form # 13 shows the results of the preliminary habitat assessment, including priority for restoration and detailed assessment, as well as restoration opportunities.

Fish Species Distribution, Abundance, and Habitat Values

Dockrill Creek is not known to be inhabited by any fish species, but has been noted as having a high potential for Dolly Varden, bull trout, and steelhead (MIC Notes, 1997). Mid-Bulkley Fish Fence staff who have walked the lower reach of this creek report that it was being used by pink spawners, although no spawning was taking place (P. Perlotto,

pers. comm.). Given the gradient and habitat quality, and assuming use by species which are known to prefer lower water temperatures for spawning, it is suspected that the following species use the creek up to the cascade/falls in reach 2: pink salmon (holding and possibly spawning), steelhead (all), rainbow (all), Dolly Varden (all), and bull trout (all).

Spawning, rearing, overwintering and holding habitat value was assessed for all reaches using methods outlined in section 3 of this document, and this is compared to the inherent salmonid habitat of a given stable channel type (see table 29 below). This information is presented in a more detailed fashion in Reach and Section descriptions to follow.

Reach	Section	1° Habitat Value	Complexity	Spawning	Rearing	Overwintering	Holding	Limiting Factors	Access	Overall Habitat Value
1	A	High	Poor	Good	Moderate	Poor	Moderate	VR, SC, T, I	Good	Moderate
	B	Very High	Good	Good	Good	Mod-Good	Good	F, T, I	Good	High
2	A	High	Good	Good	Mod-Good	Poor	Good	T, I	Good	Moderate to High
	B	Moderate	Good	Poor	Moderate	Poor	Moderate	T, I	Good	Moderate
	C	High	Good	Good	Mod-Good	Poor	Good	T, I	Good	Moderate to High

Table 29: Primary and overall fish habitat value by reach and section, including limiting factors for Dockrill Creek (see section 3.0 for key to codes)

There are no obstructions to fish movement in the study area.

Land-Use and Upslope Impact Potential

Adjacent land-uses and upslope impact potential for each reach and section is presented in table 30. More detailed discussion will follow in Reach and Section descriptions.

Reach	Section	Upslope Land-Use	Connectivity	Activity Observed	Upslope Impact Potential
1	A	R, RR	Low	No	Low
	B	F	Moderate	Yes	Moderate
2	A	F, R	High	No	Moderate
	B	F	High	No	Moderate
	C	F	High	No	Moderate

Table 30: Upslope land-use, connectivity of upslope to channel, whether mass movements were observed, and the upslope impact potential by Reach and Section for Dockrill Creek.

The Dockrill Creek basin is used primarily for forestry. Cutblocks range in age from 1969 to 1985. The railway and the Telkwa FSR both cross it in Reach 1, and it appears from small-scale air photos that the creek was diverted to mitigate flood danger to the railway. There was originally a long meander at the bottom of the creek, but this has been cut off, and the creek now runs straight down to the Bulkley from a corner just beyond the FSR crossing.

3.10.1 Reach 1

Reach 1 describes the section of creek from the mouth to a deeply incised canyon. It is moderately confined, and is crossed by the Telkwa FSR, and the railway. It was split into two sections for the purposes of this assessment:

- Section A: Mostly long, straight Cascade-Pool channel which appears to have been diverted below the FSR bridge to keep from flooding or washing out the railway.
- Section B: Riffle-Pool channel with natural channel geometry, and two streamside cutblocks.

Fish species using the reach are outlined in section 4.10 above.

Section A

This Cascade-Pool (CPcw) channel has a **high** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **degrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: poor
- Spawning: good
- Rearing: moderate
- Overwintering: poor
- Holding: moderate
- Access to adjacent sections: good

Limiting factors to habitat value are scouring, infrequent velocity refuges, low water temperatures, a lack of alternative habitats, and the probability of frazl/anchor ice formation in extreme low temperatures. Indicators of recent disturbance are extensive riffles, and limited pool frequency and extent. There is a poor amount of LWD in the section, and the distribution is even. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is deciduous pole-sapling forest with sections of shrub-herb.

