Water quality in the Toboggan Creek watershed 1996-1998: are land use activities affecting water quality and salmonid health?

D. Remington[1] and B. Donas

Department of Fisheries and Oceans
North Coast Division
Habitat and Enhancement Branch - Skeena/Nass
Box 578, Smithers, BC V0J 2N0

and

Community Futures Development Corporation of Nadina
Box 236, Houston, BC V0J 1Z0

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[1] REMINGTON ENVIRONMENTAL, RR 2 Site 59 C9, Smithers, BC V0J 2N0

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1. Background

DFO Habitat and Enhancement Branch initiated water quality monitoring in Toboggan Creek watershed in early 1996. Toboggan Creek is an important nursery stream for both wild and hatchery fish, primarily coho, pink, steelhead and Dolly Varden, with smaller populations of cutthroat trout and mountain whitefish. Toboggan Creek is also the main water source for the Toboggan Creek Hatchery, a DFO Salmonid Enhancement Program facility.

Brenda Donas, SEP Community Advisor, conducted periodic water quality sampling April 1996 to April 1998. Grab samples were taken routinely at five sites along the length of Toboggan Creek. Water quality samples were also taken from Glass Creek, the hatchery outflow channel and a Toboggan Creek tributary downstream of a man-made slough. Juvenile wild salmonids were collected from several locations in the watershed during the spring of 1996 for histological examination.

A separate, but complementary, investigation of water quality and the accumulation of attached algae (periphyton) was carried out during 1996 and 1997 involving a number of Bulkley River tributaries, including Toboggan Creek (Remington 1997, 1998). The Toboggan Creek portions of that study are reproduced in this paper.

2. Study Area

Toboggan Creek watershed is a small system flowing into the Bulkley River roughly 21 km north of Smithers (Figure 1). The headwaters and major tributaries emanate from the eastern slopes of the Hudson Bay Range and flow in an easterly direction to join as the mainstem Toboggan Creek. Glacier Gulch Creek emanates from Hudson Bay glacier (locally known as Kathlyn glacier) and flows into the head of small, shallow Toboggan Lake on the valley bottom. Upper Toboggan Creek emanates from Toboggan glacier and an alpine lake and enters at the outlet of Toboggan Lake. From here mainstem Toboggan Creek flows in a northerly direction, parallel to the main valley, across low gradient till plain for approximately 8.5 km before entering the Bulkley River. Elliot Creek and Owens Creek, which also drain the eastern slopes of the Hudson Bay Range, join it along its length.

The watershed is traversed by both the railway and Highway 16, providing many access points, and has a long history of agriculture and hobby farms. Because of this, the entire mainstem Toboggan Creek and Toboggan Lake are on private land. A mosaic of air photos (photographed in 1992) is found in the back cover pocket.

2.1 Monitoring Sites

Photographs of monitoring sites are found in Appendix 1. Monitoring sites (Figure 1) are described below:

2.1.1 Toboggan Creek sites

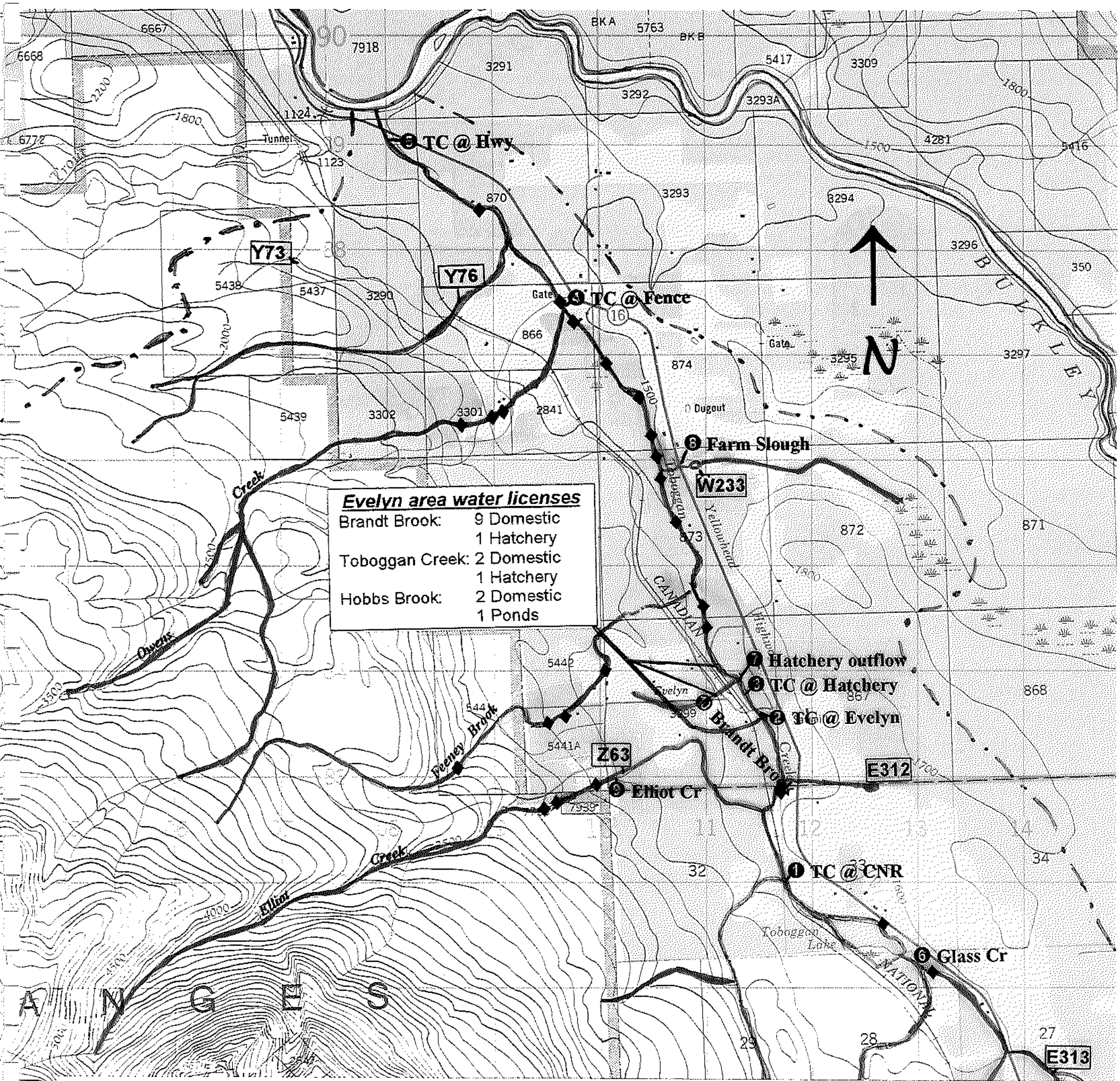
Site 1 Toboggan Creek at CNR is located at the railway bridge crossing of Toboggan Creek downstream of the lake outlet and the confluence of upper Toboggan Creek. There are beaver dam complexes both upstream of this site, at the lake outlet, and downstream of it, along the west side of the tracks.

Site 2 Toboggan Creek at Evelyn is located approximately 1 km downstream of the confluence of Elliot Creek and immediately upstream of the Evelyn Station Road Bridge.

Site 3 Toboggan Creek at Hatchery is located approximately 500 m downstream of the Evelyn Road Bridge and immediately upstream of the Toboggan Creek Hatchery outflow channel.

Site 4 Toboggan Creek at Fence is located approximately 150 m downstream of the confluence of Owens Creek and 30 m upstream of the DFO salmonid assessment fence.

Site 5 Toboggan Creek at Highway is located approximately 500 m upstream of the confluence with the Bulkley River and 70 m upstream of the Highway 16 culvert.



Evelyn area water licenses
Brandt Brook: 9 Domestic
1 Hatchery
Toboggan Creek: 2 Domestic
1 Hatchery
Hobbs Brook: 2 Domestic
1 Ponds
TC @ Hwy
TC @ Fence
Farm Slough
Hatchery outflow
TC @ Hatchery
TC @ Evelyn
Elliot Cr
TC @ CNR
Glass Cr
Brandt Brook
Y73
Y76
W233
Z63
E312
E313
N
Owens
Creek
Feeney Brook
Elliot
Creek
Toboggan Lake
Yellowhead
CANADIAN
NATIONAL
Dugout
Gate
Tunnel
Evelyn
BULKLEY

2.1.2 Toboggan Creek tributaries sites

Site 6 Glass Creek emanates from a wetland area on the valley floor and flows north into Toboggan Lake. It traverses a large hay field and has been channelized in this area in the course of agricultural development. Glass Creek was originally chosen as a control site, but sampling was discontinued because of agriculture and rural residences in the watershed.

Site 7 Toboggan Creek Hatchery. The outflow channel of the hatchery was sampled once at the outset of the study in April 1996.

Site 8 Farm Slough. A small tributary draining a farm slough located just upstream of Highway 16 on Lot 873, R5C was sampled at the downstream end of the highway culvert. The slough was excavated from the bed of a small stream by the landowner, possibly for stock watering. During snowmelt the drainage from the slough floods a wetland area upstream of the highway. Downstream of the highway a maze of beaver dams extends for 100 metres creating a large flooded area. The stream then continues in a meandering fashion towards Toboggan Creek. Rearing coho and rainbow trout/steelhead are present in the slough and the wetlands below the highway, which are classified as fisheries sensitive zones (Triton 1998). During the sampling period, a winter feedlot holding approximately 20 head of beef cattle was located immediately adjacent to the slough. The feedlot has subsequently been relocated.

Site 9 Elliot Creek was sampled for field parameters only.

Site 10 Brandt Brook is a small groundwater fed tributary, which joins Toboggan Creek near Evelyn Station. It is the domestic water source for the community of Evelyn and is an alternate water supply for the hatchery. This stream was sampled for field parameters only.

3. Methods

3.1 Sampling Methods

3.1.1 Water quality

B. Donas measured water quality parameters in the field using a LaMOTTE Fresh Water Test Kit (Model AQ-2). Parameters measured included temperature, dissolved oxygen, turbidity, pH, ammonia-N, alkalinity and carbon dioxide. During 1996, unfiltered water samples were shipped iced, on the day of collection, to the DFO West Vancouver Laboratory. During 1997 and 1998, samples were filtered in the field and frozen prior to transport to the DFO Cultus Lake Salmon Research Laboratory. Duplicate samples were taken at each site. Two sample blanks were submitted for each field trip. Low-level nutrient analysis was carried out at the DFO facilities, according to standard methods. Corrections for turbidity and colour were included in the analytical process.

D. Remington conducted periphyton (attached algae) sampling at the end of the growing season in 1996 and 1997. Methods were based on MELP *Biological Sampling Manual* (Cavanagh and others 1994). Six replicate periphyton samples were collected at each site. Periphyton was scraped and washed from a randomly selected rock into a glass container, which was immediately placed on ice in a darkened cooler. A waxed paper tracing of the sampled area was taken from each rock for area determination using a compensating planimeter. Each day, the individual samples were filtered onto a 0.45 μm filter, and 2-3 drops of $MgCO_3$ suspension added as pH buffer. The sample filters were placed in a darkened thermos containing activated desiccant and were frozen immediately. Frozen samples were shipped by air in a cooler containing dry ice to Phillip Services Corporation laboratory. All frozen samples arrived at the laboratory the following day and were kept frozen prior to chlorophyll *a* analysis.

One periphyton sample for community composition was collected at each site and preserved with Lugol's solution. Scrapings were included from at least four rocks at each site. Mary Bolin, algal taxonomist, Victoria, conducted periphyton qualitative community composition analysis.

Water quality samples were also collected at the time of periphyton sampling. Grab samples were shipped iced on the day of collection to Phillip Services Corporation laboratory for analysis. Reiseter Creek was chosen as the control site in this study because an appropriate upstream control site could not be found in the Toboggan watershed due to lack of road access. Reiseter Creek enters the Bulkley River from the opposite side of the valley to Toboggan, is approximately the same size and has similar high elevation headwaters. Reiseter Creek, in contrast to Toboggan, has little agricultural or hobby farm development and few cattle in the watershed.

3.1.2 Fish

Juvenile wild salmonids, mostly coho, were captured in minnow traps during the 1996 field season. All fish samples were iced and shipped on the day of capture to the fish pathology lab at the DFO Pacific Biological Station for histological examination.

4. Summary of Existing Information

4.1 Toboggan Lake

Toboggan Lake is a small (14.9 ha), turbid, glacier fed lake. With a mean depth of 1.1 m (maximum depth 1.9 m) the lake probably does not stratify. Toboggan Lake has a sedge shoreline, extensive aquatic vegetation and is attractive to waterfowl. A large hay field surrounds the inlet and inlet streams have been channelized in some areas. Water quality analysis, 15 September 1982, was unremarkable, except to note that low phosphorous/orthophosphorus concentrations limit productivity.

Coho, steelhead, cutthroat trout, Dolly Varden, kokanee, mountain whitefish, longnose sucker and sculpins are present in the lake and it is considered an important rearing area for salmonids (Lake Files, BC Environment, Smithers).

4.2 Toboggan Creek

Fish species present with the Toboggan Creek system include pink and coho salmon, rainbow trout/steelhead, cutthroat trout, Dolly Varden, mountain whitefish, sculpin and lamprey. Salmonid spawning and rearing habitats in the watershed are colour coded in Figure 1. Pink spawning takes place throughout the lower 8 km mainstem Toboggan Creek. Coho spawning and rearing occurs in the mainstem up to the lake and in the lower reaches of Glacier Gulch Creek, upper Toboggan Creek and Elliot Creek. Steelhead spawning occurs in several areas of Glacier Gulch Creek and upper Toboggan Creek.

The low gradient and numerous side channels of Toboggan Creek and Toboggan Lake provide a substantial amount of suitable rearing habitat for coho. Unlike pink salmon, coho remain in their natal streams for one year before smolting and migrating to sea. In Toboggan Creek, it is believed that some coho remain an additional year prior to smoltification (Saimoto 1997). The majority of steelhead young remain in freshwater for two or three years before migrating. Dolly Varden are resident throughout the system, and are found far up the mountain slopes in many tributary streams (Hancock and others 1983; Triton 1998).

Mean annual Toboggan Creek escapement for the 10 yr. period 1985-1994 are as follows (FISS website):

- Coho 2,013
- Pink (odd year) 8,000.

A minor sport fishery is reported for cutthroat and Dolly Varden. Historically, most of the angling for coho and steelhead destined for Toboggan Creek has occurred just downstream of the junction with the Bulkley River (Tredger 1979). Although all other upper Skeena waters were closed to harvest of coho in 1996, a short-duration, monitored harvest of coho was allowed at the confluence of Toboggan Creek and the Bulkley River in that year (O'Neill[a] 1997).

4.2.1 Toboggan Creek Salmon Hatchery

The Toboggan Creek Salmon Hatchery was constructed just downstream of the Evelyn Road Bridge on land leased from the CNR in 1985. The goal of the operation has been to preserve and enhance endangered stocks of coho and chinook salmon of the upper Skeena watershed, particularly endangered upper Bulkley River stocks. During the 1996-1997 year, 100,000 coho and 92,000 chinook salmon from the 1995 brood year were reared and released to various natal streams. As well, local P.I.P. projects and school classroom incubators were provided with another 10,000 coho eggs and fry. Over 187,000 chinook and coho from the 1996 brood year were reared and released in the spring of 1998.

In addition, approximately 150,000 steelhead fry were produced annually at the hatchery 1985-1987 for stocking in nearby streams. In 1989-1990 approximately 14,000 steelhead yearling fish were produced. These fish were planted in nearby Trout Creek and the mainstem Bulkley near the confluence of Trout and Toboggan Creeks. Enhanced steelhead have never been stocked into Toboggan Creek itself (O'Neill[a] 1995, 1996, 1997).

The two main water sources for the hatchery are an intake in Toboggan Creek, and an underground collection system. A third water supply is from Brandt Brook, a small spring-fed tributary. The hatchery uses the underground collection system and Brandt Brook mainly during the period of low elevation snowmelt runoff in the spring (M. O'Neill, hatchery manager, pers. comm.).

4.2.2 Toboggan Creek assessment fence

Toboggan Creek coho stock have been augmented by the hatchery since 1988 (1986 brood year). Smolts released from the hatchery are marked with coded wire tags, and adipose fin clips. An assessment (counting) fence is located 2.5 km upstream of the Bulkley confluence, and hatchery staff have enumerated adult coho returns to the system since 1989. Adult coho escapement to Toboggan Creek was estimated to be 2416 (1994), 1762 (1995) and 1185 (1996). The percentage of these fish which were hatchery origin ranged from 16.4-26% (O'Neill[a] 1995, 1996, 1997).

Adult steelhead have been enumerated at the assessment fence since 1993. Mark recapture studies were initiated in 1993, adults being spaghetti-tagged as they moved upstream through the fence and recaptured as kelts during outmigration. The escapement estimates (steelhead spawning upstream and downstream of the fence) from these studies are as follows: 287 (1994), 305 (1995) and 115 (1996). The percentage of steelhead escapement which were hatchery fish ranged from 3-7% during this period (O'Neill[b] 1994, 1995, 1996).

4.2.3 Coho smolt enumeration 1995-1997

Due to the availability of reliable adult escapement data, and the presence of a known number of marked coho smolts in the system, Toboggan Creek lends itself to studies in freshwater survival, age distribution at smoltification, migration timing and recruitment of juvenile coho salmon. In 1995, 1996 and 1997 SRK Environmental Consultants were contracted to estimate the number of juvenile fish, particularly wild coho smolts, leaving the creek. A fyke trap was operated upstream of the assessment fence during May and June to estimate wild coho abundance by comparison with marked hatchery fish and collect information on age, condition and migration timing of wild coho and other species (Saimoto 1995, 1996, 1997). Summary data from this study are found in Table 1.

Table 1 Summary of juvenile fish trapped during outmigration May-June 1995-1997

Year	Wild Coho	Hatchery Coho	Rainbow trout/ steelhead	Dolly Varden	Chinook[1]	Cutthroat Trout	Lamprey	Hatchery coho released during sampling period
1995	2867	2552	128	4	11			
1996	1829	1692	78	2	0			32,638
1997	1628	1276	133	3	7	3	21	33,255

Source: SKR Consultants Ltd. 1995, 1996, 1997

[1] Chinook present in Toboggan Creek are likely strays from other Bulkley River stocks (O'Neill pers. comm.)

