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WATERSHED ASSESSMENTS (CWAPs) FOR CRANBY CREEK AND BALLPARK CREEK, TEXADA ISLAND, BC

FINAL REPORT

Prepared by:

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Submitted To:

MINISTRY OF FORESTS, SUNSHINE COAST FOREST DISTRICT
Powell River, B.C.

Project No. 0801-00-81528

October, 2000

EXECUTIVE SUMMARY

EBA Engineering Consultants Ltd. (EBA) were retained by the Ministry of Forests, Sunshine Coast Forest District (MOF) to conduct Coastal Watershed Assessment Procedures (CWAPs) for Cranby Creek (890 ha) and Ballpark Creek (928 ha). The watersheds provide domestic water and fire protection to approximately 480 residents of the Gillies Bay Community on Texada Island, BC.

The purpose of the WAP is to assess the cumulative effects of past forest practices on the watershed and to provide recommendations for further development based on the results of the assessment. The CWAP follows guidelines of the *Coastal Watershed Assessment Procedure Guidebook*, Second Edition, April 1999.

Based on the results of the watershed assessment, the current level of impact associated with past harvesting activities and the hydrologic risk of future harvesting and road construction are concluded as follows:

- there have been relatively few, and minor terrain stability and erosion hazards associated with past development.
- no harvesting activities are proposed on Crown Land portions of the Cranby Creek watershed and 8 ha within the Ballpark Creek watershed is proposed for harvesting over the next 5 years. Cranby Lake will likely attenuate hydrologic changes in Cranby Creek, but basin size and physiography are such that there is a potential for hydrologic change in Halley Creek, a tributary to Cranby Creek, or Ballpark Creek. Future forest development plans should appreciate that these two small watersheds are not able to tolerate high ECAs.
- there is a low potential for landslides, stream channel disturbance, or riparian impact as proposed blocks in the Ballpark Creek watershed are situated on relatively stable terrain. In addition, forested buffers are indicated along adjacent streams.
- Cranby Lake, the only developed source of drinking water for the Gillies Bay community, is most susceptible to changes in water quality. Parameters of concern are fecal coliform bacteria, total organic carbon, nutrients, and temperature.

Because a large proportion (45% and 52%) of each watershed is privately owned, much development is not regulated by the Forest Practices Code. Because of this, much responsibility for ensuring a clean and safe water supply lies with local land owners and developers. Recommendations for mitigating the hazard of impacting water characteristics in the community watersheds are summarized as follows:

Forest Harvesting

- the rate of cut in the Halley Creek sub-basin of Cranby Creek, and in the Ballpark Creek watershed, should not exceed 5% of the total Crown Land portion of each watershed over a 5 year period (approximately 1% per year).
- forest harvest activities should consider the effect of harvesting on beaver activity, which may introduce coliform bacteria and may disrupt surface water drainage. As beaver find deciduous tree species more palatable, harvested sites should be planted immediately with conifer tree species immediately after harvesting to discourage the colonization of disturbed sites by alder (deciduous) tree species. Selective removal of alder in the riparian reserve zone may enhance riparian function along streams that have been previously logged but care must be taken to ensure that stream shading is not significantly decreased.
- because the lake water supply systems are sensitive to algae blooms, special precautions should be undertaken to minimize the introduction of nutrients to streams. For example, fertilization activities should be limited to a slow-release variety and buffers should be maintained along streams, wetlands, and lakes.
- Both watersheds, but Cranby Lake in particular, are sensitive to changes in temperature. To minimize the potential for summer temperature increases, streamside vegetation should be maintained within a reserve zone along all tributary streams of Cranby Lake and Ballpark Creek. The reserve zone width should also be assessed for windthrow hazard.

Roads

- as noted by the terrain mapping report, with the presence of extensive limestone deposits on Texada Island, there is the potential for the existence and development of karst and cave features (sinkholes, caves and underground drainage) that may pose safety risks and other problems during forest development. Underground cavities and channels may transport sediment directly into creeks. It is recommended that, if any karst or cave features be identified during construction, the extent of any sinkholes and potential road building and safety concerns be assessed.
- should development occur in the upper Halley Creek tributary basin, an abandoned water retention structure and washed out section of road should be rehabilitated.

Water quality monitoring, undertaken by the Gillies Bay Improvement District, should continue at sites established at Cranby Lake and on lower Ballpark Creek. Sampled parameters should include phosphate, dissolved phosphorous, nitrate, nitrite, conductivity, turbidity, total organic carbon, coliform bacteria (total and fecal) and temperature.

It is also recommended that an emergency response plan be developed in the event of a disturbance that is detrimental to the water supply. Contact names and numbers should be supplied to all contractors working in the watershed.

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1.0 INTRODUCTION

1.1 Project Background and Rationale for Watershed Assessment

EBA Engineering Consultants Ltd. (EBA) were retained by the Ministry of Forests, Sunshine Coast Forest District (MOF) to conduct Coastal Watershed Assessment Procedures (CWAPs) for Cranby Creek (890 ha) and Ballpark Creek (928 ha). The study area includes the portion of each watershed, upstream from the community water intake, and is shown in Figure 1.1. Authorization to carry out this work was provided by Mr. Brian Kukulies of MOF on May 19, 2000.

Under the Forest Practices Code (FPC OPR 14(2)) a watershed assessment is required before a forest development plan is submitted for a community watershed.