Visible impacts are channelizing at the railway and FSR crossings, aggradation below both of these crossings, and a suspected diversion of the channel into its present long, straight geometry (as witnessed by the relic channel).

There is a **low** upslope impact potential due to poor connectivity.

Due to the nature and severity of impacts in this section, as indicated by a one-fold decrease in habitat value, a low upslope impact potential, the importance of access to

upstream reaches, and the use by a suspected five target species, a **high priority** for detailed assessment and restoration is assigned.

Section B

This Riffle-Pool (RPcw) channel has a **very high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is **aggrading**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: good
- Rearing: good
- Overwintering: moderate to good
- Holding: good
- Access to adjacent sections: good

Limiting factors to habitat value are siltation, low temperatures, and the probability of frazl/anchor ice formation in extreme low temperatures. Indicators of recent disturbance are eroding banks and extensive areas of unvegetated bar. There is an abundant amount of LWD in the section, and the distribution is clumped. The extent of pool habitat is 1-25% of the wetted channel area. The riparian area is mixed pole-sapling forest with small areas of young mixed forest.

Visible impacts are bank erosion and lateral instability in the margins of logging to the streambank at cutblock openings 11 and 14.

There is a **moderate** upslope impact potential due to possible activity from the downstream end of opening #14.

Due to the nature and severity of impacts in this section, as indicated by a one-fold decrease in habitat value, a moderate upslope impact potential, and the use by a

suspected five target species, a **moderate priority** for detailed assessment and restoration is assigned.

3.10.2 Reach 2

This steeper, more incised reach runs through a confined canyon from the end of Reach 1 to the end of the study area. No impacts were noted from upslope cutblocks, but fish habitat will be described for species outlined in section 4.10

Section A

This Cascade-Pool (CPcw) channel has a **high** primary habitat value to target species in a stable state. The overall habitat value is **moderate to high** and the channel is **stable**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: good
- Rearing: moderate to good
- Overwintering: poor
- Holding: good
- Access to adjacent sections: good

Limiting factors to habitat value are poor alternative habitats, low temperatures, and the probability of frazl/anchor ice formation in extreme low temperatures.

There is a **moderate** upslope impact potential due to high connectivity and upslope land use.

A **low priority** for detailed assessment and restoration is assigned.

Section B

This Cascade-Pool (CPb) channel has a **moderate** primary habitat value to target species in a stable state. The overall habitat value is **moderate** and the channel is **stable**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: poor
- Rearing: moderate
- Overwintering: poor
- Holding: moderate
- Access to adjacent sections: good

Limiting factors to habitat value are poor alternative habitats, low temperatures, and the probability of frazl/anchor ice formation during extreme low temperatures

There is a **moderate** upslope impact potential due to high connectivity and upslope land-use.

A **low priority** for detailed assessment and restoration is assigned.

Section C

This Cascade-Pool (CPcw) channel has a **high** primary habitat value to target species in a stable state. The overall habitat value is **high** and the channel is **stable**. Habitat values for specific life-stages and general indicators of productivity are as follows:

- Complexity: good
- Spawning: good
- Rearing: moderate to good
- Overwintering: poor

- Holding: good
- Access to adjacent sections: good

Limiting factors to habitat value are poor alternative habitats, low water temperatures, and the probability of frazl and anchor ice formation at extreme low temperatures.

There is a **moderate** upslope impact potential due to high connective and upslope land-use.

A **low priority** for detailed assessment and restoration is assigned.

4.0 Recommendations

4.1 Sub-Basin and Tributary Priority for Level 1 (Detailed) Assessment

Sub-basins in the Mid-Bulkley Watershed were prioritized for Level 1 field assessments based on the following criteria:

- Relative use by target fish species
- % of reaches and sections which are high and moderate priority (see section 4-Results)
- The nature of impacts (riparian, in-stream, upslope (mass movements), hydrology (peak flows)) and land ownership status.