The number of wild and hatchery coho captured during outmigration was somewhat lower in 1996 and 1997 than 1995. The researchers attribute this to unusually high water levels during the sampling period in these two years. Snowpack was 130-150% higher than normal in the preceding two winters (L. Barak, MELP Water Management, pers. comm.). In addition, heavy showers in the spring of 1997 contributed to higher than normal water levels and cooler than normal temperatures in the creek. Higher streamflows generally reduced trapping efficiency. In 1997 flooding conditions forced reduced sampling intensity for the later part of the study period.

4.2.4 Bulkley T.S.A. fish and fish habitat inventory 1998

Triton Environmental Consultants Ltd. (1998) were retained by Pacific Inland Resources and FRBC to conduct reconnaissance level fish and fish habitat inventories in the Bulkley Forest District, including the Toboggan Creek watershed. Fieldwork in the Toboggan Creek watershed was carried out between July and September 1997. The sampling strategy was based on historical information of fish presence. Within the Toboggan watershed a number sites were noted to have been impacted by land use activities. The approximate location of these sites are shown in Figure 1, identified by the site number from the Triton report and accompanying TRIM map.

Detailed comments from the Triton report are found in Appendix 5. Observations included streams that had been “clearcut to the banks”, “banks trampled by livestock”, “total removal of riparian cover” and a creek which had been “trampled out of existence where it flowed through a feedlot”. Recommendations included further fish and water quality monitoring for the Glass Creek watershed and habitat restoration at other affected sites.

4.3 Licensed Water Use

A total of 39 water use licenses are registered in the Toboggan Creek watershed (MELP Water Management Branch). The water intake point for these licenses are indicated in Figure 1. Detailed water license information is found in Appendix 4. There are 29 licensees in the watershed using surface streams for their domestic water source. The number of subdivisions in portions of the watershed, particularly around Glass Creek, indicates that there are many more households in the watershed which are probably utilizing wells. In addition, Glass Creek, Elliot Creek, Owens Creek and the Toboggan mainstem are licensed for irrigation (ten licenses) and livestock watering (one license). Two licenses are for ponds (Hobbs Brook and Toboggan Creek). The Toboggan Creek Hatchery holds water use licenses on Toboggan Creek and Brandt Brook for fish culture.

4.4 Land Use in the Toboggan Creek Watershed

4.4.1 Transportation corridors: CN Railway, Highway 16 and power transmission line

The Grand Trunk Pacific Railway, now the Canadian National Railway, was constructed through the Bulkley valley during 1907-1914. The rail line parallels Toboggan Creek the length of the watershed, crossing it twice just below Toboggan Lake. Soon after Evelyn Station became one of the early farming settlements in the valley. At that time, the main road through the Bulkley valley was the Telkwa High Road, which runs on the opposite side of the Bulkley River. A minor road linked Lake Kathlyn and Evelyn to Smithers.

Highway 16 was completed from Hazelton to Prince Rupert in 1944 and the road link through the Toboggan watershed to Hazelton was established thereafter. In 1966 the old Bulkley River Bridge connecting Smithers to the Telkwa High Road was washed out by an ice jam. The existing bridge was built east of town and Highway 16 re-routed in the late 1960’s. This established the present Highway 16 corridor, which closely parallels Toboggan Creek, but on the opposite side than the railway.

In the late 1960’s or early 1970’s a major power transmission line was constructed the length of the Toboggan watershed, connecting Smithers to the power generation station at Kemano (Shervill 1981).

4.4.2 Mining

The Glacier Gulch mineral deposit lies partially beneath Hudson Bay (locally known as Kathlyn) glacier at the headwaters of Glacier Gulch Creek. Numerous vein deposits occur here, several of which were commercially developed in the 1930's to 1950's. More recent interest in Glacier Gulch has centered on the large low-grade molybdenum deposit. This large porphyry deposit is suitable for open pit mining much to the dismay of Smithers residents who admire the spectacular view of the glacier west of town (Gottesfeld 1985).

4.4.3 Forestry

Early settlers to the Bulkley valley were employed in hewn tie-making for the railway, in conjunction with land clearing for agriculture (Mould 1976). The hewn tie industry flourished through the 1920's and 1930's. With the introduction of portable sawmills in the 1940's there were hundreds of independently owned small scale selective and strip logging operations. The traces of these selective logging operations are still visible on the slopes above Evelyn. The small bush mills were gradually phased out and replaced with large mills at Smithers. Logging and milling operations have expanded rapidly since the 1960's, with expanded road systems and a shift to clearcut logging. Several large clearcuts appeared in Elliot and Owens Creek watersheds in the early 1970's. The Toboggan watershed is now within the Bulkley T.S.A. Clearcuts of various sizes and ages are present in the major tributaries of Toboggan Creek.

4.4.4 Agriculture

Soon after the construction of the railway in 1914, Evelyn became a center of farming activity. Today essentially the entire valley bottom is private land devoted to agriculture. Four beef cattle operations and two dairies are located in the Toboggan Creek watershed, as well as many rural residences and hobby farms. The total number of breeding cows in the watershed is estimated at 1000 head (D. Riendeau, District Agriculturalist, pers. comm.).

The beef cattle are fed forage crops during the winter months in confined feedlots on the valley bottom. During the summer months, most of the beef cattle are placed on open range in the Toboggan Range Unit, although some are placed in range units outside the watershed. The Toboggan Range Unit encompasses the tributary watersheds of Toboggan, Elliot and Owens Creeks. The dairy herds generally are confined to valley bottom high-density grazing areas in the summer and are confined to dairy barns for much of the winter.

4.4.5 Septic tanks

It is not known exactly how many rural residences and hobby farms exist in the Toboggan watershed. There are 39 water use licenses registered in the watershed, cited in Appendix 4. Many more residences and hobby farms may have wells or groundwater springs as their water sources. All residences in the watershed utilize septic tanks or sewage lagoons for treating domestic wastes.

5. Results

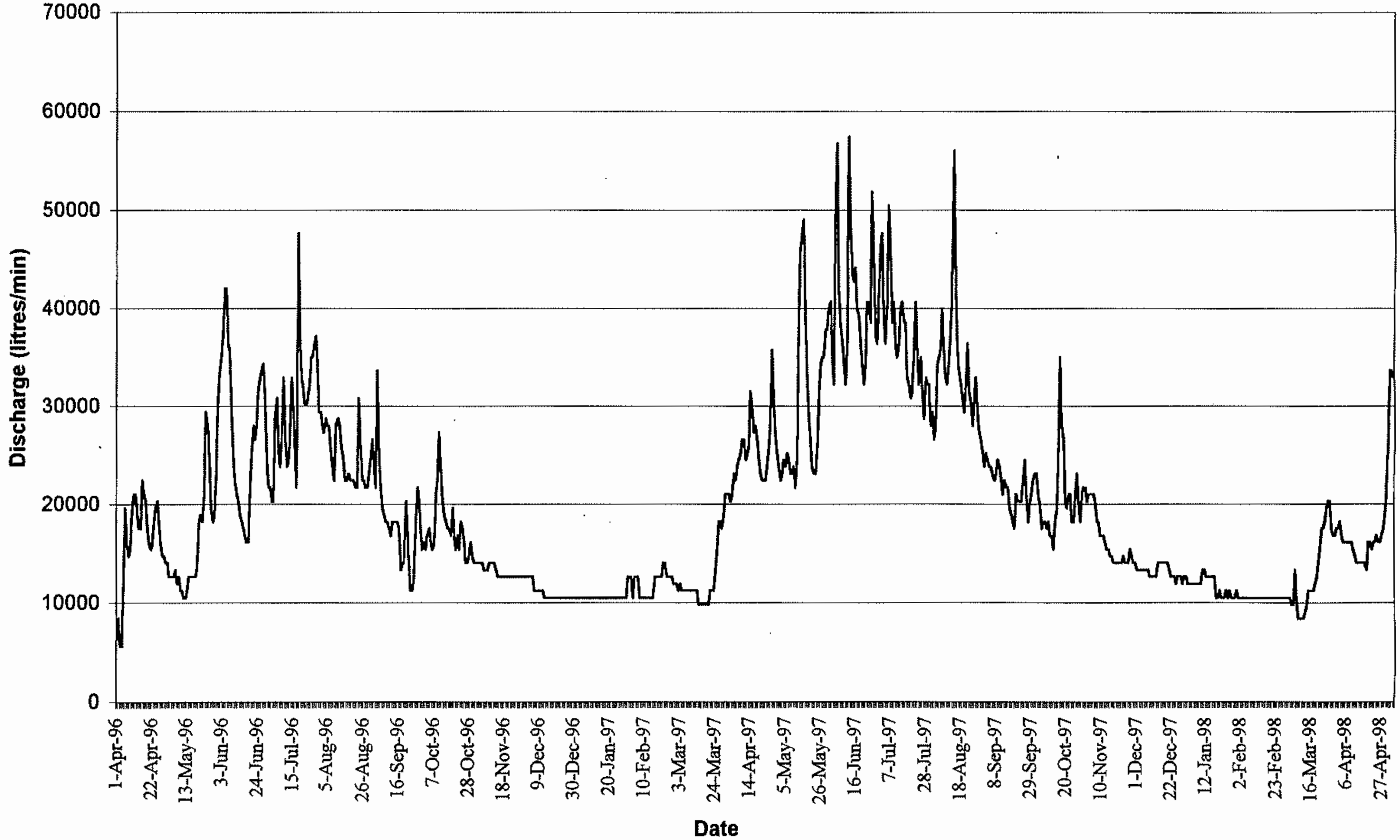
5.1 Streamflow

The Toboggan Creek streamflow, estimated by staff gauge, is recorded by hatchery staff twice daily (M. O'Neill, hatchery manager). The discharge data for the period of the study is shown graphically in Figure 2. As is typical for this climate, lowest flows of the year are observed during the winter months, with freshet occurring in March or April. The earliest snow melt occurs in the valley bottom followed by larger flows from the high elevation snowpack. Peak flows generally occur before mid-July followed by moderate summer-time flows. In some years there may be a second minor peak with the onset of fall rains in late September or October.

5.2 Water Quality Analysis

Water quality analysis data for each DFO site are found in Appendix 2 Tables 1-10. Summary water quality data are found in Table 2. Additional water quality data collected at the time of periphyton sampling are found in Appendix 2 Table 11. Periphyton biomass, at the end of the growing season in September, data are found in Appendix 2 Table 12. Periphyton taxonomic composition data are found in Appendix 2 Table 13.

Figure 2. Toboggan Creek discharge at hatchery April 1996-May 1998



streamflow3/24/99

Table 2 Water quality summary Toboggan Creek watershed 1996-1998

Monitoring site mg/l unless stated	n		Temp. water (°C)	Diss. Oxygen	Turbidity (JTU)	Field pH	Field Ammonia-N	Field Alkalinity $CaCO_3$	Field CO_2	Lab pH	Ammonia -N	Nitrate+ Nitrite -N	Nitrate -N	Nitrite -N	Nitrogen Diss. Inorg.	Nitrogen Diss. Organic	Nitrogen Total Diss.	Phos-phorus Total	Phos-phorus Diss.	SRP
Site 6, Glass Cr	5	Maximum	18.0	13	40	9.0				7.0	0.052	0.059	0.055	0.003	0.1068	1.015	1.041	0.064	0.036	
		Minimum	0.5	7	0	7.3				6.7	0.008	0.001	0.006	0.001	0.021	0.345	0.368	0.011	0.007	
		Average	4.88	10.3	20.0	8.20				6.85	0.021	0.017	0.023	0.002	0.051	0.608	0.647	0.028	0.024	
		St. Dev.	7.35	2.4	16.7	0.70				0.09	0.0164	0.0219	0.0251	0.0011	0.0430	0.2115	0.2254	0.0185	0.0131	
Site 1 TC@CNR	34	Maximum	11.0	12	30	10.0	>3.0	50.0	7	7.2	0.151	0.521	0.578	0.003	0.582	1.147	1.620	0.047	0.029	0.060
		Minimum	0.5	9	0	6.5	<0.2	24.0	3	7.1	0.002	0.079	0.033	0.001	0.035	0.060	0.103	0.005	0.007	0.001
		Average	5.79	10.2	12.4	7.41	0.80	42.67	5.4	7.13	0.026	0.358	0.198	0.002	0.230	0.371	0.624	0.018	0.019	0.010
		St. Dev.	3.61	1.1	9.0	1.15	0.85	7.45	1.8	0.08	0.0365	0.1803	0.1747	0.0013	0.1806	0.3281	0.4884	0.0140	0.0096	0.0171
Site 2 TC@Evelyn	34	Maximum	10.5	14	20	8.0	0.6	64	7	7.2	0.161	0.457	0.484	0.004	0.493	0.796	1.186	0.309	0.030	0.037
		Minimum	1.0	9	0	6.5	<0.2	32	3	7.1	0.003	0.064	0.027	0.001	0.033	0.071	0.111	0.005	0.007	0.002
		Average	6.16	11.0	11.8	7.19	0.38	45.6	4.3	7.13	0.028	0.307	0.169	0.002	0.201	0.311	0.530	0.028	0.020	0.008
		St. Dev.	3.25	1.4	8.1	0.44	0.21	8.4	1.5	0.08	0.0432	0.1573	0.1461	0.0012	0.1502	0.2365	0.3680	0.0567	0.0105	0.0106
Site3 TC@Hatchery	33	Maximum	10.2	13	30	8.0	0.8	64	7	7.3	0.227	0.448	0.484	0.025	0.491	0.891	1.285	0.035	0.021	0.036
		Minimum	1.3	8	0	6.5	<0.2	38	3	7.1	0.001	0.067	0.029	0.001	0.036	0.065	0.106	0.006	0.006	0.002
		Average	6.35	10.4	12.2	7.09	0.42	47.6	4.2	7.17	0.033	0.321	0.168	0.008	0.206	0.276	0.483	0.014	0.013	0.008
		St. Dev.	3.07	1.2	8.8	0.40	0.23	8.5	1.7	0.11	0.0566	0.1608	0.1433	0.0117	0.1548	0.2423	0.3808	0.0097	0.0077	0.0106
Site 4 TC@Fence	34	Maximum	10.2	12	40	8.2	0.8	80	7	7.4	0.279	0.389	0.427	0.005	0.488	0.994	1.304	0.059	0.045	0.034
		Minimum	1.5	7	0	6.5	<0.2	40	3	7.2	0.002	0.060	0.025	0.001	0.034	0.073	0.115	0.006	0.008	0.002
		Average	5.78	10.3	17.2	7.18	0.47	55.2	5.4	7.31	0.047	0.290	0.193	0.003	0.238	0.370	0.578	0.022	0.023	0.009
		St. Dev.	3.06	1.3	13.6	0.50	0.22	13.7	1.7	0.09	0.0717	0.1290	0.1402	0.0014	0.1737	0.3126	0.4432	0.0160	0.0151	0.0103
Site 5 TC@Hwy	34	Maximum	12.0	14	50	8.3	0.6	78	12	7.5	0.229	0.369	0.423	0.005	0.515	1.056	1.428	0.056	0.037	0.027
		Minimum	0.8	8	0	6.5	<0.2	38	3	7.4	0.001	0.065	0.035	0.002	0.039	0.065	0.113	0.006	0.009	0.002
		Average	5.71	11.1	24.1	7.27	0.38	55.2	5.3	7.45	0.024	0.281	0.201	0.003	0.228	0.371	0.572	0.023	0.023	0.008
		St. Dev.	3.35	1.4	17.0	0.53	0.21	13.0	2.9	0.07	0.0449	0.1171	0.1320	0.0014	0.1593	0.2993	0.4282	0.0160	0.0118	0.0077
Site 7 Hatchery outflow	2	Average	2.0	13.0	20	8.2				7.1	0.114	0.194	0.191	0.003	0.304	0.508	0.815	0.052	0.031	
Site 8 Farm slough	12	Maximum	13.0	11	30	7.0	3.0	100	17		2.307		0.772		2.654			0.079		0.631
		Minimum	1.0	5	0	6.0	0.2	36	7		0.017		0.014		0.045			0.017		0.003
		Average	5.88	8.2	8.8	6.52	1.09	50.7	10.5		0.473		0.204		0.715			0.050		0.126
		St. Dev.	4.25	1.7	11.3	0.22	0.75	18.0	3.78		0.8932		0.2923		1.0041			0.0244		0.2092

QA/QC— A considerable difference is apparent in ammonia-N concentrations determined in the field with the LaMOTTE water quality kit and those determined in the DFO lab. The field ammonia readings are, in some instances, many orders of magnitude greater than the lab readings. Part of the problem is that the kit analysis has a minimum detectable concentration of <0.2 mg/l-N, which is much higher than ambient ammonia concentrations in typical northern B.C. streams, which tend to have very low nutrients. There is no apparent relationship between the kit ammonia readings and the lab's, leading to the suspicion that reagent contamination may be the problem.

5.2.1 MELP water quality guidelines for the protection of aquatic life

BC Ministry of Environment (MELP) publishes approved and working water quality guidelines for the protection of a given water use, including drinking water, aquatic life, recreation and agriculture (Nagpal 1998; MELP 1998). They are developed in order that water quality data can be assessed and site-specific water quality objectives can be prepared. In general, water quality problems are non-existent if the substance concentration is lower than the guideline(s). However, if the substance concentration exceeds its guideline, an assessment of the water quality is desirable.

Microbiological indicators— Water quality analysis for microbiological indicators was conducted in conjunction with the periphyton standing crop study and data are reported in Appendix 2 Table 11. Two microbiological indicator organisms were sampled, fecal coliforms and fecal streptococci (also known as enterococci). Both are indicative of contamination from human and animal feces. The Bulkley River objective (Nijman 1986) and provincial guideline (Warrington 1988) for fecal coliforms for the protection of drinking water is ≤10 colonies/100 ml (90th percentile). The guideline for fecal streptococci is ≤3 colonies/100 ml (90th percentile). Because of the high degree of variability encountered in the use of microbiological indicators, the 90th percentile is calculated from at least 5 samples in a 30 day period.

In 1996 and 1997, water samples from the two Toboggan Creek sites and Reiseter Creek, the control stream, contained one or more microbiological indicator in exceedance of its' guideline. Since only one microbiological sample was collected per site, the data are considered inconclusive. However the fact those exceedances were common and, in one case, large (2420 colonies/100 ml fecal coliforms in Toboggan Creek September 1997) is highly suggestive of the need for further assessment.