1.2 Project Objectives

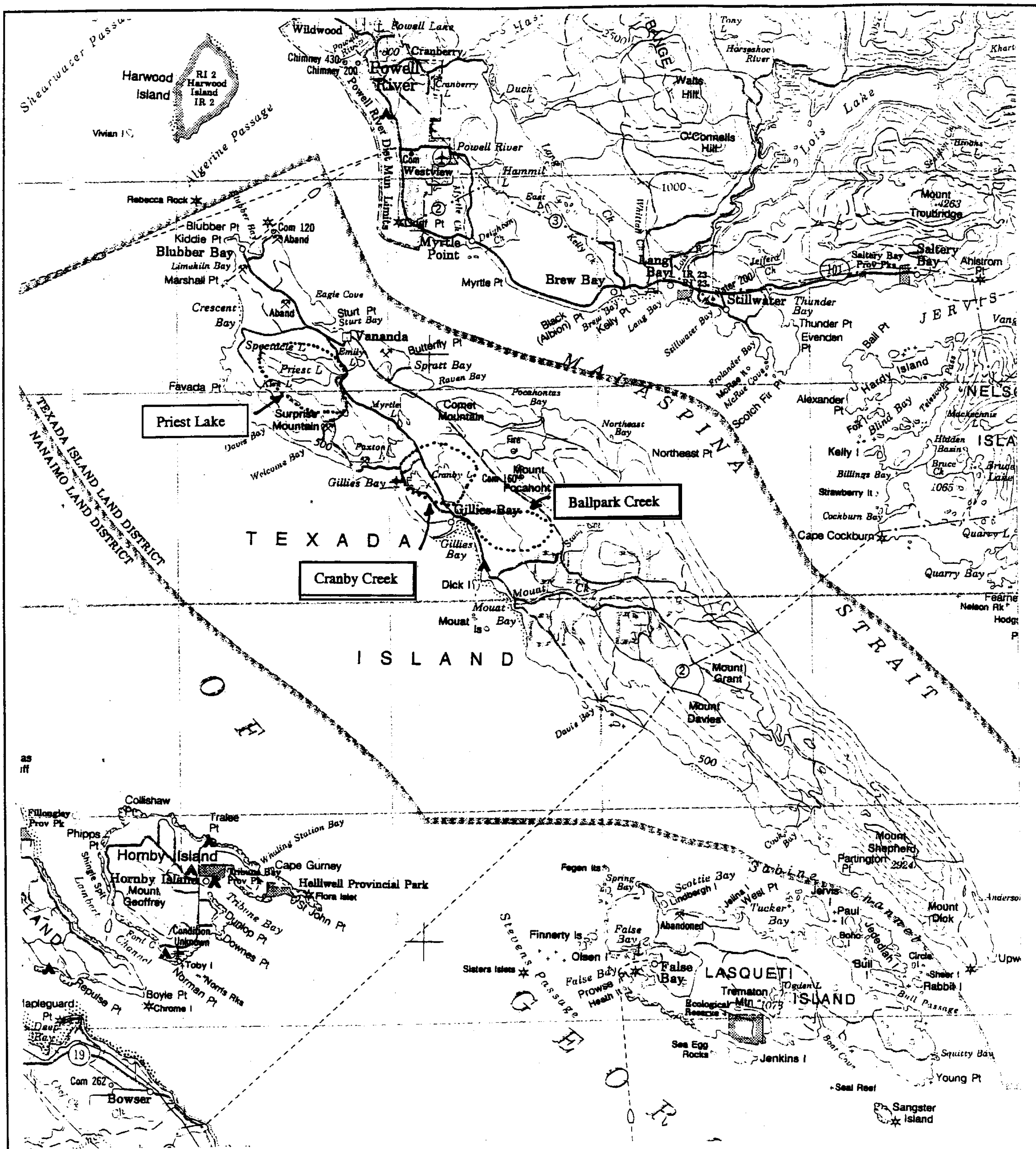
The purpose of the WAP is to assess the cumulative effects of past forest practices on the watershed and to provide recommendations for further development based on the results of the assessment. The specific objectives of the watershed assessment are to determine:

- the potential for changes in peak stream flows;
- the potential for accelerated landslide activity;
- the potential for accelerated surface erosion;
- channel bank erosion and changes to channel morphology as a result of logging the riparian vegetation;
- the potential for stream channel changes; and,
- the interaction, and cumulative effect, of all of these processes, an evaluation of which indicates the sensitivity of the watershed to further forest development.

1.3 Water Supply Characteristics and Water Resource Concerns

The Gillies Bay Improvement District holds licenses on Cranby Lake, Ballpark Creek (also known locally as Gillies Bay Creek), and Halley Creek a tributary of Cranby Creek. Cranby Lake is licensed to withdraw approximately 11 million gallons per year, Ballpark Creek licensed for 500 gallons per day, and Halley Creek is licensed for 7.3 million gallons per year. A water license has been held on Cranby Lake since 1956.

Currently Cranby Lake is the only source utilized by the Improvement District for domestic water and fire protection and 236 connections on the system service about 480 people in the Gillies Bay community. The single water intake on Cranby Lake is submerged at the east end of the lake. Water is screened and treated with chlorine and is then gravity fed to a storage tower. Ballpark Creek and Halley Creek serve as alternate



EBA Engineering Consultants Ltd.

PROJECT: Texada Island CWAPs

CLIENT: **Ministry of Forests - Sunshine Coast FD**

TITLE: Location of the Study Area

DATE:	August, 2000	DWN.:	JC	SCALE:	1:250,000	FILE NO.:	0801-00-81528	FIGURE 1.1

water supplies in the event or failure of contamination on Cranby Lake. However, there is currently no water supply infrastructure on these creeks.