The latter point is included to filter out those sub-basins where there are only restoration opportunities on private land, or where the responsibility for assessment and restoration rests solely in the jurisdiction of the Ministry of Forests' Watershed Restoration Program. Since a given channel is considered Crown Land to the top of its bankfull depth, in some cases there may be restoration opportunities within those bounds. Where there are only restoration opportunities on private riparian or upslope areas, or problems were in upstream upslope areas that did not directly impact fish habitat, these sub-basins were filtered out of the priority list. Johnston and Slaney (1996) states that priority areas for detailed assessment are those areas where there are major habitat impacts and/or high upslope impact potential that are also heavily used by target fish species for spawning, rearing, or overwintering.

Table 31 shows the decision matrix used to prioritize all sub-basins and tributaries.

Table 31: Decision Matrix to Prioritize Sub-Basins for Detailed Assessment.

Sub-Basin	Tributary	# of Units (reaches/ sections)	% High Priority Units	% Moderate Priority Units	Nature of Impacts	Land Ownership			
						Private	Reaches	Crown	Reaches
Buck	Klo	4	25	75	Upslope, hydrology	No	-	Yes	all
	Upper	2	50	0	Road, hydrology	No	-	Yes	all
	Buck	26	54	35	Hydrology, riparian, in-stream, upslope	Yes	1-2b, 4-7	Yes	3, 8-10
	Dungate	8	38	50	Upslope, riparian, road	Yes	1-2b	Yes	2c-4
McQuarrie		6	50	0	In-stream, riparian, upslope	Yes	1	Yes	2-3
Richfield	Richfield	9	30	10	Upslope, in-stream, riparian	Yes	all	No	-
	Robert Hatch	2	50	50	Riparian	Yes	all	No	-
Byman		10	33	20	In-stream, riparian, upslope	Yes	1, 2a	Yes	2b-3
Barren		4	25	50	In-stream, riparian, upslope	Yes	1, 2a	Yes	2b-3
Johnny David		3	66	33	In-stream, riparian, upslope	Yes	all	No	-
Aitken		4	50	25	Hydrology, in-stream, riparian	Yes	all	No	-
Bulkley		5	40	40	In-stream, riparian	Yes	all	No	-
Emerson		4	50	0	Upslope	Yes	1(below FSR)	Yes	1-3
Dockrill		5	20	20	In-stream, riparian	Yes	1(below RR)	Yes	1-2

Note: FSR=Forest Service Road
RR=Railway

Sub-Basin priority is as follows:

1. Buck Creek
2. Bulkley River
3. McQuarrie Creek
4. Richfield Creek
5. Aitken Creek
6. Byman Creek
7. Barren Creek
8. Emerson
9. Dockrill

Johnny David Creek was filtered out due to riparian and upslope impacts on private land.

Tributary priority within Buck Creek Sub-Basin is as follows:

1. Buck Creek
2. Dungate Creek
3. Upper Buck Creek
4. Klo Creek

Robert Hatch Creek was filtered out of the Richfield Sub-Basin priority list due to riparian impacts on private land. This leaves Richfield Creek as the only priority tributary in that sub-basin.

Appendix 7 (under separate cover) gives a cost breakdown of work to be performed in detailed assessments, by tributary. This includes preliminary restoration strategies and priorities within the sub-basins.

References (Annotated)

AGRA Earth and Environmental, 1996. Level 1 Fish Population and Riverine Habitat Assessment, Maxan Watershed. Prince George, BC. 25 pp.

- *Overview Assessment of the Maxan Watershed, including the Bulkley River to Bulkley Lake.*

AGRA Earth and Environmental, 1997. Maxan Watershed Stream Habitat Restoration and Enhancement Design Report. Calgary, Alta. 74 pp.

- *Detailed Assessment of the Maxan Watershed, including the Bulkley River to Bulkley Lake*

Atmospheric Environment Service. 1980. Extremes of Temperature and Precipitation in British Columbia. Environment Canada, Ottawa. 18 pp.

- *Details on maximum and minimum temperatures and snowfall/rainfall at climate stations in BC. Does not give all of the above for each station, but instead ranks them provincially*

Atmospheric Environment Service. 1985. Greatest Rainfall, Snowfall and Precipitation on any one Observation Day-British Columbia. Environment Canada, Ottawa. 22 pp.