Temperature— A temperature of 18° C was found in Glass Creek on 23 June 1996. This exceeds the working water quality guidelines for maximum temperature for salmonids of 8-10° C, weekly average for spawning, and 13-15 ° C, maximum for embryo survival. Glass Creek was sampled downstream of a large hay field, in which all riparian cover has been removed, and an open wetland of Toboggan Lake. The removal of riparian cover undoubtedly has influenced the high water temperature in this creek. No fish were found in Glass Creek in July 1997, although historical information indicates fish presence and suitable Dolly Varden and rainbow trout habitat is available (Triton 1998).

Dissolved Oxygen— The B.C. water quality guidelines (instantaneous minimum concentration) for dissolved oxygen for the protection of salmonids are as follows:

- All life stages (other than embryos or alevins still in gravel) 5 mg/l
- Buried embryo/alevin (water column concentration over gravel) 9 mg/l.

The dissolved oxygen concentration at Site 8, the farm slough that had been excavated from a Toboggan tributary, was 5 mg/l on 30 June 1997. The low dissolved oxygen level may be related to elevated temperatures, 10.5 to 13 ° C, which were also recorded at this site in July 1997.

A dissolved oxygen level of 6 mg/l recorded in the farm slough 19 March 1998 was not related to temperature, which was 1° C on that date. It is likely that the very high ammonia concentration recorded on that date, over 2 mg/l ammonia-N, might have caused dissolved oxygen depression by creating biological oxygen demand.

Dissolved oxygen concentrations of 7-8 mg/l were recorded in Toboggan Creek at Site 4 and Site 5 in March and April 1998. These levels are lower than levels recommended in the water column over buried embryos or alevins. Spawning and incubation of pink and coho occurs throughout the mainstem Toboggan Creek, in the vicinity of these sites. Lowered dissolved oxygen concentrations are sometimes reported under ice cover during winter. The highest ammonia-N concentrations recorded at these sites also occurred on these sampling dates but it is not known if this was related.

Nitrogen and phosphorus— Table 3 contains a comparison of Toboggan Creek summary statistics for dissolved nitrogen and phosphorus compounds with other nearby Skeena watershed streams, which were monitored over a 5 year period, 1983-1987 (Wilkes and Lloyd 1990). On average, the concentrations of dissolved nitrogen and phosphorus compounds in the Toboggan system are more than double concentrations in the other Skeena watershed streams. None of the concentrations of dissolved nitrogen and phosphorus compounds in Toboggan Creek exceed the federal or provincial water quality guidelines for the protection of aquatic life or drinking water. Elevated concentrations of dissolved nitrogen and phosphorus compounds suggest, however, that either sewage pollution or agricultural runoff is affecting water quality.

Table 3 Comparison of selected summary statistics Toboggan Creek and nearby Skeena watershed streams

	n	Mean Nitrogen	Mean T.K.N.[1]	Mean Nitrite+ Nitrate-N	Mean Ammonia-N	Mean SRP[2]
Toboggan Creek (mean of 5 sites)	34	0.561	0.372	0.311	0.032	0.009
Bulkley River at Quick	55	0.200	0.140	0.044	0.014	0.005
Kispiox River	55	0.180	0.120	0.074	0.013	0.004
Morice River	55	0.120	0.095	0.074	0.008	<0.003
Telkwa River	59	0.152	0.090		0.010	0.004

Source: Wilkes and Lloyd 1990

[1] Total Kjeldahl Nitrogen (T.K.N.) measure ammonia and organic nitrogen.

[2] Soluble Reactive Phosphorus (SRP) or orthophosphorus is a measure of dissolved biologically available phosphorus.

A brief explanation of water quality parameter terminology follows:

Ammonia is very soluble in water and includes un-ionized ammonia (NH_3) and the ammonium ion (NH_4^+). Ammonia toxicity is related to the amount of un-ionized ammonia, which is dependent upon both pH and temperature.

Total Kjeldahl nitrogen (TKN) measures both ammonia and organic nitrogen. These two nitrogen forms are important for assessing available nitrogen for biological activities and may contribute to the overall abundance of nutrients in water and thus eutrophication (McNeely and others 1979). In a non-industrialized watershed, typical sources of organic nitrogen and ammonia include sewage effluents and farm runoff. Loss of ammonia from fertilized fields can be a problem if high rates of application are used, soil conditions are poor for retention of nitrogen, or heavy rains or over-irrigation cause losses to nearby streams. High concentrations can also occur where concentrations of farm animals occur and animal manure accumulates (e.g. feed lots, dairy barns, and poultry farms).

Nitrite is usually found only in minute amounts in surface waters. Since nitrite is unstable in the presence of oxygen, it occurs as an intermediate form between ammonia and nitrates. **Nitrate** is the most stable form of combined nitrogen in surface waters. Nitrification (conversion of ammonia to nitrite to nitrate) is the principal process in the nitrogen cycle. Nitrate is highly soluble and is often the cause of groundwater and well-water contamination in areas of intensive agriculture.

Soluble reactive phosphorus (SRP), also called **orthophosphorus**, is a measure of biologically available dissolved phosphorus concentrations in water.

Ammonia— There is extensive and sometimes contradictory literature concerning the acute and chronic toxic effects of ammonia on fish. Temperature and pH regulate the balance between the highly toxic un-ionized ammonia and the not (or less) toxic ammonium. Therefore, the MELP guidelines for the protection of aquatic life varies with pH and temperature. For example, for acute toxicity at pH 6.5 and 0° C, the maximum un-ionized ammonia allowed is 0.008 mg/l-N. At pH 9.0 and 20° C, 0.214 mg/l-N un-ionized ammonia is acceptable.

The highest ammonia concentration recorded in this study was at Site 8, the farm slough excavated in a small Toboggan Creek tributary, on 19 March 1998. Ammonia concentration on that date was 2.162 mg/l-N (mean of two samples) at 1° C and 6.5 pH. This exceeds the MELP average 30-day ammonia guideline (1° C and 6.5 pH) which is 2.05 mg/l-N. The MELP maximum concentration guideline at that temperature and pH is 28.3 mg/l-N. Only one sample was taken during this time-period, which coincided with snowmelt and the first surface run-off from the nearby cattle winter feed lot. It was observed that juvenile coho and rainbow trout/steelhead were present both in the farm slough and in the wetland immediately downstream at the time.

The hatchery outflow channel was sampled on one occasion, 7 April 1996 (Appendix 2, Table 7). The mean ammonia concentration was 0.114 mg/l-N, which is well below the MELP 30-day average guideline (2° C and 7.1 pH) of 2.02 mg/l-N. The hatchery utilizes a flow of about 2200 l/min. on a year round basis (M.O'Neill, pers.comm.). The streamflow in Toboggan Creek on 7 April 1996 was 16,100 l/min resulting in a calculated dilution ratio of 1:7.3. Based on this dilution ratio, the ammonia in the hatchery outflow would be predicted to have increased the instream ammonia concentration by 0.016 mg/l-N. Background ammonia concentration on that date (Site 2 Toboggan Creek at Evelyn) was 0.056 mg/l-N.

Seasonal trends—— A seasonal trend in ammonia concentrations was observed in the watershed during the study period (illustrated in Figure 3). The highest ammonia concentrations at all sites were observed in the period of mid-February to mid-April, which coincides with the period of low elevation snow melt and surface runoff from the valley bottom. The highest values were observed on 19 March 1998. On this date high ammonia concentrations were also observed in association with run-off from one cattle winter feedlot, at Site 8. Further monitoring is needed to identify the duration and sources of elevated ammonia concentrations in runoff during freshet.

5.2.2 MELP water quality guidelines for nutrients and algae

The MELP water quality criteria for nutrients and algae (Nordin 1985) are proposed to protect water resources from degradation by excessive amounts of algae. Eutrophication is the process by which lakes and streams become biologically more productive due to increased supply of nutrients (phosphorus and/or nitrogen). If sufficiently large amounts of nutrients enter lakes and streams, man's use of waters can be impaired by the algal biomass present. Eutrophication at low levels and in some habitats may benefit sport fisheries. However as the eutrophication process accelerates, negative consequences, such as changes in fish food benthic organism communities and habitat conditions, can result in a shift in fish species away from salmonids and toward more tolerant species.

Protection of aesthetics and recreation criterion—The Bulkley River watershed objective value of less than 50 mg/m^2 chlorophyll *a* was established for protection of uses related to recreation and aesthetics (Nijman 1986). Nordin (1985) discusses the difficulty in assessing a level of algal biomass that is acceptable from the perspective of aesthetics. He cites examples in other British Columbia rivers in which algal biomass in the range of 35-100 mg/m^2 caused complaints about the appearance of the river, and reduced enjoyment of use of the river by fishermen. The growth, predominantly filamentous diatoms, was brown or brownish green, slimy and often occurred as long trailing strands. The growth coated the rocks, making footing hazardous and fouled fishing lures, making angling difficult.

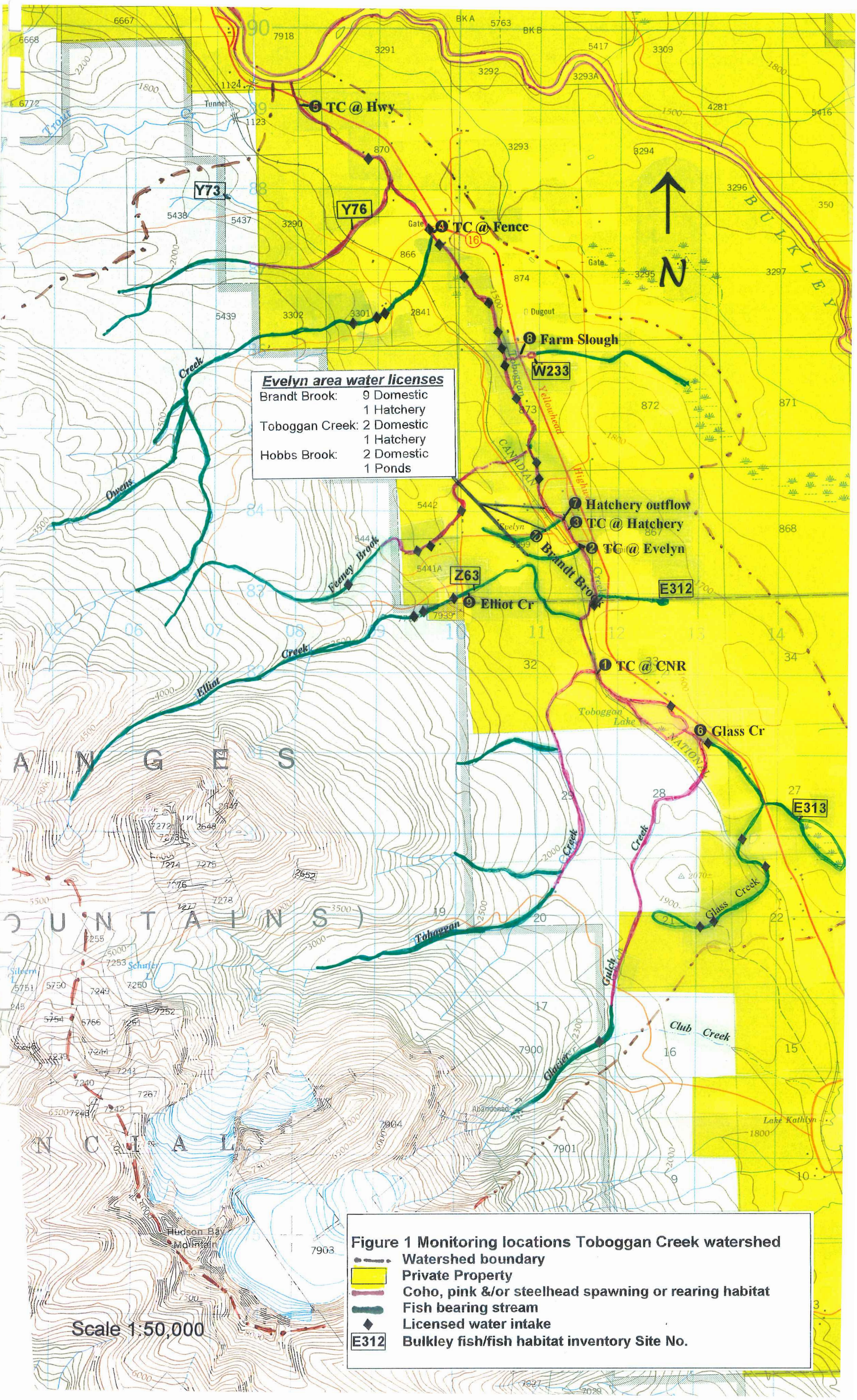
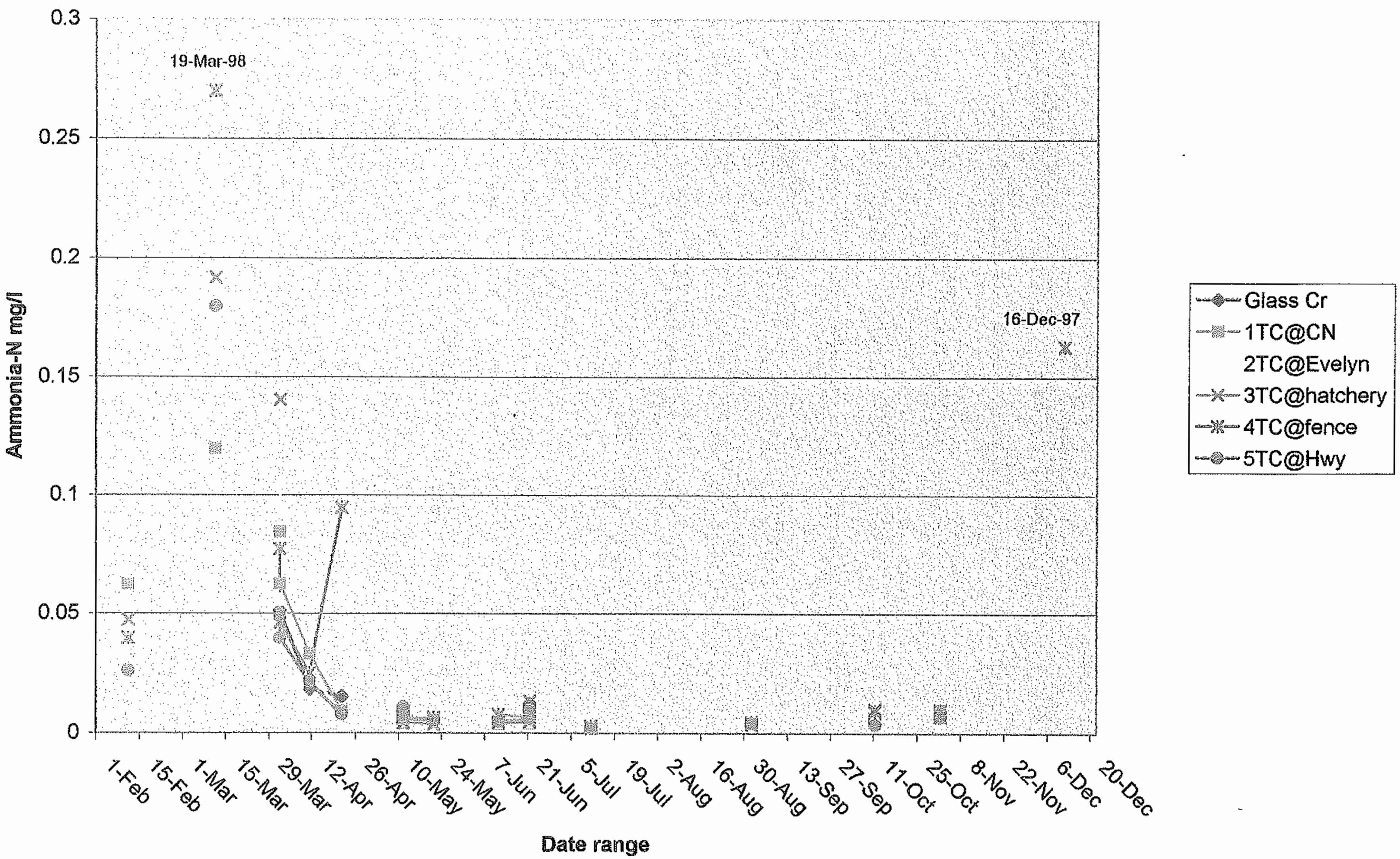


Figure 1 Monitoring locations Toboggan Creek watershed

- Watershed boundary
- Private Property
- Coho, pink &/or steelhead spawning or rearing habitat
- Fish bearing stream
- Licensed water intake
- E312 Bulkley fish/fish habitat inventory Site No.

Figure 3. Seasonal trends in Ammonia-N concentrations: Toboggan Creek watershed 1996-1998



Under the right conditions of light and temperature, nutrient enrichment can promote a shift in community composition from predominantly diatoms to a predominance of certain prolific blue green or green filamentous algae species. This is often considered a 'nuisance' condition for the following reasons (Welch 1980):

- An undesirable change in the appearance of the river and reduced enjoyment of use of the river by fishermen.
- The clogging of water intakes with floating clumps of filaments occurs.
- Many of the nuisance species of green and blue green algae that thrive in enriched environments produce undesirable tastes and odors if the affected stream is used for drinking water supply.

Protection of aquatic life guideline—A value of less than 100 mg/m^2 chlorophyll *a* is the MELP guideline to protect against undesirable changes in aquatic life. To define what levels of algal biomass in a stream represent an impairment of use for aquatic life, the scientific literature and the experience of environmental biologists working in B.C. were surveyed. Excessive amounts of algal biomass accumulation can be detrimental to fish in streams by causing the following problems:

- A secondary BOD is created that can deplete oxygen downstream as the filaments break off, or are dislodged, float away and decompose in shallow backwater areas.
- Change in oxygen concentration in streambed gravels. With heavy algal biomass, algal respiration or the decomposition of algal tissue in the gravel can damage or destroy incubating eggs. The oxygen concentration can also be affected by restriction of water flows through the gravel.
- A shift in community composition from diatoms to green and blue green filamentous algae, which are believed to be less appealing to the invertebrate food species of salmonid juveniles and fry.
- Heavy algal biomass may provide additional shelter for stream invertebrates from fish, and consequently affect fish growth and survival rates.
- Fry rearing and overwintering may be impaired by algal growth as well. Excellent habitat for fry (such as cobble) where fry rear and overwinter in the spaces between the cobbles provides high survival. Reduction in oxygen could reduce survival particularly for some species.