Residents outside the boundaries of the Improvement District frequently rely on groundwater sources such as springs, shallow, and deep wells for domestic water supply. One of the main areas on Texada Island where springs are licensed and developed for use is located south-east of Gillies Bay along School Road, in the Ballpark Creek watershed. Many of the wells, most of which are shallow (less than 15 m deep) run dry in the summer low flow period.

An assessment and balance of water resources supply and demand on Texada Island was completed for a graduate thesis (Hay, 1985). In examining the water resource potential on Texada the research determined that, on an island-wide basis, water is abundant. Despite this, residents that rely on shallow wells, springs, or seasonal streams for water experience shortage during summer months. During the course of analysis it also became clear that land use threats to water quality exist.

Water quality parameters that are identified as a concern by the Gillies Bay Improvement District include:

- turbidity;
- conductivity;
- temperature;
- trihalomethanes, a harmful byproduct of chlorination that is associated with high concentrations of Total Organic Carbon; and
- coliform bacteria.

Because the intake lies within a lake, nutrient levels are also a concern due to the risk of eutrophication. Another concern for the Improvement District is that forest harvest and road building activities do not disturb, or damage, subsurface water supply infrastructure (i.e. distribution lines).

1.4 Watershed Advisory Committee Consultation

A Watershed Advisory Committee (WAC), a group representing resource interests in the watershed, was assembled for the Cranby and Ballpark Creek CWAP, and met on June 28, 2000 on Texada Island. Members included representatives of the Gillies Bay Improvement District, Ministry of Forests (MOF), Ministry of Environment, Lands and Parks (MELP), and a representative of Texada Forest Land Reserve Ltd., a private logging company. The purpose of the meeting was to identify water resource issues and provide background information for the assessment.

As there is little to no proposed forest development, a final WAC meeting was not organized. Comments on the draft report were received from MOF and MELP but were not received from the Gillies Bay Improvement District.

2.0 WATERSHED CHARACTERISTICS

2.1 General Physiography

The Cranby Creek (890 ha) and Ballpark Creek (928 ha) watersheds are located upslope from the community of Gillies Bay on the west side of Texada Island, which is situated off the Sunshine Coast near Powell River, BC (Figure 1.1). Both creeks flow west into the Strait of Georgia. The small watersheds have a low overall relief and are characterized by rolling topography. Cranby Creek, more so than Ballpark Creek, has many small wetlands and lakes, one of which is Cranby Lake, the source of domestic water supply for the community.

2.2 Climate and Hydrology

The climate on Texada Island is characterized as warm and relatively dry in the summer and moist and mild in the winter with very little snow (Green and Klinka, 1994). Texada Island, specifically the northern half of the island, is generally drier than the mainland sunshine coast. Texada Island receives 957 mm of precipitation per year on average (as recorded at the Texada Island airstrip near Gillies Bay - Environment Canada Climate Stn. 1048140). While average annual precipitation recorded at the Powell River airport (Environment Canada Stn 1046391) is 1233 mm. While some precipitation does fall as snow, the mild maritime climate, combined with basin size and physiography, prevent snow from remaining for long periods of time. Consequently, snow is unlikely to persist through the low flow period.

There are no streamflow measurement stations on Texada Island. Using the Rational Formula Method (Coulson, 1991), the estimated peak flow runoff in Cranby Creek is 15 m^3/s, and 18 m^3/s in Ballpark Creek.

Two nearby stations were selected to characterize flows in the study area watersheds. Streamflows for Ogden Creek (WSC Stn. # 08HB047; 1.86 km^2), located on Lasqueti Island southeast of Texada Island, are compared to those of Lang Creek (WSC Stn. #08GB007; 128 km^2). The mean annual discharge of Odgen Creek is 0.025 m^3/s, or 0.013 m^3/s per km^2. The mean annual discharge of Lang Creek is 4.22 m^3/s, or 0.033 m^3/s per km^2. Based on this comparison, flows on Texada Island are approximately 2.5 times less than that experienced on the mainland. Using unit discharge estimates on Lasqueti Island, mean annual flows in Cranby Creek are estimated to be 0.116 m^3/s and, in Ballpark Creek, mean annual flows are estimated to be 0.121 m^3/s.

On Texada Island, the dominant hydrologic process is generated by rain and, less commonly, rain-on-snow. Low flow periods occur in the summer between May and October. Peak flow periods occur in the winter between November and January.

2.3 Geology, Geomorphology and Soils

Bedrock at the northern part of Texada Island is characteristically volcanic basalt and breccia (Webster and Ray, 1991) overlain by massive calcareous and dolomitic limestone at the very north part of the Island. There are a number of active limestone quarries that extract the pure limestone. The nature of the underlying bedrock has a notable influence on the stability of the terrain. In the Gillies Bay area bedrock exposures may include shale, siltstone, sandstone, conglomerate and coal. These are relatively weak friable and fissile rocks that break down into surficial material that has significant component of fines in the matrix.

The lower slopes of the study area are covered by accumulations of till, glaciofluvial or glaciolacustrine material. Surficial materials are typically medium-textured pure sand (Quadra Sand) with very little silt and clay deposited as outwash deposits overlain with till and related glaciomarine drift. Depths range from less than 0.2 m to greater than 1 m. There is an area in the Cranby Lake area where Quadra Sand overlies a very compact unit of till, thought to be a remnant of the last glacial event (Contour Geoscience Ltd., 2000).