- *Presents the above information by station.*

David Bustard and Associates. 1989. Fish Population Monitoring in Foxy and Buck Creeks. Smithers, BC. 21 pp.

- *Fish population monitoring in Upper Buck Creek for Equity Silver Mines as part of a regular impact assessment program. Gives information on habitat, populations, and life-stages*

FHIIP (Fish Habitat Inventory and Information Program). 1991. Stream Summary Catalogue. Subdistrict #4D. Smithers (Volume 2). Department of Fisheries and Oceans, BC Ministry of Environment.

- *Information on waterbody descriptions, obstructions, flows, fish species distributions, escapements, life-history timing, enhancement/management activities, land-use, water quality, and productivity (and potential productivity) where information is available. A useful information source for larger waterbodies (3-5 order basins), otherwise light on detail. Good for obtaining other references.*

FISS (Fish Information Summary System). 1995. NTS Map #'s 93L07, 93L08, 93L09. BC Environment. Fish and Wildlife Branch. Smithers.

- *Distribution of fish species and critical habitats overlaid on 1:50 000 scale mapsheets. I found these maps to be incomplete and inaccurate for this watershed.*

Government of British Columbia. Department of Lands, Forests and Water Resources. 1973. Contract for River Improvement Works. Contract #73-1A. Buck Creek at Houston. Victoria, BC. 5 pp+drawings.

- *Invitation to tender for the flood dyking carried out at Houston at the bottom of Buck Creek. Detailed information on works carried out.*

Haas, G. 1997. bull trout and Dolly Varden Identification and Biology Workshop. Unpublished workshop handout and notes. MELP Fisheries Branch. Research and Development, UBC, Vancouver. 13 pp.

- *Includes identification key and methods, life-history information, and an excellent reference list for bull trout and Dolly Varden.*

HCC (Houston Centennial '71 Committee). 1971. Marks on the Forest Floor-A Story of Houston, British Columbia. Houston, BC. 152 pp.

- *Contains abundant information on the evolution and history of land-use in the watershed, as well as the origin of place-names.*

Johnston, N.T. and Moore, G..D. 1995. Guidelines for Planning Watershed Restoration Projects. Watershed Restoration Technical Circular No. 1. MELP, Victoria. 52 pp.

- *A steering document for WRP which provides "higher-level" perspectives on the FHAP and watershed restoration in BC.*

Johnston, N.T. and Slaney, P.A. 1996. Fish Habitat Assessment Procedure. Watershed Restoration Technical Circular No. 8. MELP, Victoria. 97 pp.

- *The toolbox of procedures for doing an Overview or Level 1 (Detailed) FHAP. Also provides good references on fisheries and fluvial information and techniques specific to WRP.*

LaRose, C (Broman Lake Band) and Rencoret, B (DKK Development Corp.). 1996. Level 1 Roads, Hillslopes and Gullies Assessment for Watershed Restoration, Mid-Bulkley Watershed. Nadina Community Futures Development Corporation. Houston, BC. 11 pp. + maps and appendices.

- *Reconnaissance level assessment of upslope impacts in the watershed. Constrained by Ministry of Forests eligibility guidelines on what was eligible for assessment and restoration, and thus it missed some important impacts. Information was presented in Access Units rather than within watershed boundaries, which is also problematic.*

Lillesand, T.M. and Kiefer, R.W. 1994. Remote Sensing and Image Interpretation (3rd Ed.). John Wiley and Sons Publishing. Toronto. 750 pp.

- *An excellent resource and standard text on aerial photography, film, flight planning, and air photo interpretation.*

Lister, D.B. and Finnigan, R.J. 1997. Rehabilitating Off-Channel Habitat pgs.7-1 to 7-29 **in:** ed. P.A. Slaney and D. Zaldokas. 1997. Fish Habitat Rehabilitation Procedures. Watershed Restoration Technical Circular #9. MELP, Vancouver. 15 chapters+glossary+references

- *When, where, how and why to rehabilitate off-channel habitats, as well as case studies of successful projects and projected costs.*

MELP Stream Files. 1974. Unpublished habitat survey of Klo Creek. D. Remington/J. Amos. Skeena Region MELP Office, Smithers, BC. 2 pp.