5.2.3 Toboggan Creek periphyton standing crop and community composition

Periphyton standing crop — The 1996 and 1997 periphyton biomass data are found in Appendix 2 Table 12. In general, the periphyton standing crop was lower at all sites surveyed in 1996 than 1997. This was believed to be due to heavy rains and high water flows causing scouring of the streambed prior to the sampling period. The periphyton standing crop was low in Reiseter Creek in both years, <14 mg/m^2. The periphyton standing crop was moderate at Toboggan Creek Site 2, just downstream of the Evelyn Station Road Bridge in both years. The guideline for protection of recreation and aesthetics (50 mg/m^2) was exceeded at Site 4, Toboggan Creek at the assessment fence in 1997. Periphyton standing crop on that date was 74.3 mg/m^2.

Periphyton community composition— Periphyton community composition data at each monitoring site are found in Appendix 2 Table 13. Many habitat factors regulate the spatial distribution of riverine algae, which are not well understood. It should be noted that only one sample was taken at each site, therefore these data should be viewed as a general qualitative representation of the periphyton community.

Reiseter Creek— Bacillariophyceae (diatoms) composed 100% of the periphyton community of Reiseter Creek in both years of study.

Toboggan Creek— The periphyton composition at Site 2 Toboggan Creek at Evelyn Road was 100% diatoms in 1997, but included 0.5% *Cladophora* sp. in 1996.

The periphyton community at Site 4, Toboggan Creek upstream of the DFO assessment fence, was comprised of 75% diatoms in 1996 and 95% diatoms in 1997. In 1996 the periphyton community was almost 25% *Spirogyra* sp. Other algae present were the green filamentous *Cosmarium* sp. and *Ulothrix* sp. Also present in 1997 was the filamentous blue green algae *Oscillatoria* sp. (5%).

Spirogyra and *Ulothrix* are green filamentous algae often associated with organic enrichment in streams (Hellawell 1986). *Oscillatoria* is a blue green filamentous algae which is associated with eutrophication (Palmer 1977).

5.3 Fish Histological Analysis

Letters, summary tables and detailed histological reports for juvenile salmonids trapped in Toboggan Creek and the farm slough in 1996-1997 are found in Appendix 3. The most common pathology observed in Toboggan watershed salmonids was mild to severe lamellar hyperplasia of the gills, sometimes accompanied by sloughing of the lamella or secondary infection. Most of the fish submitted for examination were from the upper watershed, Sites 1-3 upstream of the hatchery. Gill damage was most common in June and July, although some damage was observed later in the season. Massive lamellar hyperplasia and sloughing was also observed in coho collected at Site 8, the farm slough, in June 1996.

Degenerative changes in the liver were also observed in the upper watershed and farm slough fish, mainly in the June and July samples. Liver sections showed degenerative changes including nuclear pleomorphism and pyknosis, uneven vacuolation, indistinct cytoplasmic detail and necrotic cells. Some liver sections contained basophilic striae in the hepatic cytoplasm indicating increased cellular activity and suggesting detoxifying activity. Necrotic cells were observed in the anterior kidney in many samples as well.

It is impossible to identify any particular toxicant by histological examination alone (J. Bagshaw, histologist, pers. comm.). The damage observed in Toboggan Creek and farm slough fish appears to be similar and may represent slightly different exposure to the same toxicant. The gill damage appears to be the result of an immediate sub-acute irritant. The liver and kidney damage appears to represent the process of detoxification as the result of longer-term chronic exposure to low levels of a toxicant.

Haywood (1983) reviewed the extensive literature on ammonia toxicity in fish. Ammonia has been found to produce histopathological changes in fish gill structure in numerous studies. The usual effects appear as a general thickening of the epithelial membrane with associated hyperplasia; sometimes there is a breakdown of the pillar cell structure of the secondary lamellae resulting in sloughing. This general disruption of branchial structure effectively reduces the surface area of the gill membrane, with resultant reduction in oxygen-diffusing capacity. The susceptibility of salmonids to bacterial fish disease is closely linked with extensive gill hyperplasia caused by ammonia. The exact concentrations of ammonia reported to produce gill damage in various studies has varied depending on other (known and unknown) variables, including dissolved oxygen, CO_2, temperature, ionic gradients, species, life stage and size, acclimation and stress.

In the crowded conditions found in salmon hatcheries, evidence of gill damage, similar to that described as characteristic of ammonia poisoning, as well as reduced growth and increased bacterial disease, have been associated with ammonia at concentrations far below that recommended as "safe" (Meade 1985).

6. Discussion

6.1 Fish Habitat

Fish habitat inventory conducted in 1997 noted a number of land use activities that were negatively affecting fish habitat, including clear cutting to the bank, trampling by livestock and total removal of riparian cover.

6.2 Water Quality

6.2.1 Toboggan Creek

Microbiological indicators— Fecal coliforms and fecal streptococci concentrations in Toboggan Creek exceeded provincial guidelines for protection of drinking water on late summer sampling dates in 1996 and 1997. This is of concern because of the numerous residents of the watershed who take their domestic water supply from Toboggan Creek and its tributaries.

Temperature— Temperature in Glass Creek exceeded provincial guidelines for protection of salmonids in June 1996. The total removal of riparian cover along lower Glass creek has undoubtedly influenced the water temperature in this small stream, which historically is believed to have supported Dolly Varden and rainbow trout.

Dissolved oxygen— The recommended dissolved oxygen concentration to protect buried embryos or alevins is 9 mg/l in the water column over spawning gravels. Dissolved oxygen levels of 7 and 8 mg/l were recorded in lower Toboggan Creek in March and April 1998.

Nutrients— Nitrogen and phosphorus concentrations in Toboggan Creek do not exceed water quality guidelines for the protection of aquatic life or drinking water, but are elevated compared to other nearby streams. Elevated concentration of dissolved nitrogen and phosphorus compounds is suggestive of either sewage pollution or agricultural runoff.

Ammonia— Ammonia concentrations in Toboggan Creek did not exceed maximum or 30-day average ammonia guidelines for the protection of aquatic life. A seasonal trend in ammonia concentrations was observed, with a spike in ammonia concentrations in the period of mid-February to mid-April. This coincides with annual freshet in the watershed. Typically, low elevation runoff from the valley bottom enters the system first, followed by a much higher volume of high elevation runoff from mountain snowpack.

Periphyton standing crop— Water quality guidelines for nutrients and algae are intended to protect streams from excessive amounts of benthic algae. The provincial guideline and the objective developed specifically for the Bulkley River basin for protection of aesthetics and recreation (<50 mg/m^2) was exceeded in lower Toboggan Creek in 1997. Mean periphyton standing crop at Site 4 in 1997 was 74.3 mg/m^2. This is below the periphyton standing crop guideline for protection of aquatic life (juvenile salmonids) of 100 mg/m2. Filamentous blue green and green algae genera often associated with organic enrichment were present, but not widespread.

Early signs of eutrophication— Toboggan Creek is showing signs of early eutrophication: elevated bacterial and nutrient concentrations contributing to algae growth and other undesirable changes to stream biota. A seasonal spike in ammonia and other nutrient concentrations coinciding with early freshet suggests that low elevation, or valley bottom, surface runoff may be the source of nutrients. There is no indication that the degree of algae growth in the watershed at this time is having a negative effect on salmonid resources. However, experience has shown that eutrophication caused by diffuse, or watershed-wide, sources is often very difficult to mitigate. Over time, as more people and livestock move into the watershed and more roads and land clearing occurs, the eutrophication process generally accelerates. This is why it is an important trend to monitor, and to address through sound watershed stewardship.

6.2.2 Farm slough

Drainage from a slough, which had been excavated in a small tributary, was the subject of investigation during 1997-1998. The tributary was a known coho and rainbow trout/steelhead rearing stream. The 20 cow-calf operation was investigated because of the unfortunate choice of winter feedlot location adjacent to and draining into the slough. An ammonia concentration higher than the provincial 30-day average guideline for ammonia was recorded during freshet, March 1998. Dissolved nitrogen and phosphorus concentrations in this tributary were generally far higher than any other Toboggan watershed sites monitored during the 1997-1998 period. Because of concern for the health of juvenile coho and rainbow trout/steelhead in the slough and downstream, a DFO fish protection order was issued and the winter feedlot was subsequently relocated.

6.2.2 Toboggan Creek Hatchery

An increase in fish production at the Toboggan Creek Hatchery is taking place in 1998-1999. An additional 140,000 coho fry are being produced over the 1997-1998 production year (M. O'Neill, hatchery manager, pers. comm.). Only one water quality sample has been taken from the outflow of the hatchery to Toboggan Creek. A calculation of dilution ratio in the mainstem on that date, early April 1996, indicates a small increase in ammonia and nutrients would occur in the mainstem as a result of that discharge. Further investigation is required to determine seasonal and average hatchery discharge quality and to assess this in relation of annual low flows, which occur in wintertime in this and other northern watersheds.

6.3 Fish Health

Histological analysis of juvenile salmonids from the Toboggan Creek watershed in 1996 showed the presence of gill and, sometimes, liver and kidney pathology, particularly in upper watershed fish and early in the season (June - July). Histological examination can only determine the presence of an irritant or toxicant, but cannot identify any particular toxicant by itself. The gill pathologies reported are similar to those reported for ammonia toxicity. But this seems unlikely given that monitored ammonia concentrations in Toboggan Creek were much lower than those reported to produce chronic or acute ammonia toxicity.

It is of interest to note that juvenile salmonids from the farm slough had a high percentage of similar gill, liver and kidney pathology. Elevated concentrations of ammonia were identified in the farm slough tributary in the spring of 1998.

It appears that either 1) the periodic water quality sampling in 1996-1998 missed a peak of ammonia runoff or 2) some other toxicant was the cause of gill and organ damage. Possible other toxicant sources include:

- Highway 16, the CN Rail line and the power transmission line, which pass through the watershed in very close proximity to Toboggan Creek and Lake. The use of herbicides or de-icing agents on these rights of way has not been investigated.
- Farm fields surround Toboggan Lake and its tributary, Glass Creek. The use of herbicides and fertilizers in the upper watershed has not been investigated.
- The height of high elevation snowmelt runoff occurs in June and July, bringing high fine particulate loads from the glaciated headwaters. A large mineral body and old mine workings are present in the Glacier Gulch Creek headwaters. Metals concentrations in this drainage have not been investigated.

6.4 Land Use Activities and Eutrophication

6.4.1 Transportation corridors

The three transportation corridors through the Toboggan watershed have all resulted in removal of riparian cover from portions of the mainstem and tributaries. The use of herbicides or de-icing agents on these rights of way has not been investigated. The CN rail right of way, in particular, is in close proximity to Toboggan Lake and its wetlands as well as Toboggan Creek mainstem.

6.4.2 Mining

Although active mineral exploration and mine development can contribute nitrogen to streams through use of explosives, inactive mine workings would not be expected to contribute to eutrophication.

6.4.3 Forestry

When streamside vegetation is removed, summer water temperatures usually increase in direct proportion to the increase in sunlight that reaches the water surface. While fish productivity might be enhanced in cold headwater streams, the increased water temperature may have negative effects in the lower watershed.

Clogging of surface gravels by fine inorganic sediments can restrict intergravel flow enough to lower dissolved oxygen concentrations. This problem usually occurs only when large or persistent volumes of sediment emanate from active road systems, mass soil movements, bank slumps or destabilized upstream channels (Scrivener and Brownlee 1989).

Although the harvesting of timber interrupts the cycling of nutrients between vegetation and soils, most studies reveal no significant impact on nutrient levels in forest streams. Concentrations of inorganic nutrients (e.g. N, P, K, Ca) in streams may increase after logging, but usually by moderate amounts and for short periods. Likewise, 5- to 10-fold increases in nutrient releases after slash burning have shown rapid returns to earlier levels (Chamberlin 1991). Most of the clearcuts in the Toboggan watershed have reached the 'green-up' stage and therefore would not be expected to contribute a significant increase in nutrient levels to streams.

6.4.4 Agriculture

The Toboggan Creek watershed contains two dairies and four beef cattle operations, as well as an unknown number of hobby farms. The estimated total cattle population in the watershed is 1000 animal units (D. Reindeau, District Agriculturalist, pers. comm.).

Gaherty and others (1996) describe the typical cattle operation in the Bulkley valley as consisting of range or grazing areas, confined feedlot areas, and feed storage areas. Cattle are kept on free-range grazing areas and confined feedlot areas, or in barns for part of the year. Perennial forage crops are grown for over-winter feed. Most farms use wood waste or straw as bedding material in the barn or calving grounds. High density grazing areas and confined feedlots may have accumulated manure, and soiled bedding is removed from the barn and stored outside on a regular basis.

Several concerns regarding these practices have been documented. The Ministry of Agriculture, Fisheries and Food, through the Best Agricultural Waste Management Plan (1993) has audited beef operations across the province. These audits identified several aspects of cattle farming that directly affect surface water or ground water, including improper burial of dead animals (27% of 34 operations surveyed); release of silage effluent and wasted feed (27%); improper manure handling or storage (36%); yard runoff from outdoor cattle pens in proximity of watercourses (91%); improper cattle watering facilities with direct access to water courses (50%); and leachate production from sawdust storage (25%).

Grazing—Well drained slopes with a herbaceous vegetation cover have a low susceptibility to surface runoff and erosion, and where manure is exposed to snowmelt runoff it is widely distributed rather than concentrated as in livestock wintering areas. Wetlands that are intensively grazed may be significant sources of nutrients since they are source areas of snowmelt and storm runoff and are subject to flooding.

Gaherty and others (1996) assessed the contribution of grazing lands to water quality concerns to not be significant. Cattle densities on rangelands are very low and with very limited winter use. The concerns identified related to the use of natural waters for watering. Cattle in the region generally have unlimited access to streams or lakes for watering, which may cause bank erosion and direct deposition of manure, a microbiological as well as nutrient hazard.

Livestock wintering areas— In agricultural areas nutrient losses from livestock wintering areas or feedlots generally exceed those from other agricultural sources by several orders of magnitude (Loehr 1974). Gaherty and others (1996) identified winter feed lots as an environmental risk to water bodies in the Skeena Region through manure runoff. Snowmelt runoff produced on the frozen surfaces of wintering areas entrains nutrients in manure in both particulate and dissolved forms. Where contaminated runoff reaches nearby streams high nutrient loads may result. Livestock manure is rich in nutrients, both nitrogen and phosphorus. Estimated total nitrogen and phosphorus produced by livestock in the Toboggan watershed on an annual basis is found in Table 4.

A comparative study of nutrient export from forested and agricultural watersheds on the Boreal Plain north of Edmonton was reported recently by Cooke and Prepas (1998). High ammonia export during spring runoff from the watershed with two cow-calf operations suggested that much of the organic nitrogen from livestock waste that accumulated over the winter was converted to ammonia in runoff. This is likely due to cold temperatures over winter and during spring runoff at this latitude that do not facilitate further bacterial breakdown of ammonia to nitrate.

Other operations on cattle farms that may affect water quality include feed storage (particularly silage) and sawdust storage. Silage runoff, because of its high biochemical oxygen demand (BOD) and nutrient content is a more potent contaminant than manure, and so is especially important. Further study is required to identify if there are problems that may be associated with the location and operation of winter feedlot and dairy operations in the watershed.

Table 4 Estimated total nitrogen and phosphorus (P_2O_5) produced annually by cattle in the Toboggan Creek watershed

Animal Units[1]	Nutrient Coefficient per A.U.[2]	Phosphorus (P2O5) lb/yr	Nutrient Coefficient per A.U.[2]	Nitrogen lb/yr
Dairy - 150 A.U.	80 lb/yr	12,000	170 lb/yr	25,500
Beef - 850 A.U.	30.47 lb/yr	25,900	71.64 lb/yr	60,894
Total		37,900		86,394

1 Animal Unit: one cow and calf

2 Source: Bangay 1976.

Fertilization—Fertilizer application has been recognized in other agricultural basins as a frequent cause of stream enrichment (Cooper 1993). In the study area most fertilizer is applied to perennial forage crops on well drained uplands which would be subject to minimal surface runoff. Excessive surface irrigation or heavy rainfall would have the potential to transport fertilizer broadcast on the field surface, but it is expected that such cases would be rare. The most significant potential for fertilizer loss to streams is at sites that are poorly drained or subject to flooding. Poorly drained riparian areas and wetlands have the potential to deliver nutrients from fertilizers to streams by flooding, storm runoff and subsurface flow. The Toboggan watershed has numerous wetlands, particularly immediately upstream and downstream of the lake (see air photo mosaic in back cover pocket).

Accelerated erosion—A final mechanism of phosphorus loss to surface waters in agricultural areas is by surface erosion or channel bank erosion. Sediments may be transported from road surfaces, ranch yards or fields under cultivation. However, in the Toboggan watershed erosion is expected to be minimized by the maintenance of perennial forage crops.

No-till replanting systems have been introduced to the valley in recent years. Logan (1982) in his review of the effects of conservation tillage on phosphate losses from agricultural land, found that, while no-till was quite efficient in reducing the total particulate phosphate load, no-till increased or had no effect on the dissolved P load to watersheds.

Channel bank erosion may be accelerated by human manipulation of channels and by use of streamside areas by livestock. A number of examples of channel manipulation and stream bank trampling by livestock were noted in the fish habitat inventory conducted in 1997 (Triton 1998). A more detailed channel inspection would be required to assess the significance of intensive use of riparian areas by grazing livestock, of livestock watering sites or the impact of channel modification on sediment and nutrient transport.

6.4.5 Septic Tanks

Septic system effluent has high nutrient and microorganism concentrations derived from human feces and phosphorus-rich detergents. Many studies have shown that, where septic tanks are located on well drained mineral soils set back an approved distance from receiving waters, there is little likelihood of contamination. Generally only areas with highly permeable soils or high groundwater levels are susceptible to problems. In these situations septic discharges can seep into underground water sources, contaminating both well water and nearby streams.

The Toboggan and nearby Kathlyn watersheds have both seen considerable human population growth in recent years. The Kathlyn Lake area has recently been included in the Town of Smithers sewage collection system.

7. Recommendations

- It is suggested that DFO take the lead role in establishing a watershed stewardship initiative for the Toboggan Creek watershed. Although on a much larger scale, the FRAP (1997) *Fraser Basin: Sustainability through responsibility* initiative provides an excellent example. The attractive and non-technical report and accompanying posters summarize knowledge of the river's fish, habitat and water quality – including ongoing problems and concerns. Highlighted throughout are actions DFO has taken, studies that are underway, and actions everyone can take, to improve the health of the river and its fish. Topics of specific concern to the Toboggan Creek watershed which could be addressed are fish health, watershed eutrophication, microbiological water quality for domestic water users, the salmon and steelhead hatchery operations, water withdrawals relative to instream flow requirements for fish and fish habitat requirements, such as riparian cover. Emphasis would be placed on stewardship opportunities for transportation corridors, rural residents and hobby farm owners, beef cattle and dairy operations, mining and forestry.