Surficial material is generally covered with litter, fermentation, humus and pedalogic soil. The overlying organic layer is generally thin (< 6 cm) and easily disturbed or removed (Contour Geoscience Ltd., 2000).

There are extensive areas of low-lying ground between and adjacent to lakes in the study area. Some of these areas are poorly drained and swampy and are likely underlain with clayey and silty lake bottom material. There are also 'strings' of bogs and small lakes, that form, depending upon the depth of the present day water table.

2.4 Water Quality

The Gillies Bay Improvement District conducts water quality monitoring on a semi-regular basis at a number of sites in the Cranby Creek watershed. One of the sites is located at the Cranby Lake water intake. Laboratory analytical results, dated as early as 1989, were provided for the purposes of this study.

The most recent results (06/20/00) indicate that all parameters sampled at the Cranby Lake intake, except True Colour, which is an aesthetic parameter, meet Canadian (CCME, 1999) and British Columbia (MELP, 1998) drinking water standards. The results are included as Appendix A. Water quality parameters identified as a potential for concern are described as follows and several are summarized in Table 2.1:

- *Temperature* – Forest cover provides shade to streams and harvesting streamside vegetation can increase peak summer stream temperatures. Temperature changes tend to be cumulative along the channel since thermal energy is not easily lost. Increased temperatures elevate the metabolic oxygen demand, which in conjunction with reduced oxygen solubility, impacts many species and can contribute to eutrophication in downstream reservoirs, or lakes.

Temperatures in Cranby Lake have been recorded as high as 24° C. The intake is located in deeper water so it is likely a bit cooler. The provincial criterion for temperature is 15°C, which indicates that elevated lake temperatures are a concern for domestic water quality.

- *Nutrients (nitrogen and phosphorous)* – Logging, fire, and forest fertilization temporarily increase dissolved inorganic nitrogen (nitrate and ammonia) by introducing organic material and sediment. Relative to the total amount of available nitrogen, these increases are generally small. Nitrogen concentrations may also increase as a result of inadequate human waste disposal, livestock, wildlife, and atmospheric fallout.

  Primary production (i.e. plant growth) in lakes is limited by nutrients, namely phosphorous. Inputs of phosphorous are the prime contributing factors to eutrophication, which can change water chemistry, reduce dissolved oxygen levels, and decrease esthetic values. Research indicates that non-point sources of phosphorous include septic tanks, recreation, livestock and other animals, and soil erosion.

  Most recent concentrations of nitrate and nitrite (combined) in Cranby Lake is 0.06 mg-N/L. The provincial criterion for nitrate is 10 mg/L, and nitrite is 1 mg-N/L. The provincial criterion for total phosphorous concentrations in lakes is 10 mg/L. Historical concentrations of total phosphorous and total dissolved phosphorous are below the laboratory detection limit.

- *Coliforms* – The presence of coliform bacteria may indicate contamination from human or animal waste. The total coliform group of microorganisms includes fecal coliforms and non-fecal coliforms, which are naturally present in soils and on vegetation. Fecal contamination of water may indicate the presence of harmful pathogenic organisms.

  Where there is disinfection, the provincial criterion for total fecal coliform in drinking water is 10 (90^{th} percentile). Where there is partial treatment of the water supply, the criteria is 100. Coliform bacteria concentrations in Cranby Lake are periodically elevated and are a concern to water users. Total coliform concentrations have ranged from 7 to 3400. Fecal coliform bacteria was not detected in the most recent water analysis but has, historically, reached concentrations of 2000. Potential sources of contamination include: septic systems, wildlife (specifically, beaver or deer), and domestic animals.

- *Total Organic Carbon* - Total Organic Carbon (TOC) is a measure of dissolved and particulate organic carbon, which is comprised of humic substances and partly degraded plant and animal materials. Sources of organic material may be associated with organic substrates in Cranby Lake. Cranby Lake was a wetland area that was logged and flooded prior to the construction of a small earth-filled dam. Anecdotal evidence suggests that wetland organics and soils were not cleared prior to flooding and that occasional clumps of peaty organic matter float to the surface of the lake. In addition, beavers dislodge material and stir up sediment at the bottom of the lake.

  Although there are currently no provincial drinking water criteria for TOC, the US EPA recently set 4 mg/L TOC as a limit to prevent the formation of trihalomethane, a harmful by-product of chlorination. Total organic carbon concentrations have ranged from 2 mg/L to 8.5 mg/L and the most recent analysis recorded TOC concentrations of 8 mg/L. Historical analysis for trihalomethane in the Gillies Bay water supply indicates that the concentration was below the laboratory detection limit for all samples. The provincial criteria for trihalomethane in drinking water is 100 μg/L.

Table 2.1 Selected Water Quality Parameter Concentrations (Cranby Lake)

Date	Total Organic Carbon (mg/L)	Trihalomethanes (total) (μg/L)	Total Coliforms (/100ml)	Fecal Coliforms (/100ml)
Provincial Criteria[1]		*100*		*10*
03/15/89		<DL	-	-
08/29/90	8.5	-	13	-
11/01/91	7.5	<DL	3400	2000
04/22/92	2.0	<DL	600	24
08/20/97		-	-	-
06/20/00	8.0	<DL	7	<DL

Source: Gillies Bay Improvement District
[1] – British Columbia Water Quality Guidelines (Criteria) (MELP, 1998)
<DL – less than laboratory detection limit
- - no analysis conducted for this parameter

2.5 Fisheries, Wildlife and Significant Vegetation Characteristics

2.5.1 Fisheries

Fish distribution information is provided by the Ministry of Forests on the forest development plan maps and was corroborated by representatives of the Gillies Bay Improvement District.