- *Habitat survey of Klo Creek from the headwaters to the Buck Creek confluence with fish sampling above the present site of the Equity Mine Road crossing. Carried out before any significant amounts of logging or the construction of the mine road.*

MELP Stream Files. 1977. Unpublished memorandum re: Miscellaneous Fishery Observations-Bulkley Watershed. D. Bustard. 1 pp.

- *Indicates habitat quality and obstructions to fish migration on Aitken Creek and Emerson Creek from a helicopter overflight in August (low flows).*

MELP Stream Files, 1980. Unpublished memorandum re: Upper Bulkley Inventory. M. O'Neill. 1 pp.

- *Fish sampling and general comments on habitat quality above the culvert at the end of Reach 3 of McQuarrie Creek. Culvert at this point does not appear to be an obstruction.*

MELP Stream Files. 1980b. Unpublished memorandum re: Buck Creek. M. Lough. 1 pp.

- *Account of steelhead and chinook presence in Buck Creek above the cascade barrier.*

MELP Stream Files. 1986. Unpublished letter from Glenda Ferris of the Buck Creek Residents Association to Equity Silver Mines re: fish populations and population sampling in Buck Creek. 7 pp.

- *Excellent account of fish distribution and the actual location of barriers in the Buck Creek watershed. Reports of steelhead, coho, and chinook sightings above the cascade barrier in reach 3.*

MELP Stream Files, unknown date. Population estimates of Game Fish Species in the Upper Bulkley River with reference to a 1948 Skeena MS report, 2 pp.

MIC (Morice District IWAP Round Table Committee Meeting notes). 1997. Unpublished. BC Conservation Foundation, Smithers. 8 pp.

- *Information on ECA's, fish distribution and suspected distributions, land-use, hydrology, land ownership, forest fires, and future logging potential in the Morice District.*

NCFDC (Nadina Community Futures Development Corporation). 1996. Bulkley River Fish Fence Project Report. DFO Smithers, and NCFDC, Houston.7 pp.

- *Escapement and miscellaneous data for target species in the Mid-Bulkley watershed in 1996.*

NCFDC. 1997. Unpublished preliminary results of Fish Fence escapements to October 15, 1997. NCFDC, Houston. 1 pp.

RIC (Resources Inventory Committee). 1996. Aerial Photography and Videography Standards: Application for Stream Inventory and Assessment. MELP RIC, Victoria, BC. 53 pp.

- *MELP standards on aerial photography and videography. Provides similar information to Lillesand and Kiefer (1994).*

SKR Consultants Ltd. 1997. Assessment of Overwintering Habitat and Distributions of coho salmon (*Oncorhynchus kisutch)* in the Mid-Bulkley Watershed (Houston to Bulkley Lake), January-March 1997. DFO, Smithers. 56 pp.

- *A good preliminary study of overwintering habitat conditions in tributaries to the Bulkley based on water temperatures, DO, pH, and percent open water, and an empirical analysis of fish condition (Fulton's Condition Factor) at the sites in question. Most of the sites were biased to easily accessible areas. Distributions of overwintering salmonids were extrapolated from these sites. Excellent recommendations for further studies of sidechannels and lakes, as well as studies of culvert barriers (ie-data gaps).*

Slaney, P.A, R.J. Finnigan and R.G. Millar. 1997. Accelerating the Recovery of Log Jam Habitats: Large Woody Debris-boulder Complexes. pgs. 9-1 to 9-24 **in:** ed. P.A. Slaney and D. Zaldokas. 1997. Fish Habitat Rehabilitation Procedures.

- *Good treatise on the importance of LWD for salmonid species and techniques and specifics of rehabilitation.*

Slaney, P.A. and A. Martin. 1997. Planning Fish Habitat Rehabilitation Projects: Linking to Habitat Protection. pgs. 1-1 to 1-23. **in:** ed. P.A. Slaney and D. Zaldokas. 1997. Fish Habitat Rehabilitation Procedures.

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