- Further assessment of eutrophication in the Toboggan Creek watershed is recommended, and the assessment of nutrients and algae is an effective monitoring method. The 1996 and 1997 growing seasons were preceded by winters with unusually high snowpack. The high snowpack resulted in relatively high summer streamflows and cool temperatures, which would be expected to inhibit periphyton growth in those years. Annual assessment of periphyton standing crop at several points in the mainstem would provide, over time, an assessment of trophic status and trends in the watershed. Monitoring for nutrient loading in the major tributary streams of the watershed may help focus remedial action on nutrient sources. Possible sources of microbiological and nutrient enrichment to streams in the watershed include septic tanks, agricultural wastes and fertilizers and discharge from the salmon hatchery, all of which require further monitoring.

- Further assessment of salmonid health problems, which have been identified in the upper Toboggan watershed, is recommended. A monitoring program should be devised that addresses the following questions:

  Are herbicides or other chemical agents being applied to the rights of way for the rail line, highway or power transmission line which may be entering the system though surface runoff and affecting fish health?

  Are herbicides, fertilizers or ammonia runoff from agricultural areas entering the system through runoff and affecting fish health?

  Are particulates found in runoff from glaciers or metals concentrations from glacially influenced mineral deposits in Toboggan Creek headwaters affecting fish health?

- Monitoring of nutrients and microbiological indicators in runoff from livestock wintering areas, manure and silage storage sites and dairy parlors is recommended for the Toboggan watershed. Landowner contact should only be undertaken in cooperation with Ministry of Agriculture, Fisheries and Food and the B.C. Cattlemen's Association peer advisory committee. The Conservation Check List found In the *Watershed stewardship: a guide for agriculture* (DFO 1997) could be an educational tool, in addition to focusing remedial action. A rating system based on terrain runoff potential, location relative to streams, and cattle numbers and management has been used successfully in focusing remedial action in other central interior watersheds (Hart and Mayall 1991). Alternatively, the environmental sustainability parameter (Palmer and Rising 1996), which was developed for the Fraser River Valley and rates farm waste management practices relative to a selected sample of area farms, could be adapted to this farming area.

- A water quality impact assessment should accompany the increase in capacity that is taking place at the Toboggan Creek Hatchery in 1999. At least a one-year study, which includes upstream and downstream monitoring, as well as in-hatchery and discharge monitoring is suggested. Periods of low winter streamflow should be targeted as well as periods of maximum fish biomass and feed consumption at the hatchery. Hatchery water supplies should be assessed in relation to *Summary of water quality criteria for salmonid hatcheries* (Sigma 1983).

  Once a year, during early summer, the hatchery outdoor rearing ponds are drained and bottom sludge accumulation is pumped out (M. O'Neill pers. comm.). The sludge, which is presumably very nutrient rich, is deposited on the embankment behind the channels. Periodic monitoring during and following this process is suggested, in order to ensure that the current practices are successful in preventing nutrient runoff from reaching Toboggan Creek.

- There is some evidence that microbiological water quality of drinking water sources (tap water) in the Toboggan Creek watershed should be monitored. Status and trends in microbiological water quality are also an effective indicator of overall watershed health. Microbiological monitoring programs are carried out routinely in several Smithers area lake watersheds, including Kathlyn Lake, as part of MELP's water quality objectives monitoring program (Boyd and others 1984). The monitoring protocol requires five samples in 30 days. It is suggested that early spring, during the start of low elevation snow melt and surface runoff, should be the targeted time period.

- Instream flow assessment for the Toboggan Creek watershed is recommended. This would include analysis of licensed water withdrawals and streamflow trends from hatchery discharge data and other nearby monitored watersheds. An assessment of actual water volumes withdrawn for irrigation, rather than licensed volumes, is needed in order to complete this assessment. Information on actual water volumes withdrawn for irrigation could be gathered during on-site visits, or by mail-out questionnaire methods.

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Appendix 1. Toboggan Creek watershed monitoring site photographs

Site 2, Toboggan Creek upstream Evelyn Station Road bridge

Site 3, Toboggan Creek upstream hatchery outflow channel

Appendix 1. Toboggan Creek watershed monitoring site photographs

Site 4, Toboggan Creek upstream DFO salmonid assessment fence

Site 5, Toboggan Creek upstream Highway 16 culvert

Appendix 1. Toboggan Creek watershed monitoring site photographs

Site 8, Farm slough. (Note cattle winter feedlot in background).

Site 8, Farm slough

Appendix 2 Table 1. Site 1, Toboggan Creek at CNR bridge, water quality analysis April 1996-April 1998

mg/L unless stated	Temp. water (°C)	Diss. Oxygen	Turbidity (JTU)	Field pH	Field Ammonia	Field Alkalinity $CaCO_3$	Field CO_2	Lab pH	Ammonia N	Nitrate+ Nitrite -N	Nitrate N	Nitrite - N	Nitrogen Diss. Inorg.	Nitrogen Diss. Organic	Nitrogen Total Diss.	Phos-phorus Total	Phos-phorus Diss.	SRP
Date	MDC	0-10	0-200	3.0-10.0	0.2 - 3.0	0-200	0-50	0.1	0.001	0.001	0.001	0.001	computed	0.001	0.001	0.001	0.001	0.001
7-Apr-96	1.0	9	30	8.2				7.1	0.062	0.243	0.240	0.003	0.301	0.541	0.846	0.046	0.029	
								7.1	0.063	0.244	0.241	0.003	0.304	0.556	0.863	0.046	0.028	
16-Apr-96	2.5							7.1	0.033	0.440	0.437	0.003	0.470	1.147	1.620	0.036	0.021	
								7.1	0.033	0.438	0.435	0.003	0.468	1.088	1.559	0.033	0.023	
28-Apr-96	4.0	11	10	8.1				7.2	0.010	0.521	0.520	0.001	0.530	0.280	0.810	0.012	0.007	
								7.2	0.008	0.512	0.511	0.001	0.519	0.371	0.891	0.011	0.007	
20-May-96	9.0	10	10	7.7					0.004	0.517				0.400	0.921	0.009		
									0.005	0.508				0.211	0.724	0.009		
23-Jun-96	9.8	10	0						0.004	0.080				0.244	0.329	0.009		
									0.004	0.079				0.271	0.354	0.007		
15-Jul-96	10.0	10	0	7.0					0.002		0.033		0.035	0.209	0.244	0.007		
									0.002		0.036		0.039	0.312	0.351	0.007		
3-Sep-96	8.5	10	20						0.004		0.039		0.043	0.060	0.103	0.020		
									0.003		0.039		0.042	0.064	0.107	0.021		
15-Oct-96									0.005		0.033		0.038	0.096	0.134	0.008		
									0.007		0.033		0.040	0.091	0.130	0.007		
2-Apr-97	0.5	9	20	10.0	>3.0	48	7											
3-Apr-97	1.8	9		10.0	0.6	50	7											
10-Apr-97	4.2	9	20	6.5	0.6	48	7											
21-Apr-97	5.8	9	10	7.0	0.6	40	7											
13-May-97	11.0	11	20	7.0	0.8	36	3		0.003		0.576		0.580			0.040		0.003
									0.004		0.578		0.582			0.047		0.003
28-May-97	8.0	12	10	7.0	2.0	40	3		0.004		0.189		0.193			0.009		0.003
									0.005		0.188		0.193			0.008		0.003
11-Jun-97	10.0	11	20	7.0	<0.2	40	3		0.003		0.083		0.086			0.016		0.004
									0.004		0.081		0.085			0.017		0.004
30-Jun-97	10.5	10	0	6.5	<0.2	24	4		0.004		0.045		0.049			0.005		0.001
									0.004		0.042		0.046			0.005		0.002
2-Nov-97	4.0	11	10	7.0	<0.2	44	4		0.008		0.254		0.262					0.003
									0.011		0.254		0.265					0.002
16-Dec-97											0.163							
											0.161							
13-Feb-98	1.5	12	10	6.5	<0.2	44	7		0.063		0.140		0.203			0.008		0.002
									0.061		0.138		0.199			0.008		0.002
19-Mar-98	4.0	9	20	6.5	0.6	50	7		0.151		0.107		0.258					0.060
									0.088		0.109		0.197					0.045
2-Apr-98	4.0	11	0	6.5	0.6	48	6		0.086		0.117		0.203			0.027		0.013
									0.082		0.117		0.199			0.029		0.013
Maximum	11.0	12	30	10.0	>3.0	50.0	7.0	7.2	0.151	0.521	0.578	0.003	0.582	1.147	1.620	0.047	0.029	0.060
Minimum	0.5	8.6	0	6.5	0.6	24.0	3.0	7.1	0.002	0.079	0.033	0.001	0.035	0.060	0.103	0.005	0.007	0.001
Average	5.79	10.16	12.4	7.41	0.83	42.67	5.42	7.13	0.0260	0.3583	0.1979	0.0024	0.2296	0.3714	0.6241	0.0181	0.0191	0.0102
St. Dev.	3.61	1.07	9.0	1.15	0.52	7.45	1.83	0.08	0.0365	0.1803	0.1747	0.0013	0.1806	0.3281	0.4884	0.0140	0.0096	0.0171

Appendix 2, Table 2. Site 2, Toboggan Creek upstream Evelyn Station Road bridge, water quality analysis April 1996-April 1998

mg/L unless stated	Temp. water (°C)	Diss. Oxygen	Turbidity (JTU)	Field pH	Field Ammonia-N	Field Alkalinity $CaCO_3$	Field CO_2	Lab pH	Ammonia -N	Nitrate+ Nitrite -N	Nitrate -N	Nitrite -N	Nitrogen Diss. Inorg.	Nitrogen Diss. Organic	Nitrogen Total Diss.	Phos-phorus Total	Phos-phorus Diss.	SRP
Date	*MDC*	*0-10*	*0-200*	*3.0-10.0*	*0.2 - 3.0*	*0-200*	0-50	0.1	0.001	0.001	0.001	0.001	computed	0.001	0.001	0.001	0.001	0.001
7-Apr-96	1.0	12	20	7.9				7.1	0.056	0.212	0.208	0.003	0.264	0.574	0.841	0.050	0.030	
								7.1	0.056	0.209	0.206	0.004	0.261	0.594	0.859	0.048	0.030	
16-Apr-96	2.5	14	20	7.6				7.1	0.026	0.364	0.361	0.003	0.387	0.796	1.186	0.030	0.023	
								7.1	0.025	0.367	0.364	0.003	0.389	0.738	1.129	0.032	0.022	
28-Apr-96	4.5	12	10	8.0				7.2	0.008	0.442	0.441	0.001	0.449	0.332	0.782	0.011	0.007	
								7.2	0.008	0.438	0.437	0.001	0.445	0.253	0.699	0.010	0.007	
20-May-96	8.0	10	10	7.6					0.005	0.456				0.202	0.662	0.009		
									0.005	0.457				0.188	0.650	0.009		
23-Jun-96	9.8	10	0						0.005	0.064				0.304	0.373	0.006		
									0.004	0.066				0.276	0.346	0.005		
15-Jul-96	9.5	10	0	7.0					0.003		0.034		0.036	0.205	0.241	0.007		
									0.003		0.035		0.038	0.207	0.245	0.008		
3-Sep-96	8.2	9	20						0.003		0.037		0.040	0.071	0.111	0.025		
									0.005		0.037		0.042	0.076	0.117	0.309		
15-Oct-96									0.006		0.027		0.033	0.084	0.117	0.006		
									0.007		0.028		0.035	0.080	0.115	0.005		
2-Apr-97	1.4	10	20	7.0	0.6	64												
10-Apr-97	5.1	9		6.5	0.6	42	7											
21-Apr-97	6.8	10	10	7.0	0.6	40	4											
13-May-97	10.0	12	20	7.0	0.6	44	4		0.009		0.482		0.491			0.031		0.003
									0.009		0.484		0.493			0.034		0.003
28-May-97	8.0	11	10	7.5 <	0.2	44	4		0.004		0.168		0.172			0.008		0.003
									0.005		0.167		0.172			0.008		0.006
11-Jun-97	10.0	10	20	7.0	0.2		3		0.005		0.072		0.077			0.013		0.005
									0.003		0.071		0.075			0.014		0.005
30-Jun-97	10.5	11	0	6.5 <	0.2	32	6		0.008		0.038		0.046			0.006		0.002
									0.006		0.038		0.045					0.002
2-Nov-97	4.0	11	10	7.0 <	0.2	44	3		0.010		0.216		0.226					0.004
									0.007		0.215		0.223			0.009		0.002
16-Dec-97									0.027		0.151		0.178					0.002
											0.152							
13-Feb-98	1.5	13	10	7.0 <	0.2	44	3		0.052		0.067		0.118			0.009		0.003
									0.060		0.113		0.173			0.009		0.002
19-Mar-98	5.0	11	20	7.5 <	0.2	50	3		0.155		0.107		0.262					0.037
									0.136		0.110		0.247					0.033
2-Apr-98	5.0	13	0	7.0	0.6	52	6		0.050		0.106		0.156			0.030		0.011
									0.161		0.105		0.265			0.033		0.011
Maximum	10.5	14	20	8.0	0.6	64	7	7.2	0.161	0.457	0.484	0.004	0.493	0.796	1.186	0.309	0.030	0.037
Minimum	1.0	9	0	6.5	0.2	32	3	7.1	0.003	0.064	0.027	0.001	0.033	0.071	0.111	0.005	0.007	0.002
Average	6.16	11.0	11.8	7.19	0.38	45.6	4.3	7.13	0.0282	0.3073	0.1692	0.0025	0.2012	0.3111	0.5296	0.0276	0.0197	0.0077
St. Dev.	3.25	1.4	8.1	0.44	0.21	8.4	1.5	0.08	0.0432	0.1573	0.1461	0.0012	0.1502	0.2365	0.3680	0.0567	0.0105	0.0106

Appendix 2, Table 3. Site 3, Toboggan Creek upstream of hatchery outflow channel, water quality analysis May 1996-April 1998

mg/L unless stated	Temp. water (°C)	Diss. Oxygen mg/L	Turbidity (JTU)	Field pH	Field Ammonia-N	Field Alkalinity $CaCO_3$	Field CO_2	Lab pH	Ammonia -N	Nitrate+ Nitrite -N	Nitrate -N	Nitrite -N	Nitrogen Diss. Inorg.	Nitrogen Diss. Organic	Nitrogen Total Diss.	Phos-phorus Total	Phos-phorus Diss.	SRP
Date	MDC	0-10	0-200	3.0-10.0	0.2 - 3.0	0-200	0-50		0.001	0.001	0.001		computed	0.001	0.001	0.001	0.001	0.001
16-Apr-96	2.5	12	20	7.7				7.1	0.055	0.342	0.317	0.025	0.371	0.723	1.096	0.031	0.018	
								7.1	0.030	0.364	0.361	0.003	0.391	0.891	1.285		0.021	
28-Apr-96	4.5	11	10	8.0				7.3	0.011	0.417	0.416	0.001	0.427	0.319	0.746	0.009	0.006	
								7.2	0.008	0.417	0.416	0.001	0.424	0.312	0.737	0.010	0.006	
20-May-96	8.0	10	10	7.7					0.004	0.445				0.175	0.624	0.009		
									0.004	0.448				0.186	0.638	0.009		
23-Jun-96	9.8	9	0						0.004	0.067				0.255	0.326	0.007		
									0.005	0.067				0.269	0.341	0.006		
15-Jul-96	9.5	8	0	7.0					0.002		0.036		0.039	0.211	0.250	0.008		
									0.001		0.035		0.037	0.199	0.236	0.010		
3-Sep-96	8.5	9	20						0.003		0.036		0.039	0.075	0.114	0.022		
									0.005		0.036		0.041	0.065	0.106	0.025		
15-Oct-96									0.012		0.029		0.041	0.093	0.134	0.006		
									0.008		0.029		0.036	0.089	0.125	0.007		
2-Apr-97	1.3	11	20	7.0	0.8	50	7											
10-Apr-97	4.3	10	20	7.0	0.6	48	7											
21-Apr-97	5.2	10	20	7.0	0.6	52	3											
30-Apr-97	9.0	10	10	7.0	0.6	38	4											
13-May-97	10.0	11	30	7.0	0.6	40	3		0.006		0.481		0.488			0.035		0.003
									0.007		0.484		0.491			0.032		0.003
28-May-97	8.0	11	10	7.0	0.2	44	3		0.004		0.166		0.170			0.007		0.003
									0.003		0.167		0.170			0.008		0.003
11-Jun-97	9.0	9	20	7.0	0.2		3		0.005		0.072		0.076			0.017		0.004
									0.004		0.071		0.075			0.015		0.004
30-Jun-97	10.2	10	0	6.5 <	0.2	40	4		0.011		0.040		0.051					0.002
									0.016		0.041		0.057			0.006		0.002
2-Nov-97	4.0	11	10	7.0 <	0.2	48			0.006		0.206		0.212			0.010		0.002
									0.007		0.199		0.206			0.009		0.002
16-Dec-97											0.155							
											0.157							
13-Feb-98	1.5	13	10	7.0 <	0.2	40	3		0.047		0.148		0.195			0.009		0.002
									0.048		0.145		0.192			0.009		0.002
19-Mar-98	4.0	11	10	6.5	0.6	64	6		0.157		0.120		0.277					0.029
									0.227		0.122		0.348					0.036
2-Apr-98	5.0	12	0	7.0 <	0.2	60	3		0.139		0.111		0.250			0.032		0.014
									0.141		0.111		0.252			0.028		0.014
Maximum	10.2	13	30	8.0	0.8	64	7	7.3	0.227	0.448	0.484	0.025	0.491	0.891	1.285	0.035	0.021	0.036
Minimum	1.3	8	0	6.5 <	0.2	38	3	7.1	0.001	0.067	0.029	0.001	0.036	0.065	0.106	0.006	0.006	0.002
Average	6.35	10.4	12.2	7.09	0.42	47.6	4.2	7.17	0.0326	0.3207	0.1680	0.0075	0.2059	0.2758	0.4826	0.0144	0.0129	0.0079
St. Dev.	3.07	1.2	8.8	0.40	0.23	8.5	1.7	0.11	0.0566	0.1608	0.1433	0.0117	0.1548	0.2423	0.3808	0.0097	0.0077	0.0106