The records indicate that Ballpark Creek is fish-bearing to the headwater reaches. Juvenile fish (possibly coho salmon) were observed along lower sections of the stream during the field inspection. Upper reaches of the stream likely support populations of cutthroat trout and/or Dolly Varden char.

Fish passage on Cranby Creek is likely limited to about the lower 760 m. There are impassable barriers below the main road, including the culvert beneath the road itself. There may be resident fish in Cranby Lake, which means that resident fish may populate all low gradient (i.e. less than 20% gradient) streams in the watershed.

A rare and unique species of stickleback, called the Vananda Limnetic Stickleback (*Gasterosteus* Sp 14 and Sp 15) has been recorded in Emily Lake, Priest Lake, and Spectacle Lake. Another species of stickleback has been recorded in Paxton Lake (Paxton Lake Limnetic Stickleback, *Gasterosteus* Sp 4 and Sp 5). There are no recorded occurrences of these red-listed fish species in Cranby Lake.

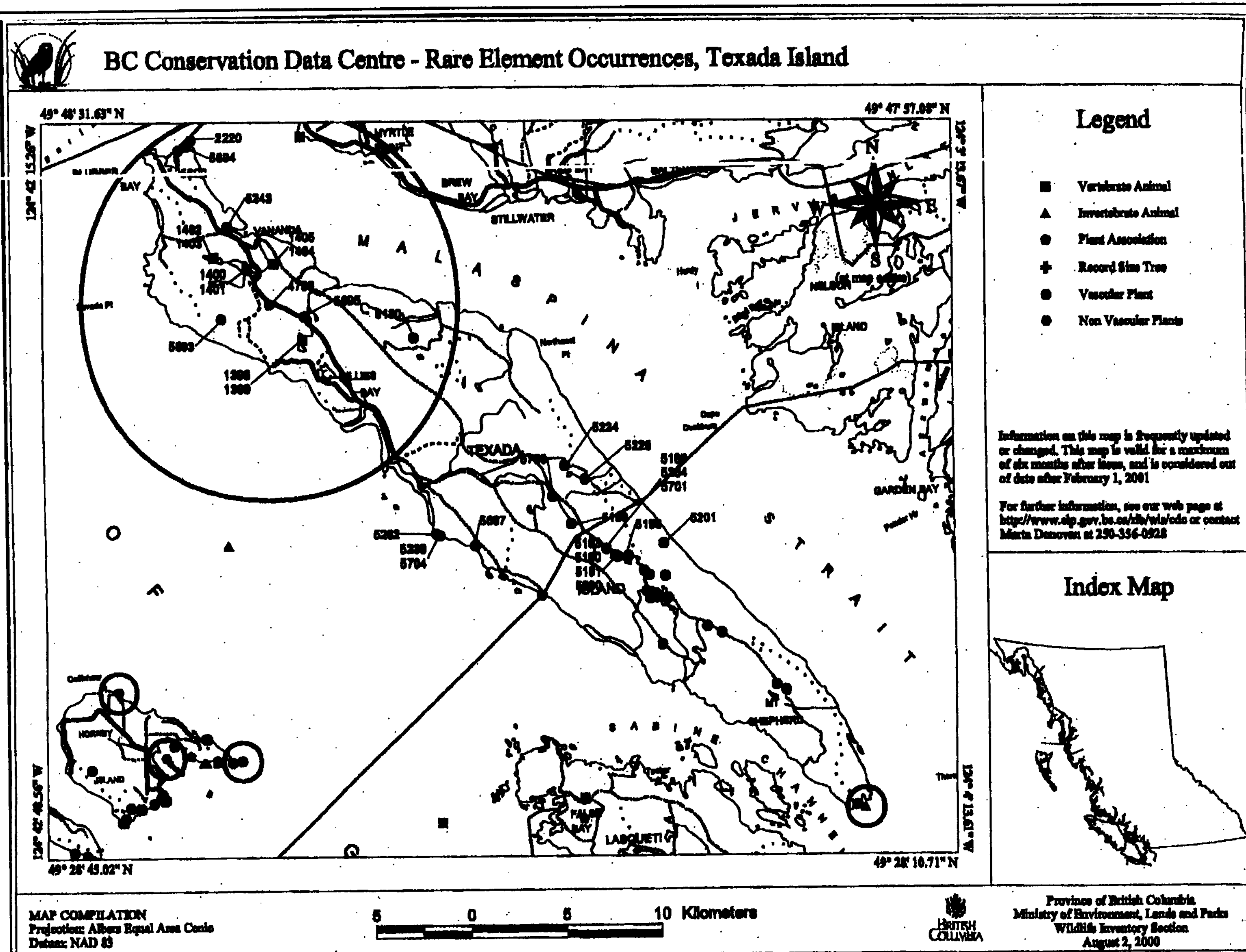
2.5.2 Wildlife

Wildlife characteristics on Texada Island are not well documented but the island is known to support a large population of black-tailed deer, as there are no natural predators to the deer (i.e. cougar or bear) on the island. There are raccoon and beaver, as well as freshwater turtle, garter snakes, frogs, and the alligator lizard. The Texada Island bird list shows approximately 200 resident or transient bird species. Species of interest include osprey, bald eagles, Great Blue heron, the Rufous Hummingbird, and Black Brant geese.

2.5.3 Significant Vegetation

The B.C. Conservation Data Center (CDC) maintains an inventory of known occurrences of rare species or natural plant communities. The CDC database represents information available at the time of the request and is updated or amended regularly. The CDC database lists a number of red- and blue-listed vascular plant species on Texada Island, although not necessarily within the two watersheds of interest for this study. These are summarized in Table 2.2 below and are shown in the map compiled by the CDC in Figure 2.1.

BC Conservation Data Centre - Rare Element Occurrences, Texada Island



EBA Engineering Consultants Ltd.	Project: Texada Island CWAPs
Client: Ministry of Forests	BC CDC - Rare Element Occurrences
DATE: August, 2000	FILE NO. 0801-00-81528 FIGURE 2.1

Table 2.2 List of Red- and Blue-Listed Plant Species Recorded on Texada Island

Vascular Plant Species	Provincial List Status[1]
Macoun's Groundsel (*Senecio macounii*)	Blue-listed
chaffweed (*Anagallis minima*)	Blue-listed
least moonwort (*Botrychium simplex*)	Blue-listed
green-sheathed sedge (*Carex feta*)	Blue-listed
western St. John's wort (*Hypericum scouleri nortoniae*)	Blue-listed
fleshy jaumea (*Jaumea carnosa*)	Blue-listed
one-leaved malaxis (*Malaxis brachypoda*)	Blue-listed
northern adder's-tongue (*Ophioglossum pusillum*)	Red-listed
california sword-fern (*Polystichum californicum*)	Red-listed
poison oak (*Toxicodendron diversilobum*)	Blue-listed

Source: B.C. Conservation Data Centre (August, 2000)

3.0 PAST AND PROPOSED FORESTRY ACTIVITIES

3.1 Past Forest Harvest Activities

Forestry activities have occurred on Texada Island since the late 1910s. Currently, there are four licenses to harvest Crown Land on Texada Island. These include:

- R.H. Barbour Co. Ltd. (License No. A20487)
- Charles Klein Logging Co. Ltd. (License No. A20489)
- Hagman and Sons Logging Ltd. (License No. A20494)
- Van Anda Logging Co. Ltd. (License No. A20507)

On private land, land clearing and forest harvesting is largely unregulated. Much of the private land being logged is owned by Texada Island Forest Reserve Ltd. and is currently managed by Charles Boulet, of Perdix Land Management Ltd.

3.2 Proposed Forest Harvest and Road Building

No forest harvest or road building activities are currently proposed on Crown Land portions of the Cranby Lake watershed (to 2005). In the Ballpark Creek watershed, two small cutblocks (total area approximately 8 ha, or less than 1% of total area) are proposed. A short section of new road (280 m) is proposed to access the new block in the Ballpark Creek watershed.

[1] Provincial List Status: Red-listed includes any indigenous species or sub-species considered to be Extirpated, Endangered, or Threatened in B.C. Blue-listed includes any indigenous species or sub-species considered to be Vulnerable in B.C.

4.0 CWAP METHODS

This CWAP follows guidelines of the *Coastal Watershed Assessment Procedure Guidebook*, Second Edition, April 1999. A more detailed description of assessment procedures is outlined below.

4.1 Delineate and Confirm Watershed Boundaries

Community watershed boundaries are based on the height of land and are derived by the Ministry of Environment, Lands and Parks using 1:20,000 scale TRIM maps. Based on consultation with the WAC, the watershed boundary of Cranby Creek was confirmed in the field.

The field confirmation indicated that there are no culverts beneath the road separating Paxton Lake and Cranby Lake. A linear clearing between the two lakes is remnant of a pipeline used by the nearby iron mine to pump water from Cranby Lake to Paxton Lake during times of low water. The pump system operated for a short period between the late 1960s and the early 1970s (H. Diggon, pers. comm., 2000).

The watershed boundary on the south side of the watershed lies along the Airport Road. The small airstrip does not appear to store fuel, nor are there airplane maintenance facilities. There is a small drainage ditch on the airport side of the road that drains to a small natural wetland area before passing through a single culvert beneath the road. There is a low likelihood that surface water contamination could reach Cranby Lake from the airport facility.

4.2 Peak Flow and Hydrologic Recovery Analysis

Based on recent research by Ziemer (1998), the greatest effect of logging on stream flow peaks is to increase the size of the smallest peaks (i.e. 1 in 2 to 5-yr events) during the driest antecedent conditions, with the effect declining as storm size and watershed wetness increases. The effect on major floods (i.e. peak flows) is apt to be minor compared to the influence of rainfall and basin storage. Discharge peaks in "smaller" watersheds also tend to have greater post-logging response than "larger" watersheds (Jones and Grant,1996). As such, a 20% ECA in a small watershed may be considered to be a greater concern than a 20% ECA in a large watershed. This said, the effect on a small basin with a predominance of lakes and wetlands, is likely much less.

Peak flows in the two watersheds are dominated by rain and, very occasionally, rain-on-snow processes. Members of the Gillies Bay Improvement District indicated no concern with respect to peak flows in the Cranby Lake watershed. Due to the ability for lakes to attenuate the hydrologic effect of peak flows, peak flow effects are not likely to be of concern for the Cranby Lake watershed. Field inspection of Halley Creek, a tributary of

Cranby Creek, indicated that a surface water diversion structure resulted in a localized washout. Halley Creek may be more susceptible to changes in forest cover.