Appendix 2, Table 4. Site 4, Toboggan Creek upstream of DFO fence, water quality analysis April 1996-April 1998

mg/L unless stated	Temp. water (°C)	Diss. Oxygen	Turbidity JTU	Field pH	Field Ammonia N	Field Alkalinity $CaCO_3$	Field CO_2	Lab pH	Ammonia -N	Nitrate+ Nitrite N	Nitrate -N	Nitrite -N	Nitrogen Diss. Inorg.	Nitrogen Diss. Organic	Nitrogen Total Diss.	Phos-phorus Total	Phos-phorus Diss.	SRP
Date	*MDC*	*0-10*	*0-200*	*3.0-10.0*	*0.2 - 3.0*	*0-200*	0-50	0.1	0.001	0.001	0.001	0.001	computed	0.001	0.001	0.001	0.001	0.001
7-Apr-96	1.5	10	40	8.2				7.2	0.0460	0.2671	0.263	0.0044	0.3087	0.7423	1.0554	0.0589	0.0368	
								7.2	0.046	0.264	0.260	0.005	0.306	0.994	1.304	0.059	0.045	
16-Apr-96	2.5	12	30	7.8				7.3	0.022	0.389	0.386	0.003	0.408	0.875	1.286	0.033	0.020	
								7.3	0.028	0.367	0.363	0.003	0.391	0.861	1.255	0.033	0.020	
28-Apr-96	4.0	11	10	8.1				7.4	0.097	0.368	0.366	0.001	0.463	0.370	0.748	0.012	0.008	
								7.4	0.092	0.370	0.369	0.001	0.461	0.350	0.730	0.013	0.008	
20-May-96	7.0	10	10	7.7					0.005	0.381				0.247	0.633	0.012		
									0.007	0.376				0.220	0.602	0.018		
23-Jun-96	9.8	10	0						0.006	0.060				0.276	0.342	0.010		
									0.007	0.062				0.259	0.328	0.011		
15-Jul-96	9.0	9	0	7.0					0.002		0.035		0.037	0.186	0.223	0.010		
									0.003		0.034		0.037	0.196	0.233	0.012		
3-Sep-96	8.5	10	40						0.005		0.039		0.044	0.088	0.132	0.037		
									0.004		0.039		0.042	0.073	0.115	0.032		
15-Oct-96									0.009		0.025		0.034	0.098	0.132	0.006		
									0.010		0.026		0.036	0.094	0.129	0.006		
2-Apr-97	2.4	11	20	7.0	0.8	60	6											
10-Apr-97	4.3	12	30	6.5	0.6	52	7											
21-Apr-97	3.8	10	20	7.0	0.6	50	7											
30-Apr-97	7.5	10	10	7.0	0.6	58	4											
13-May-97	7.0	12	30	7.0	0.6	40	3		0.009		0.427		0.435			0.042		0.003
									0.009		0.423		0.431			0.039		0.003
28-May-97	8.5	11	10	7.0	< 0.2	40	4		0.006		0.134		0.140			0.011		0.004
									0.007		0.134		0.141			0.011		0.006
11-Jun-97	9.5	10	20	7.0	< 0.2		3		0.007		0.062		0.069			0.015		0.005
									0.008		0.062		0.071			0.015		0.005
30-Jun-97	10.2	10	0	6.5	< 0.2	40	4		0.008		0.039		0.048			0.008		0.002
2-Nov-97									0.009		0.147		0.156			0.012		0.003
									0.010		0.167		0.178					0.002
16-Dec-97									0.166									
									0.160									
13-Feb-98	1.5	12	10	7.0	< 0.2	60	7		0.039		0.163		0.202			0.010		0.003
									0.041		0.160		0.200			0.008		0.003
19-Mar-98	3.0	7	30	7.0	0.6	80	7		0.279		0.210		0.488					0.028
									0.261		0.210		0.470					0.034
2-Apr-98	4.0	8	0	7.0	0.6	72	7		0.068		0.343		0.411			0.039		0.019
									0.086		0.338		0.425			0.041		0.017
Maximum	10.2	12	40	8.2	0.8	80	7	7.4	0.279	0.389	0.427	0.005	0.488	0.994	1.304	0.059	0.045	0.034
Minimum	1.5	7	0	6.5	0.2	40	3	7.2	0.002	0.060	0.025	0.001	0.034	0.073	0.115	0.006	0.008	0.002
Average	5.78	10.3	17.2	7.18	0.47	55.2	5.4	7.31	0.0472	0.2904	0.1935	0.0030	0.2382	0.3705	0.5779	0.0218	0.0230	0.0092
St. Dev.	3.06	1.3	13.6	0.50	0.22	13.7	1.7	0.09	0.0717	0.1290	0.1402	0.0014	0.1737	0.3126	0.4432	0.0160	0.0151	0.0103

Appendix 2, Table 6. Site 5, Toboggan Creek upstream Highway 16 culvert, water quality analysis April 1996-April 1998

mg/L unless stated	Temp. water (°C)	Diss. Oxygen	Turbidity JTU	Field pH	Field Ammonia N	Field Alkalinity $CaCO_3$	Field CO_2	Lab pH	Ammonia -N	Nitrate+ Nitrite -N	Nitrate -N	Nitrite -N	Nitrogen Diss. Inorg.	Nitrogen Diss. Organic	Nitrogen Total Diss.	Phos-phorus Total	Phos-phorus Diss.	SRP
Date	*MDC*	*0-10*	*0-200*	*3.0-10.0*	*0.2 - 3.0*	*0-200*	0-50	0.1	0.001	0.001	0.001	0.001	computed	0.001	0.001	0.001	0.001	0.001
7-Apr-96	1.5	14	50	8.3				7.4	0.038	0.286	0.281	0.005	0.319	0.699	1.023	0.056	0.035	
								7.4	0.041	0.288	0.283	0.005	0.324	0.659	0.988	0.056	0.037	
16-Apr-96	2.5	12	50	8.0				7.5	0.023	0.340	0.336	0.004	0.358	0.860	1.222	0.042	0.021	
								7.4	0.020	0.352	0.348	0.004	0.368	1.056	1.428	0.041	0.025	
28-Apr-96	4.5	11	20	8.3				7.5	0.008	0.350	0.348	0.002	0.356	0.406	0.763	0.016	0.009	
								7.5	0.008	0.330	0.328	0.002	0.336	0.446	0.784	0.017	0.010	
20-May-96	6.5	11	20	7.7					0.006	0.365				0.261	0.631	0.015		
									0.005	0.369				0.274	0.648	0.015		
23-Jun-96	10.0	10	0						0.005	0.065				0.259	0.329	0.014		
									0.006	0.066				0.305	0.377	0.013		
15-Jul-96	9.0	10	10	7.0					0.002		0.039		0.041	0.203	0.244	0.007		
									0.001		0.041		0.042	0.173	0.215	0.012		
3-Sep-96	8.8	10	50						0.005		0.043		0.049	0.065	0.113	0.038		
									0.003		0.043		0.046	0.067	0.113	0.032		
15-Oct-96									0.003		0.035		0.039	0.100	0.138	0.006		
									0.004		0.035		0.039	0.101	0.140	0.006		
2-Apr-97	4.8	11	30	7.0	0.6	60	6											
10-Apr-97	4.1	12	30	7.0	0.6	52	7											
21-Apr-97	3.4	11	20	7.0	0.6	48	5											
13-May-97	6.0	12	30	7.5	0.6	38	3		0.013		0.423		0.437			0.041		0.004
									0.008		0.419		0.428			0.042		0.004
28-May-97	9.0	11	20	7.0	0.2	52	4		0.005		0.138		0.142			0.011		0.003
									0.004		0.139		0.144			0.011		0.003
11-Jun-97	10.0	10	30	7.0 <	0.2		3		0.005		0.069		0.074			0.022		0.006
									0.004		0.070		0.075			0.020		0.006
30-Jun-97	12.0	10	0	6.5 <	0.2	44	12		0.009		0.047		0.056			0.009		0.003
									0.010		0.046		0.057			0.010		0.002
2-Nov-97	4.0	12	10	7.0 <	0.2	44			0.006		0.186		0.192					0.003
									0.007		0.181		0.188					0.003
16-Dec-97											0.201							
											0.204							
13-Feb-98	0.8	13		7.0 <	0.2	64	7		0.026		0.224		0.251			0.008		0.003
									0.026		0.226		0.252			0.009		0.003
19-Mar-98	2.0	8	40	7.0	0.6	78	3		0.130		0.285		0.415					0.027
									0.229		0.286		0.515					0.021
2-Apr-98	4.0	12	0	7.0 <	0.2	72	3		0.050		0.365		0.415			0.040		0.016
									0.051		0.367		0.417			0.039		0.015
Maximum	12.0	14	50	8.3	0.6	78	12	7.5	0.229	0.369	0.423	0.005	0.515	1.056	1.428	0.056	0.037	0.027
Minimum	0.8	8	0	6.5	0.2	38	3	7.4	0.001	0.065	0.035	0.002	0.039	0.065	0.113	0.006	0.009	0.002
Average	5.71	11.1	24.1	7.27	0.38	55.2	5.3	7.45	0.0238	0.2810	0.2013	0.0035	0.2276	0.3709	0.5723	0.0232	0.0227	0.0075
St. Dev.	3.35	1.4	17.0	0.53	0.21	13.0	2.9	0.07	0.0449	0.1171	0.1320	0.0014	0.1593	0.2993	0.4282	0.0160	0.0118	0.0077

Appendix 2, Table 6. Site 6, Glass Creek, water quality analysis April-June 1996

mg/L unless stated	Temp. water (°C)	Diss. Oxygen	Turbidity (JTU)	Field pH	Lab pH	Ammonia -N	Nitrate+ Nitrite -N	Nitrate -N	Nitrite -N	Nitrogen Diss. Organic	Nitrogen Total Diss.	Phos-phorus Total	Phos-phorus Diss.
Date	*MDC*	*0-10*	*0-200*	*3.0-10.0*	0.1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
7-Apr-96	0.5	9	40	9.0	6.9	0.051	0.058	0.055	0.003	0.706	0.815	0.064	0.036
					6.8	0.052	0.059	0.055	0.003	0.685	0.795	0.054	0.035
16-Apr-96	2.0	13	20	8.2	6.8	0.015	0.010	0.007	0.003	1.015	1.041	0.035	0.028
					6.7	0.021	0.008	0.006	0.003	0.820	0.849	0.033	0.029
28-Apr-96	5.0	11	0	8.3	6.9	0.016	0.007	0.007	0.001	0.563	0.586	0.019	0.007
					7.0	0.015	0.007	0.006	0.001	0.650	0.672	0.020	0.008
20-May-96	12.0	8	20	7.3		0.008	0.001			0.470	0.478	0.016	
						0.008	0.001			0.484	0.493	0.015	
23-Jun-96	18.0	7	0			0.011	0.011			0.345	0.368	0.011	
						0.013	0.011			0.345	0.369	0.011	
Maximum	18.0	13	40	9.0	7.0	0.052	0.059	0.055	0.003	1.015	1.041	0.064	0.036
Minimum	0.5	7	0	7.3	6.7	0.008	0.001	0.006	0.001	0.345	0.368	0.011	0.007
Average	4.88	10.3	20.0	8.20	6.85	0.0209	0.0174	0.0227	0.0024	0.6084	0.6467	0.0278	0.0237
St. Dev.	7.35	2.4	16.7	0.70	0.09	0.0164	0.0219	0.0251	0.0011	0.2115	0.2254	0.0185	0.0131

Appendix 2, Table 7. Site 7, Toboggan Creek Hatchery outflow, water quality analysis April 1996

mg/L unless stated	Temp. water (°C)	Diss. Oxygen	Turbidity (JTU)	Field pH	Lab pH	Ammonia -N	Nitrate+ Nitrite N	Nitrate -N	Nitrite -N	Nitrogen Diss. Organic	Nitrogen Total Diss.	Phos-phorus Total	Phos-phorus Diss.
Date	MDC	0-10	0-200	3.0-10.0	0.1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
7-Apr-96	2.0	13.0	20	8.2	7.1	0.113	0.195	0.192	0.003	0.506	0.814	0.055	0.032
					7.1	0.114	0.193	0.189	0.003	0.510	0.817	0.050	0.030
Average	2.0	13.0	20.0	8.2	7.1	0.114	0.194	0.191	0.003	0.508	0.815	0.052	0.031

Appendix 2, Table 8. Site 8, Farm slough (Lot 873 R5C), water quality analysis April 1997-April 1998

mg/L unless stated	Temp. water (°C)	Diss. Oxygen	Turbidity (JTU)	Field pH	Field Ammonia-N	Field Alkalinity $CaCO_3$	Field CO_2	Ammonia -N	Nitrate -N	Phosphorus Total	SRP
Date	*MDC*	*0-10*	*0-200*	*3.0-10.0*	*0.2 - 3.0*	*0-200*	0-50	0.001	0.001	0.001	0.001
3-Apr-97	2.0	8	0	6.5	0.6	50	7				
7-Apr-97	2.6	8		6.0	1.0	44	17				
10-Apr-97	2.2	10	20	6.5	0.8	38					
14-Apr-97		10		6.5	0.6						
21-Apr-97	4.7	10	10	6.8	1	40	7				
30-Apr-97	9.4	8		6.5	1.5	38	13				
1-May-97	6.2	7		6.5	1.5	36	11				
28-May-97	12.0	8		6.5	0.8	52	10				
11-Jun-97	13.0	8	0	7.0	0.2		7	0.017	0.053	0.019	0.003
								0.017	0.053	0.017	0.004
30-Jun-97	10.5	5	0	6.5	0.6	52	16	0.023	0.023	0.033	0.014
								0.033	0.014	0.058	0.034
2-Nov-97	4.0	7	10	6.5	2.0	60		0.060	0.021	0.072	0.052
								0.059	0.019	0.068	0.049
16-Dec-97									0.015		
									0.014		
19-Mar-98	1.0	6	30	6.5	3.0	100	10	2.017	0.351		0.378
								2.307	0.346		0.631
2-Apr-98	3.0	11	0	6.5	0.6	48	7	0.093	0.770	0.079	0.044
								0.106	0.772	0.058	0.048
Maximum	13.0	11	30	7.0	3.0	100	17	2.307	0.772	0.079	0.631
Minimum	1.0	5	0	6.0	0.2	36	7	0.017	0.014	0.017	0.003
Average	5.88	8.2	8.8	6.52	1.09	50.7	10.5	0.4732	0.2041	0.0504	0.1257
St. Dev.	4.25	1.7	11.3	0.22	0.75	18.0	3.8	0.8932	0.2923	0.0244	0.2092

Appendix 2, Table 9. Site 9, Elliot Creek, field water quality analysis April 1997

mg/L unless stated	Temp. water (°C)	Diss. Oxygen	Turbidity (JTU)	Field pH	Field Ammonia-N	Field Alkalinity $CaCO_3$	Field CO_2
Date	*MDC*	*0-10*	*0-200*	*3.0-10.0*	*0.2 - 3.0*	*0-200*	*0-50*
10-Apr-97	4.4	10	0	7.0	<0.2	62	7
21-Apr-97	4.7	9	0	7.0	0.6	80	6

Appendix 2, Table 10. Site 10, Brandt Brook, field water quality analysis April-June 1997

mg/L unless stated	Temp. water (°C)	Diss. Oxygen	Turbidity (JTU)	Field pH	Field Ammonia-N	Field Alkalinity $CaCO_3$	Field CO_2
Date	*MDC*	*0-10*	*0-200*	*3.0-10.0*	*0.2 - 3.0*	*0-200*	*0-50*
3-Apr-97	4.1	12	0	7.5	<0.2	144	6
21-Apr-97	6.0	11	0	7.0	<0.2	112	10
30-Apr-97	10.6	10	0	7.0	<0.2	120	7
28-May-97	10.0		0	7.0	<0.2	140	5
11-Jun-97	11.0	10	0	7.0	<0.2		6

Appendix 2 Table 11. Toboggan Creek and Reiseter Creek water quality analysis 1996-1997

			Site 2, Toboggan @ Evelyn Stn. Rd		Site 4, Toboggan @ DFO assessment fence		Reiseter @ High Road	
Sampling date	Unit	MDC	25-Jul-96	10-Sep-96	25-Jul-96	11-Sep-96	30-Jul-96	11-Sep-96
Temperature water	°C		13.3	10.2	13.9	10.3	9.7	7.9
Dissolved Oxygen	mg/L	0.1	8.4	9.4	8.3	10.5	9.8	11.0
Field pH	pH units	0.1						
Lab pH	pH units	0.1	7.2	7.3	7.5	7.4	7.9	7.9
Specific Conductance	uS/cm	1	50	59	59	73	83	118
Residue Nonfilterable (TSS)	mg/L	4	15	< 4	16	9	5	10
Turbidity	NTU	1	6.69	2.49	5.11	3.51	4.70	0.89
Ammonia-N	mg/L	0.005	0.006	< 0.005	0.009	0.011	< 0.005	< 0.005
Nitrate + Nitrite-N	mg/L	0.02	0.055	0.035	0.035	0.055	0.025	0.035
Nitrite-N	mg/L	0.005	< 0.005	< 0.005	< 0.005	0.005	< 0.005	< 0.005
Nitrate-N	mg/L	0.02	0.05	0.03	0.03	0.05	< 0.02	0.03
Nitrogen Dissolved Inorganic	mg/L	computed	0.056	0.035	0.039	0.061	0.025	0.035
SRP	mg/L	0.001	< 0.003	0.005	< 0.003	0.005	0.004	< 0.003
Phosphorus - Total	mg/L	0.003	0.014	0.009	0.015	0.009	0.007	< 0.003
Fecal Coliform	QT MPN	1	80	4	36	16	12	20
Fecal Streptococcus	CFU/0.1L	1	130	72	14	124	4	152

			Site 2, Toboggan @ Evelyn Stn. Rd.	Site 4, Toboggan @ DFO assessment fence	Reiseter @ High Road
Sampling date	Unit	MDC	18-Sep-97	22-Sep-97	17-Sep-97
Temperature water	°C		8.8	8.5	8.8
Dissolved Oxygen	mg/L	0.1	9.7	10.4	10.6
Field pH	pH units	0.1	7.6	7.7	8.1
Lab pH	pH units	0.1	7.3	7.7	8.0
Specific Conductance	uS/cm	1	64	74	105
Residue Nonfilterable (TSS)	mg/L	4	< 4	4	< 4
Ammonia-N	mg/L	0.005	< 0.005	0.009	0.007
Nitrate + Nitrite-N	mg/L	0.02	< 0.02	< 0.02	0.1
Nitrite-N	mg/L	0.005	< 0.005	0.007	0.075
Nitrate-N	mg/L	0.02	< 0.02	< 0.02	0.03
Nitrogen Dissolved Inorganic	mg/L	computed	< 0.025	0.029	0.037
SRP	mg/L	0.001	0.005	0.006	0.010**
Phosphorus - Total	mg/L	0.003	0.008	0.009	0.009**
Fecal Coliform	QT MPN	1	13	2420	23**
Fecal Streptococcus	CFU/0.1L	1	156	70	<1**

Source Remington 1997; 1998.