The hydrology of Ballpark Creek is likely to be affected by land clearing. Local resident, Mr. Charles Boulet, indicated that December flows in Ballpark Creek tend to be "flashy". While in the summer, flows are very low. Field indicators of peak flow channel disturbance (i.e. scoured streambanks, pool frequency and extent, and sedimentation) are only slight along the lowest reaches of Ballpark Creek.

To determine the cumulative hydrologic effect of past forest harvest and road construction, an analysis of hydrologic recovery is conducted. In general, the hydrologic effect of harvested areas, which uses tree height as an indicator, is reduced as trees grow. This reduction is termed "hydrologic recovery".

Hydrologic recovery attributed to stand regeneration is expressed as the equivalent clearcut area (ECA) index. By current methods, ECA index values are related to tree height as shown in Table 4.1. Using the ECA index, harvested areas are "reduced" by that amount of recovery. For example, if the average canopy height in a 100 ha cutblock is 4 m the equivalent clearcut area is 75 ha (100 ha less 25% hydrologic recovery).

Table 4.1 – Equivalent Clearcut Area (ECA) Index

Stand Height (m)	ECA Index, or Hydrologic Recovery
0 to 3 m	0%
3 to 5 m	25%
5 to 7 m	50%
7 to 9 m	75%
9 m +	90%

Source: CWAP Guidebook (Interim Method), 1999

Stand heights, projected to 1999, are obtained from the forest inventory database. The database contains information for Crown Land but contains out of date stand height information for private land. Forest inventory information for private land was last updated in 1991. About 45% of the Cranby Lake watershed, and 52% of the Ballpark Creek watershed, are privately owned. Private lands in each watershed are not extensively cleared and rural residential lots tend to be relatively small, with grassed yards. Where logging activities have occurred on private land, the harvested areas are predominantly selective, or partial cuts, and regenerated stands are comprised of a higher proportion of deciduous tree species.

For the purpose of this study, it is assumed that an additional 5% of all private land is currently cleared. This accounts for 20 ha in the Cranby Lake watershed and 24 ha in the Ballpark Creek watershed, which will be added to the area of cleared land. This is a reasonable estimate based on a review of 1999 air photos. This estimate accounts for residential land clearing and historic partial (selective) forest harvesting. Based on a qualitative comparison of 1988 and 1999 air photos, it appears that the percentage of cleared private land has increased.

4.3 Sediment Source Survey, Stream Channel and Riparian Assessment

The purpose of this component-level analysis for the watershed assessment is to determine the significance of past forestry-related impacts and to determine the relative hazard related to future harvesting activities.

A reconnaissance-level sediment source survey, stream channel assessment, and riparian assessment were completed for the study watersheds. Each component was completed by the following methods:

- Information Review – For the sediment source survey, recently completed terrain and terrain stability mapping provides the key source of terrain information (Contour Geoscience Ltd., 2000).
- Air Photo Review - 1988 1:15,000 scale and 1999, 1:15,000 scale air photos were also reviewed. For the stream channel assessment, channel characteristics are summarized and evidence of past hydrologic or sedimentation disturbances are documented. Due to vegetative cover over the small stream channels the use of air photos to complete the channel stability assessment was restricted;
- Field Assessment – overview-level field assessment to confirm ratings, to supplement information where vegetation obscured ground and channel conditions, and determine the sensitivity to disturbance.

5.0 RESULTS

5.1 Peak Flow and Hydrologic Recovery Analysis Results

Equivalent clearcut areas (ECAs) were calculated for the Cranby and Ballpark Creek watersheds. The results, summarized in Table 5.1, indicate that 151 ha, or 17% of the Cranby Creek watershed, has been logged and that 353 ha, or 38% of the Ballpark Creek watershed, has been logged. The equivalent clearcut area for Cranby Creek is 28 ha, or 3% and the ECA for Ballpark Creek is 138 ha, or 15%. A summary of forest inventory data used to calculate ECAs is presented in Appendix B of this report.

These numbers likely underestimate the amount of logging that has occurred on private land. Because land clearing and/or harvesting that occurs on private land is not regulated in the same way as activities on Crown Land the ECAs must be recalculated assuming that a certain proportion of private land is cleared.

Assuming that 5% of private land is currently cleared and that the average stand height in these clearings is less than 3 m (a conservative estimate), then a revised ECA is calculated (see Table 5.1). The revised estimated equivalent clearcut area for the two watersheds, based on these assumptions, is as follows:

- 5.4% for the Cranby Creek watershed; and
- 17% for the Ballpark Creek watershed.

Table 5.1 Current Equivalent Clearcut Area (ECA) Values

		Crown Land		Private Land	
Watershed	**Area (ha)**	**Total Area Logged**	**Equivalent Clearcut Area**	**Area (ha)**	**Revised ECA[1]**
Cranby Creek	890	151 ha, 17%	**28 ha, 3%**	398 ha	**48 ha, 5.4%**
Ballpark Creek	928	353 ha, 38%	**138 ha, 15%**	483 ha	**162 ha, 17%**

[1] – Revised ECA assumes that an additional 5% of private land is currently logged

There are two small cutblocks proposed for the Ballpark Creek watershed. The total area of these blocks (approx. 8 ha) represents a less-than 1% increase in the ECA. No forest harvest activities are proposed in the Cranby Lake watershed at this time.