**Phosphorus and bacteriology resampled 2-Oct-97 because of sample contamination at lab.
Water samples were turbid on that date due to 2 1/2 " rain in preceeding 3 days.

Appendix 2 Table 12. Toboggan and Reiseter creeks periphyton biomass (as chlorophyll *a*) at end of growing season 1996 and 1997

mg/m^2 Chlorophyll *a*	Site 2 Toboggan @ Evelyn Stn. Rd. 10-Sep-96	Site 4 Toboggan @ DFO assessment fence 11-Sep-96	Reiseter @ High Road 11-Sep-96
Rep 1	14.5	11.9	1.9
Rep 2	5.8	70.1	2.2
Rep 3	7.1	108.0	3.1
Rep 4	2.8	12.6	1.7
Rep 5	11.7	56.5	2.3
Rep 6	26.4	18.5	1.6
Mean	**11.4**	**46.3**	**2.1**
mg/m^2 Chlorophyll *a*	Site 2 Toboggan @ Evelyn Stn. Rd. 18-Sep-97	Site 4 Toboggan @ DFO assessment fence 22-Sep-97	Reiseter @ High Road 17-Sep-97
Rep 1	4.1	72.8	23.3
Rep 2	142.0	34.8	22.6
Rep 3	18.8	88.4	9.5
Rep 4	13.9	49.3	9.7
Rep 5	10.9	126.0	7.4
Rep 6	12.1	lost sample	9.5
Mean	**33.6**	**74.3**	**13.7**

Appendix 2 Table 13. Periphyton taxonomic composition Toboggan and Reiseter creeks 1996 & 1997

Site 2 Toboggan Creek @ Evelyn 10-Sep-96

Chlorophyta	0.5 %
Cladophora sp.	100 %
Chrysophyta	99.5 %
Bacillariophyceae	
Synedra ulna	20 %
Achnanthes spp.	20 %
Cymbella caespitosa	10 %
Gomphonema spp.	10 %
Surirella angustata	10 %
Fragilaria spp.	20 %
Epithemia sorex	10 %

* Large amount of inorganic sediment present in sample.

Site 2 Toboggan Creek @ Evelyn 18-Sep-97

Chrysophyta	100 %
Bacillariophyceae	
Synedra ulna	60 %
Gomphonema sp.	20 %
Cymbella sp.	10 %
Tabellaria fenestrata	10 %

* Inorganic sediment present

Site 4 Toboggan Creek @ fence 11-Sep-96

Chlorophyta	25 %
Cosmarium sp.	2 %
Spirogyra sp.	98 %
Chrysophyta	75 %
Bacillariophyceae	
Fragilaria spp.	6 %
Gomphonema geminatum	70 %
Cymbella spp.	10 %
Achnanthes spp.	7 %
Gomphonema spp.	5 %
Stauroneis phoenicentron	2 %

* Algal mats composed of Spirogyra sp.
and Gomphonema geminatum on stalks.
Large amount of inorganic sediment present.

Site 4 Toboggan Creek @ fence 22-Sep-97

Cyanophyta	5 %
Oscillatoria sp.	100 %
Chrysophyta	95 %
Bacillariophyceae	
Gomphonema geminatum	55 %
Synedra ulna	20 %
Achnanthes sp.	10 %
Cymbella sp.	15 %

* Algal mat:
Gomphonema geminatum on stalks
Spirogyra sp.
Ulothrix sp.
Oscillatoria sp.

Reiseter Creek @ High Road 11-Sep-96

Chrysophyta	100 %
Bacillariophyceae	
Gomphonema geminatum	30 %
Synedra ulna	10 %
Hannaea arcus	10 %
Achnanthes spp.	20 %
Gomphonema spp.	20 %
Fragilaria spp.	10 %

Reiseter Creek @ High Road 17-Sep-97

Chrysophyta	100 %
Bacillariophyceae	
Synedra ulna	20 %
Gomphonema geminatum	20 %
Gomphonema sp.	20 %
Cymbella sp.	15 %
Diatoma tenue v. elongatum	10 %
Cocconeis placentula	5 %
Hannaea arcus	5 %

* Algal Clumps: Gomphonema geminatum on stalks

Appendix 3. Toboggan Creek salmonid histological summaries by site and detailed histology reports

Fisheries and Oceans | Pêches et Océans

MEMORANDUM NOTE DE SERVICE

To / A: Brenda Donas

From / De: Dorothee Kieser

Security Classification - Classification de sécurité	
Our file - Notre référence	5500-7
Your File - Votré référence	
Date	December 16, 1996

Subject / Object: Health Check of Stocks in the Toboggan Creek Area

Attached is a complete summary of results of all samples you collected from Toboggan Creek and near-by streams. This report adds the September and October results to the earlier outline. You will notice that in general the samples submitted for the two recent months show fewer histological abnormalities in all groups than the earlier samples (with the exception of the coho sampled at the fence). Again I must emphasize that we received very small sample sizes from each group which leaves room for questions whether these samples are representative of the population of fish in a particular section of the creek. In total, however, some trends based on the histological evaluation seem to appear: 1) fish collected later in the season are in better shape than fish collected in June and July, and, 2) fish from some areas, particularly the hatchery and CNR bridge area, appear to show more abnormalities than fish from other collection sites.

Regarding your memo of October 7/96, we would likely be prepared to continue sampling fish from this and other projects. However, it may become a funding issue and we would have to recover our costs, especially if an intensive sampling program were proposed.

Let me know if you have any questions on this.

Happy holiday season,

Dorothee

Canada

Fisheries and Oceans
Pêches et Océans

Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, B.C. V9R 5K6

July 11, 1996

Brenda Donas
Community Advisor
Department of Fisheries and Oceans
Box 578
Smithers, B.C. V0J 2N0

Dear Brenda:

Subject: Toboggan Creek Samples

Attached are the individual histology reports for the samples submitted to date from the Toboggan Creek study. As well I have summarized the results in a table for ease of comparison. Please note that it is important to look at the individual reports for details of the histological analysis. The table just provides an indication that there is a tissue abnormality.

What emerges in a confused picture. With the possible exception of Benjamin dugout, where all groups examined show some kidney damage and most groups have abnormalities in the liver, no consistent type of damage is apparent. For example all samples collected at the railway bridge in May appear normal, while the samples collected in June show distinct gill and liver abnormalities. At the hatchery, coho sampled in both May and June show necrotic cells in the kidney, but only the June sample has damaged gills. Rainbows sampled at the hatchery appear normal in the May sample, but show some abnormality in both liver and kidney in June. Part of the difficulty in interpretation arises from the small sample size available for each entry. Other factors may be the age of the fish and fish species which could influence susceptibility to the "agent" causing the observed changes.

Further samples may help in interpreting the results.

Sincerely yours,

Dorothee Kieser
Fish Pathologist

cc. J. Bagshaw

Canada

Upper Glass Creek

May: no sample

June: cutthroat
underyrl (96-144)
2 fish
normal

Elliot Creek near Railway

Feb 97: DV

fry (97-29)

1 fish

Gill: mod. lamellar hyperplasia and epitheliocystis infection

otherwise normal

Toboggan @ CNR (Railway Bridge)

May:	coho (96-106) 1 fish normal	Dolly Varden fry (96-107) 1 fish normal	Rainbow yrl (96-102) 1 fish gill: Dermocystidium parasite
June:	coho fry (96-141) 1 fish gill: hyperplasia liver: degenerative changes kidney (blood vessel): necrotic cells		
	coho underyrl (96-140) 2 fish gill: hyperplasia liver: severe degenerative changes kidney: occ. necrotic cells nares: very necrotic areas		
Sept:	coho underyrl (96-189) 1 fish No pathology seen	coho underyrl (96-187) 1 fish post-mortem changes	coho adv. fry (96-188) 7 fish kidney (head): occ. necr. cell stomach: contains sac-fry
Oct:	coho fry (996-227) 4 fish generally normal	coho underylg (96-225) 4 fish generally normal	RBT underylg 1 fish gen. normal
	coho yrl (96-223) 1 fish gen. normal		

Toboggan @ Evelyn

May: coho
Adv. fry (96-101)
kidney: necrotic cells
liver: necrotic cells

June: coho
fry (96-138)
7 fish
gill: severe sloughing and oedema
kidney (head): occ. necrotic cells

July: coho
underyrl (96-157)
8 fish
generally normal tissues

Sept.: coho
adv. fry (96-193)
3 fish
kidney(head): occ. necrotic cell

coho
underyrl (96-190)
6 fish
generally normal

Oct: coho
adv. fry 996-228)
7 fish
generally normal

RBT
underylg (96-226)
1 fish
generally normal

Feb/97 RBT
fry (97-26)
1 fish
liver: sm focus of infl. cells

Toboggan @ Hatchery

May:	coho adv. fry (96-104) 4 fish kidney: occ. necrotic cell	rainbow fry (96-103) 1 fish normal	
June:	coho adv. fry (96-142) 3 fish gill: lamellar hyperplasia liver: incr. cell activity & necr. kidney: occ. necrotic cell	rainbow yrl (96-139) 1 fish liver: increased. cell activity kidney: occ. necrotic cell	
July:	coho underyrl (96-156) 9 fish gill: lamellar hyperplasia. Necrotic cells in filaments and in epithelium of nares. Kidney: frequent necrotic cells. (anterior end)	coho (labelled TC @ hatchery) underyrl (96-158) 4 fish gill: necrotic cells head kid: necr. cells and numerous mitotic figures liver: necrotic cells nares: necrotic cells	
Sept:	coho adv. fry (96-194) 5 fish gill: 1 fish only sl. lamellar hyperplasia	coho ylg (96-191) 4 fish no pathology	RBT ylg (96-192) 1 fish kidney (head) frequent necrotic cells
Oct:	coho fry (96-229) 8 fish gills: 50% of fish with sl lam. hyperplasia	coho underylg (96-224) 1 fish generally normal	DV im. adult (96-222) 1 fish generally normal
Feb 97:	coho ygl (97-28) 2 fish generally normal	RBT ylg (97-27) 3 fish generally normal	

Toboggan @ Fence

May: no samples

June: coho
smolt (96-136)
1 fish
normal

coho (labelled TC @ fence)
smolt (96-143)
1 fish
kidney: occ. necr. cell

Sept: coho
undervlg (96-186)
2 fish
kidney (head): frequent necrotic cells
stomach: frequent necrotic cells in mucosal layer

Toboggan @ Dugout (Benjamin Dugout)

May: Coho
age? (96-105)
5 fish
Liver: frequent necrotic cells
Kidney: Frequent necrotic cells

Dolly Varden
yrl (96-100)
2 fish
Liver: necrotic cells
kidney: necrotic cells

June: coho
fry (96-137)
3 fish
gill: massive hyperplasia and sloughing
liver: active
kidney: occ. necrotic cells

coho
yrl (96-134)
2 fish
kidney (head): occ. necrotic cells

September: No sample
October: No sample

PACIFIC BIOLOGICAL STATION
HISTORICAL SERVICES
PATHOLOGY REPORT

Urgent ☐ Routine ☑ Hold ☐ Hist. # H96-167

Date Required ________ Date June 24/96

Contributor Diagnostics Contributor's # 96-144

Source Upper Glass Cr.

Species Cutthroat Sex ________ Age underylg.

Tissues Submitted 2 whole fish

Reason for Submission ongoing study of environmental effects

GROSS DESCRIPTION

Microscopic Examination

Sections of gill liver and kidney show essentially normal tissue structure.

DIAGNOSIS

J. Bagshaw (Histologist)

Pacific Biological Station
Historical Services
Pathology Report

Urgent ☒ Routine ☐ Hold ☐

Hist. # H96-134

Date Required ASAP

Date May 22, 1996

Contributor Diagnostics

Contributor's # 96-107

Source [illegible]

Species Dolly Varden

Sex

Age fry

Tissues Submitted whole

Reason for Submission Pollution investigation - HC

Gross Description

Microscopic Examination

Sections show essentially normal tissues.

Diagnosis

J. Bagshaw (Histologist)

PACIFIC BIOLOGICAL STATION
HISTORICAL SERVICES
PATHOLOGY REPORT

Urgent ☒ Routine ☐ Hold ☐ Hist. # H96-133

Date Required ASAP Date May 22 '96

Contributor Diagnostics Contributor's # 96-106

Source Toboggan Cr. @ CNE bridge

Species Coho Sex ____ Age ____

Tissues Submitted Whole

Reason for Submission pollution investigation - HC

GROSS DESCRIPTION

Microscopic Examination

Sections reveal essentially normal tissue structures.

DIAGNOSIS

J. Bagshaw (Histologist)

Pacific Biological Station
Historical Services
Pathology Report

Urgent ☒ Routine ☐ Hold ☐ Hist. # H96-179

Date Required ASAP Date May 22 '96

Contributor Diagnostics Contributor's # 96/03

Source Tokaggan L. @ CNR bridge

Species Rainbow Sex ______ Age yearling

Tissues Submitted Whole

Reason for Submission pollution investigation - HC

Gross Description

Microscopic Examination

Gill sections show ~~[illegible]~~ generally normal structures however a large cystic structure involving 4 filaments can be seen & in one area & appears to contain zoospores of an unknown species (dermocystidium)
Other tissues appear essentially normal

Diagnosis

J. Bagshaw (Histologist)

Pacific Biological Station
Historical Services
Pathology Report

Urgent ☐ Routine ☑ Hold ☐ Hist. # H96-164

Date Required ______ Date June 24/96

Contributor Diagnostics Contributor's # 96-141

Source Toboggan Cr. at Railroad bridge

Species coho Sex ______ Age fry

Tissues Submitted 1 whole fish

Reason for Submission ongoing study of environmental effects

Gross Description

Microscopic Examination

Sections of gill show severe hyperplasia of the lamellar epithelium and some oedema.

Liver sections show degenerative changes including nuclear pleomorphism uneven vacuolation and very indistinct cytoplasmic detail.

Sections of kidney show occasional necrotic cells of the endothelial surface of the blood vessels.

Diagnosis

J Bagshaw

J. Bagshaw (Histologist)

PACIFIC BIOLOGICAL STATION
HISTORICAL SERVICES
PATHOLOGY REPORT

Urgent ☐ Routine ☑ Hold ☐ Hist. # H96-163

Date Required ______ Date June 24/96

Contributor Diagnostics Contributor's # 96-140

Source Toboggan Cr. @ Railroad bridge

Species Coho Sex ______ Age under yr.

Tissues Submitted 2 whole fish

Reason for Submission ongoing study of environmental effects

GROSS DESCRIPTION

Microscopic Examination

Sections of gill show moderate hyperplasia of the lamellar epithelium, some myxobacteria can be seen.

Sections of kidney show occasional necrotic cells.

Sections of liver show severe degenerative changes - nuclear pyknosis and swelling with a loss of staining reaction very basophilic cytoplasms and necrotic cells.

The epithelium within the nares (sinuses) is

DIAGNOSIS very necrotic - no organisms can be seen.

J. Bagshaw (Histologist)

Pacific Biological Station
Historical Services
Pathology Report

Urgent ☑ Routine ☐ Hold ☐

Hist. # H96-128

Date Required ASAP

Date May 22 '96

Contributor Diagnostics

Contributor's # 96/01

Source Toboggan Cr @ Evelyn

Species Coho

Sex

Age Smolt

Tissues Submitted Whole

Reason for Submission pollution investigation - HC

Gross Description

Microscopic Examination

Gill sections normal - Gut fine

Liver shows degenerative changes + necrotic foci

Head Kidney - frequent necrotic cells

Diagnosis

J Bagshaw (Histologist)

PACIFIC BIOLOGICAL STATION
HISTORICAL SERVICES
PATHOLOGY REPORT

Urgent ☐ Routine ☑ Hold ☐ Hist. # H96-161

Date Required ______ Date June 24/96

Contributor Diagnostics Contributor's # 96-138

Source Toboggan @ Evelyn

Species Coho Sex ______ Age fry

Tissues Submitted 7 whole fish

Reason for Submission ongoing study of environmental effects

GROSS DESCRIPTION

Microscopic Examination

Sections of gill show severe lamellar sloughing and oedema.

~~Liver sections are to be sent in this sample.~~ Liver sections are essentially normal.

Head kidney shows occasional necrotic cells.

DIAGNOSIS

J. Bagshaw (Histologist)

Pacific Biological Station
Historical Services
Pathology Report

Urgent ☒ Routine ☐ Hold ☐ Hist. # H96-131

Date Required ASAP Date May 22'96

Contributor Diagnostics Contributor's # 96-104

Source Tobaggan Cr. @ Hatchery

Species Coho Sex ______ Age Juv. fry

Tissues Submitted whole (4)

Reason for Submission pollution investigation - NC

Gross Description

Microscopic Examination

Gills are normal. Occasional necrotic cells found in kidney interstitium. Large fibrotic area in peritoneal cavity suggestive of ricketsial infection.

Diagnosis

J. Bagshaw (Histologist)

PACIFIC BIOLOGICAL STATION
HISTORICAL SERVICES
PATHOLOGY REPORT

Urgent ☒ Routine ☐ Hold ☐ Hist. # H96-130

Date Required ASAP Date May 22 '96

Contributor Diagnostics Contributor's # 96 105

Source Tobaggan C. @ Hatchery

Species Rainbow Sex [illegible] Age 6+1

Tissues Submitted Whole

Reason for Submission pollution investigation - HC

GROSS DESCRIPTION

Microscopic Examination

No pathological changes

DIAGNOSIS

J. Bagshaw (Histologist)

Pacific Biological Station
Historical Services
Pathology Report

Urgent ☐ Routine ☑ Hold ☐ Hist. # H96-165

Date Required ______ Date June 24/96

Contributor Diagnostics Contributor's # 96-142

Source Toboggan Cr. @ Hatchery

Species coho Sex ______ Age adu. fry

Tissues Submitted 3 whole fish

Reason for Submission ongoing study of environmental effects

Gross Description

Microscopic Examination

Sections of gill show a mild degree of lamellar hyperplasia – no organisms can be seen.

Liver sections show indications of increased cellular activity suggested by the striated basophilia in the hepatic cytoplasm (possibly a detoxifying activity) – no cellular damage can be seen in two of the fish however the third shows frequent pyknotic nuclei and some frank necrosis.

Occasional necrotic cells are seen in the kidney interstitium.

Diagnosis

J. Bagshaw (Histologist)

Pacific Biological Station
Historical Services
Pathology Report

Urgent ☐ Routine ☑ Hold ☐ Hist. # H96-162

Date Required ________ Date June 24

Contributor Diagnostics Contributor's # 96-139

Source Toboggan Cr. @ Hatchery

Species RBT Sex ______ Age ylg.

Tissues Submitted 1 whole fish

Reason for Submission ongoing study of environmental effects

Gross Description

Microscopic Examination

Sections of gill show normal structure. Liver sections show essentially normal architecture and nuclear structure, however there are eosinophilic granular change in the cytoplasm of many hepatocytes - no organisms can be seen.

Sections of kidney show occasional necrotic cells.

Diagnosis

Bagshaw (Histologist)

Pacific Biological Station
Historical Services
Pathology Report

Urgent ☐ Routine ☑ Hold ☐ Hist. # H96-159

Date Required ________________ Date June 24/96

Contributor Diagnostics Contributor's # 96-136

Source Toboggan Cr. @ Fence

Species Coho Sex ________ Age Smolt

Tissues Submitted 1 whole fish

Reason for Submission ongoing study of environmental effects

Gross Description

Microscopic Examination

Sections of gill show some normal areas and a small degree of hyperplasia.
Liver sections appear normal.
Head kidney shows occasional necrotic cells.

Diagnosis

J. Bagshaw (Histologist)

PACIFIC BIOLOGICAL STATION
HISTORICAL SERVICES
PATHOLOGY REPORT

Urgent ☐ Routine ☑ Hold ☐ Hist. # H96-166

Date Required ______ Date June 24/96

Contributor Diagnostics Contributor's # 96-143

Source TC @ Fence

Species Coho Sex ______ Age smolt

Tissues Submitted 1 whole fish

Reason for Submission ongoing study of environmental effects

GROSS DESCRIPTION

Microscopic Examination

Sections of gill liver and kidney show essentially normal tissue structures.

DIAGNOSIS

J. Bagshaw (Histologist)

PACIFIC BIOLOGICAL STATION
HISTORICAL SERVICES
PATHOLOGY REPORT

Urgent ☒ Routine ☐ Hold ☐ Hist. # H96-132

Date Required ASAP Date May 22 '96

Contributor Diagnostics Contributor's # 96-105

Source Toboggan Cr (Dugout)

Species Coho Sex ______ Age ______

Tissues Submitted Whole (5)

Reason for Submission Pollution investigation - HC

GROSS DESCRIPTION

Microscopic Examination

Frequent necrotic cells in liver, vacuolation - suggestive of toxic insult
Kidney - occasional necrotic cells
Gills are essentially normal
* Frequent necrotic cells in head kidney

DIAGNOSIS

J. Bagshaw (Histologist)

Pacific Biological Station
Historical Services
Pathology Report

Urgent ☑ Routine ☐ Hold ☐ Hist. # H96-127

Date Required ASAP Date May 22 '96

Contributor Diagnostics Contributor's # 96100

Source Tobossan Cr. dugout.

Species Dolly Varden Sex _____ Age _____

Tissues Submitted whole. (2)

Reason for Submission pollution investigation - HC

Gross Description

Microscopic Examination

Sections of gill show essentially normal structure.

Liver and kidney sections show frequent necrotic cells.

Diagnosis

J. Bagshaw (Histologist)

PACIFIC BIOLOGICAL STATION
HISTORICAL SERVICES
PATHOLOGY REPORT

Urgent ☐ Routine ☑ Hold ☐ Hist. # H96-158

Date Required ____________ Date June 24

Contributor Diagnostics Contributor's # 96-134

Source Benjamin Dugout

Species coho Sex ______ Age ylg.

Tissues Submitted 2 whole fish

Reason for Submission ongoing study of environmental effects

GROSS DESCRIPTION

Microscopic Examination

Occasional necrotic cells in the head kidney. Gills essentially normal. Other tissues unremarkable.

DIAGNOSIS

J. Bagshaw (signature)

J. Bagshaw (Histologist)

Pacific Biological Station
Historical Services
Pathology Report

Urgent ☐ Routine ☑ Hold ☐ Hist. # H96-160

Date Required ______ Date June 24/96

Contributor Diagnostics Contributor's # 96-137

Source Benjamin Dugout

Species Coho Sex ______ Age fry

Tissues Submitted 3 whole fish

Reason for Submission ongoing study of environmental effects

Gross Description

Microscopic Examination

Sections of gill show massive hyperplasia and sloughing of the lamellar epithelium, many aberrations chambers can be seen in the lamellae coupled with necrotic cells.

Sections of liver show essentially normal structure, however there are basophilic striae in the hepatic cytoplasm suggestive of increased activity (? detoxification)

Sections of head kidney show occasional necrotic cells.

Diagnosis

J. Bagshaw (Histologist)

Appendix 4. Water Use Licenses in the Tobbogan Creek watershed

Source	License No.	Year Issued	Quantity[1]	Use	Licensee	Address
Toboggan Creek	C055912	1980	2.00 CS	Ponds	Butz, T.J. & L.C.	Box 783 Smithers, BC,V0J 2NO
	C040409	1970	1000.00 GD	Domestic	Landrock, K.S. & K.A.	RR1 C9 S23 Smithers, BC,V0J 2NO
	C068089	1989	40.00 AF	Irrigation	Hopps, T & L.R.	RR1 C1 S23 Smithers, BC,V0J 2NO
	F038718	1965	500.00 GD	Domestic	Collingwood Sales Ltd.	Box 2408 Smithers, BC,V0J 2NO
	C060179	1983	3000.00 GD	Domestic	Evelyn Mountain View Farms Ltd.	RR1 Smithers, BC,V0J 2NO
	F041164	1965	2500.00 GD	Domestic	Reitsma, J. & S.	Box 754 Smithers, BC,V0J 2NO
			150.00 AF	Irrigation		
	F041164	1965	2500.00 GD	Domestic	Reitsma, J. & S.	Box 754 Smithers, BC,V0J 2NO
			150.00 AF	Irrigation		
	C031864	1966	1000 GD	Domestic	Benjamin, R.M. & B.A.	RR1 Smithers, BC,V0J 2NO
			30.00 AF	Irrigation		
	F020874	1966	500.00 GD	Domestic	Lychak, P.	RR1 Smithers, BC,V0J 2NO
	C058964	1981	500.00 GD	Domestic	Currie. R. B.	Box 853 Smithers, BC,V0J 2NO
			23.00 AF	Irrigation		
	F112281	1984	2.00 CS	Fish Culture	Toboggan Creek Salmon and Steelhead Enhancement Society	RR1 C23 S25 Smithers, BC,V0J 2NO
	F020452	1964	500.00 GD	Domestic	Headley, E.F.	RR1 C24 S25 Smithers, BC,V0J 2NO
Owens Creek	Z110315	1995	98.00 AF	Irrigation	Huisman, O.	RR1 C7 S25 Smithers, BC,V0J 2NO
	F010352	1929	1000.00 GD	Domestic	Van Alphen, K.J.	Box 3814 Smithers, BC,V0J 2NO
			50.00 AF	Irrigation		
	F010351	1929	500.00 GD	Domestic	Mott, D.C. & J.A.	RR1 C21 S25 Smithers, BC,V0J 2NO
			50.00 AF	Irrigation		
	F010351	1929	500.00 GD	Domestic	Mott, D.C. & J.A.	RR1 C21 S25 Smithers, BC,V0J 2NO
			50.00 AF	Irrigation		
Huisman Brook	C047325	1974	1500.00 GD	Domestic	Huisman, O.	RR1 C7 S25 Smithers, BC,V0J 2NO
Feeney Brook	C038402	1971	1000.00 GD	Domestic	Glass, D.G. & J.	Box 2042 Smithers, BC,V0J 2NO
	C107668	1970	500.00 GD	Domestic	Raufer, H. & G.	RR1 Raufer Rd, C6 S25

[1] CS indicates cubic feet per second
GD indicates gallons per day
AF indicates acre-foot

Appendix 4 (continued). Water Use Licenses in the Tobbogan Creek watershed

Source	License No.	Year Issued	Quantity[1]	Use	Licensee	Address
Brandt Brook	F112281	1984	2.00 CS	Fish Culture	Toboggan Creek Salmon and Steelhead Enhancement Society	RR1 C23 S25 Smithers, BC,V0J 2NO
	C106091	1993	500.00 GD	Domestic	Klassen, D. & J.D.	Box 20113 Smithers, BC,V0J 2NO
	C054813	1979	500.00 GD	Domestic	Mettler, M. J.	Box 3716 Smithers, BC,V0J 2NO
	C029303	1963	500.00 GD	Domestic	Greengrass, P.C. & C.V.	RR1 C32 S25 Smithers, BC,V0J 2NO
	C040897	1972	500.00 GD	Domestic	McKay M.K. & L.J.	RR1 Dunlop Street, C27 S25 Smithers, BC,V0J 2NO
	C051408	1977	500.00 GD	Domestic	Corneau,R.	Box 3793 Smithers, BC,V0J 2NO
	C058119	1981	500.00 GD	Domestic	Mager, J.C. & T.A.	Box 3822 Smithers, BC,V0J 2NO
	C058120	1981	500.00 GD	Domestic	Boomsma, R.M. & E.A.	RR1 C39 S25 Smithers, BC,V0J 2NO
	C110539	1995	500.00 GD	Domestic	Duguay, J.	RR1 C27 S25 Smithers, BC,V0J 2NO
Hobbs Brook	C057172	1966	1500.00 GD	Domestic	Veenstra, J. & S.	RR1 C22 S25 Smithers, BC,V0J 2NO
	C057172	1966	1500.00 GD	Domestic	Veenstra, J. & S.	RR1 C22 S25 Smithers, BC,V0J 2NO
	C058963	1981	0.00 TF	Ponds	Veenstra, J. & S.	RR1 C22 S25 Smithers, BC,V0J 2NO
Elliot Creek	C110079	1970	500.00 GD	Domestic	Lychak, D.P. & J.	Box 621 Smithers, BC,V0J 2NO
	C110080	1970	1000.00 GD 80.00 AF	Stock Watering Irrigation	Lychak Enterprises Ltd.	Box 621 Smithers, BC,V0J 2NO
	C106257	1993	500.00 GD 9.90 AF	Domestic Irrigation	Glass, D.G. & J.	Box 2042 Smithers, BC,V0J 2NO
Glacier Gulch	C068043	1988	12.00 CS	Land Improvement	Bulkley-Nechako Regional District	Box 820 Burns Lake, BC V0J 1E0
Glass Creek	C104619	1971	1000.00 GD	Domestic	Storeys Ranch Ltd.	RR1 Smithers, BC,V0J 2NO
	C104331	1992	70.00 AF	Irrigation	Storeys Ranch Ltd.	RR1 Smithers, BC,V0J 2NO
	F040688	1968	1000.00 GD	Domestic	Horlings, A. & L.	RR2 C8 S43 Smithers, BC,V0J 2NO
	C062049	1985	500.00 GD	Domestic	Van Der Meulen, E. & A.	RR1 C37 S27 Smithers, BC,V0J 2NO
	C047203	1973	500.00 GD	Domestic	Nordings, W.F.	Box 2732 Smithers, BC,V0J 2NO
	C111915	1996	500.00 GD	Domestic	Edie, A. G. & Taugher, J.A.	RR1 C13 S27 Smithers, BC,V0J 2NO

Source: MELP Water Management, Smithers

[1] CS indicates cubic feet per second
GD indicates gallons per day
AF indicates acre-foot

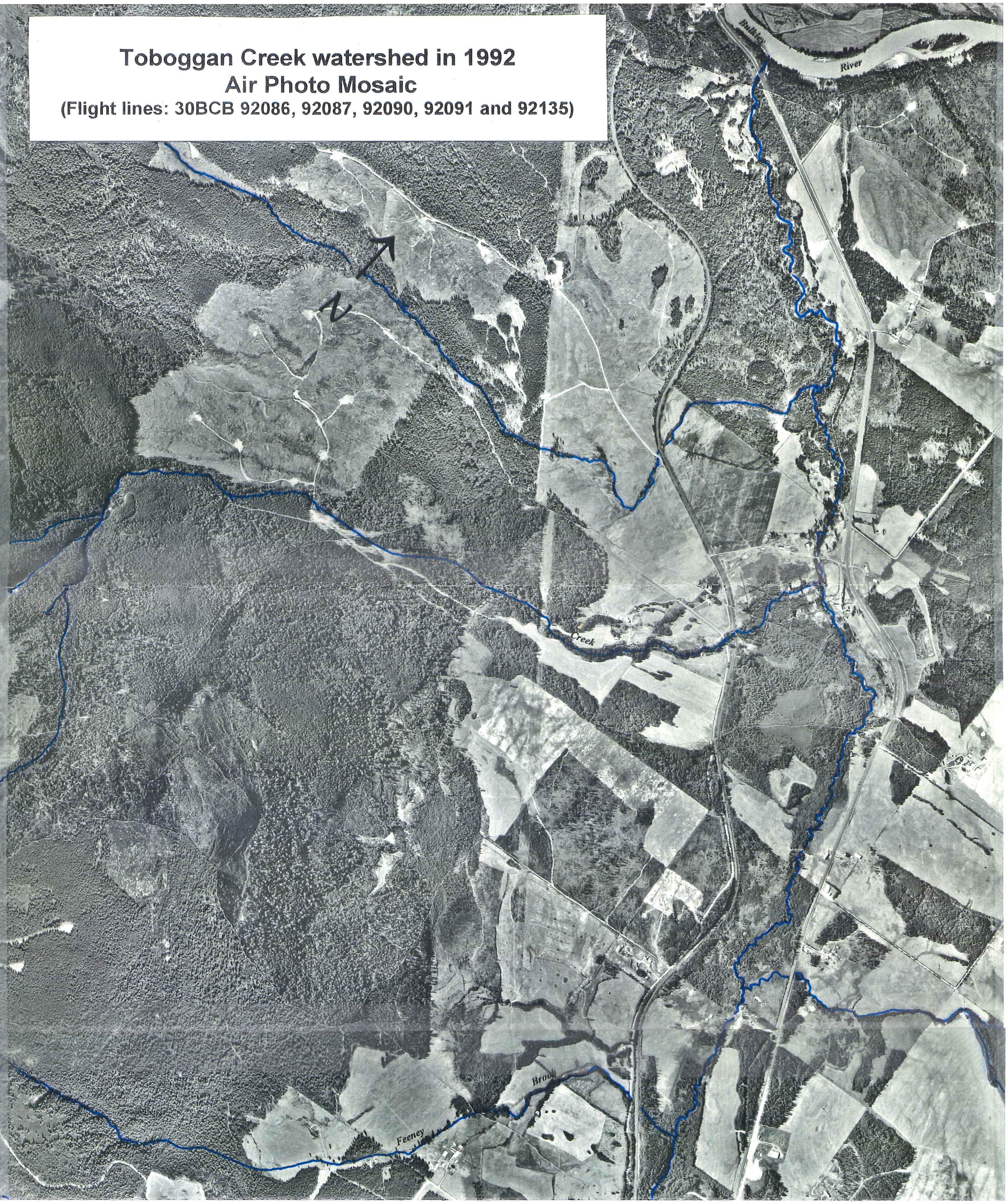
Appendix 5. Text comments and site notes from Reconnaissance Level Fish and Fish Habitat Inventory in the Bulkley T.S.A. (Working Unit #14 - Toboggan)

DFO/MELP Stream Survey Form Site Number[1]	Site Name	Comments
Text comments	Toboggan Creek	Toboggan Creek and Kathlyn Creek systems are quite productive for fish, in spite of the impacts of intensive human development surrounding these watersheds. A water quality monitoring program is strongly recommended for these systems, as they provide crucial habitat for Pacific Salmon species.
Y73	Trib to Toboggan Cr.	Even at higher flows this stream would have only limited rearing habitat of deep runs and polls. The stream is logged right down to the banks. Future sampling at high flows is recommended.
Y76	Trib to Toboggan Cr.	This could be a very significant salmon spawning/rearing stream with some habitat restoration. At present, cattle have free run of the stream bed. The sampled area flows through a large pasture in which the riparian cover has been removed. This site lacks habitat complexity.
W233	Trib to Toboggan Cr.	Upstream of the Hwy 16 crossing, a large slough was dug by the land owner. Downstream of the highway a maze of beaver dams extends for 100 meters, creating a large flooded area. Coho were caught at the highway, so with the entire area being flooded, the whole area is at least a fisheries sensitive zone.
Z63	Elliot Cr.	A large gravel pit was noted on the right bank of Elliot Creek in reach 2. No sedimentation problems were noted but periodic monitoring of this pit is recommended.
Text comments	Toboggan Lake	Fisheries sensitive zones were noted on the southern shore of Toboggan Lake (wetlands).
E312	Not a Creek	This used to be a creek, but it flowed through a feedlot and was trampled out of existence by livestock. Below the highway the stream is actually a wetland.
Text comments	Glass Cr.	The historical information indicated the presence of: sockeye, coho, Dolly Varden, cutthroat trout, mountain whitefish, largescale sucker and sculpin in Toboggan Lake. No fish were caught in Glass Creek which was electroshocked in reach 1 or in the tributary, also electroshocked in reach 1. Glass Creek flows alongside Highway 16 and is located in an agriculturally developed area. Additional water quality sampling is recommended.
E313	Trib. To Glass Cr.	This reach has been impacted by livestock activity, trampled banks were noted by the crew. All riparian cover has been removed in the field that this creek runs through. Little rearing and limited potential spawning habitat were observed in the sampling area.

Source: Triton Environmental Consultants Ltd. 1998. Reconnaissance level fish and fish habitat inventory in the Bulkley T.S.A. (Working Unit #14 - Toboggan). Contract report and TRIM maps prepared for Pacific Inland Resources (FRBC), Smithers.

[1] Approximate site locations are noted by Site Number in Figure 1.

Toboggan Creek watershed in 1992
Air Photo Mosaic
(Flight lines: 30BCB 92086, 92087, 92090, 92091 and 92135)



Elliot
Creek
Toboggan Lake
Highway
16
Glass
Creek
CN Railway