As discussed previously, peak flow effects are not likely to be of concern for the Cranby Lake watershed due to the ability for the lake to attenuate peak flows. In the Halley Creek and Ballpark Creek watersheds, there is a greater concern for the hydrologic effects of forest harvest due to the lack of lake or wetland areas in the downstream sections of the stream.. This is of particular concern for Ballpark Creek due to the direct connectivity between hillslopes and the stream channel. There is a possibility that the hydrology of Ballpark Creek will be affected. It is, however, unlikely that the current level of harvesting proposed will have a noticeable effect on flows. To ameliorate short-term hydrologic effects, it is recommended that harvesting be limited to 5% of the total watershed area over 5 years (equivalent to approximately 1% per year). Since such a large proportion of the watershed is privately owned, the recommended rate of cut should be applied to the Crown Land portion.

5.2 Landslide and Stream Sedimentation Hazard Assessment

Based on the terrain mapping and terrain stability assessment completed by Contour Geoscience Ltd. (2000), there are no areas identified as potentially unstable (Class IV) or unstable (Class V) terrain. There were no mappable landslides noted as the study area is strongly influenced by bedrock that is either at or very near the surface. There are steep bedrock pitches within some areas that exhibit some evidence of historic rockfall activity. The colluvial material associated with this activity is generally coarse rubble or blocks, materials that is not prone to erosion and has not been transported very far downslope.

Table 5.2 Reach Characteristics for Cranby and Ballpark Creeks

Reach No.	Length (m)	Approx. Width (m)	Avg. Gradient (%)	Channel Type	Hillslope-Channel Coupling	Riparian Vegetation Type & Stand Structure	Riparian Logging (y/n)	Role of Riparian Vegetation	Current Channel Stability Rating	Channel Sensitivity to Hydrologic Change **	Notes
Cranby Creek											
1 *	50	5	<1	RPg	Direct	Deciduous	yes, nearby road	provides stream cover	DI	Moderate to High	d/s confluence of Cranby and Ballpark Creeks. Low gradient, estuarine channel
2	720	not visible	2.7	not visible	Direct	Deciduous	yes	provides cover and long-term stability	not visible	Moderate	d/s water intake
3	1600	2	3.4	RPg/c -w	Direct	Mixed	yes	provides long-term stability	S	Moderate	culvert under road is barrier to fish passage
4	Cranby Lake	-	-	-	Direct	Mixed	no	lake side cover and shade	-	-	
5	900	not visible	5	not visible	Direct	Mixed	no	provides long-term stability	not visible	Low	
6	Paxton Lake	-	-	-	Direct	Mixed	yes, 1944-1950	lake side cover and shade	-	-	
7	400	not visible	7.5	not visible	Direct	Mixed	yes, 1944-1950	provides long-term stability	not visible	Low	
Halley Creek (trib. to Cranby Ck.)											
1-1	1100	not visible	8	not visible	Direct	Mixed	yes, 1948 & 1959	provides long-term stability	not visible	Low	
1-2	Wetland	-	-	-	Direct	Coniferous	yes, 1959	cover and shade	-	-	
1-3	1690	not visible	6	not visible	Direct	Coniferous	no	provides long-term stability	not visible	Low	
Ballpark Creek											
2-1	1640	3	3	RPg-w	Direct	Deciduous - Youg Forest	yes, private land	provides long-term stability and fish habitat	S	Moderate to High	lower part of reach lies within Gillies Bay community
2-2	1240	not visible	4	not visible	Direct	Mixed - Mature Forest	yes, 1945-48 and 1965	provides long-term stability and fish habitat	not visible	Moderate	
2-3	1330	not visible	7.5	not visible	Direct	Mixed	yes	provides long-term stability and fish habitat	not visible	Moderate	
3-1	550	2	9	CPc-w	Direct	Mixed	yes	provides long-term stability and fish habitat	S	Moderate	
3-2	700	not visible	13	not visible	Direct	Mixed	yes, 1977-1979	provides long-term stability and fish habitat	not visible	Moderate	

Note: Reach characteristics are based on 1999 air photos (approx. 1:15,000 scale) and are, therefore, approximate.

* Note - Reach 1 is downstream from confluence of Cranby and Ballpark Creeks

** Note - Sensitivitiy judgement based on field investigation and air photo assessment

Bankfull Width - the width of the water surface at bankfull stage which occurs just prior to flooding when the brim-full channel overflows with no banks exposed (Hogan, et al, 1996)

Channel Type -
- RPg - gravel, riffle-pool
- RPg-w - gravel, riffle-pool with functioning wood
- RPc - cobble, riffle-pool
- CPc - cobble, cascade-pool
- CPc-w - cobble, cascade-pool with functioning wood

Hillslope-Channel Coupling - indicates the connectivity between the hillslopes and the channel. Coupling may be direct, indirect or none, depending on the width of the floodplain.

that the first reach of Ballpark Creek upstream from the main road crossing (Reach 2-1) is low gradient (approx. 3%), with alternating sequences of gravel shoals (riffles) and shallow pools created by scour around woody debris or larger rocks. The channel, somewhat incised in unconsolidated material and bedrock, appeared to be relatively stable. There were only slight indications of peak flow channel disturbance in this reach. Morphological field indicators included undercut streambanks and shallow pools. Woody debris appeared to provide in-stream cover for fish and contributed to channel complexing and stability.

Upper reaches of Ballpark Creek and of a tributary stream are generally narrow (approx. 2 m) and increase slightly in gradient. There is extensive woody debris within the channel, and minor evidence of alluvial sediment transport. Although all reaches of the system have historically been logged, no indications of channel instability were noted.

Flows into Cranby Creek, downstream from Cranby Lake, are regulated by a wooden weir. As lake levels drop below the weir, little water is supplied to the lower reaches of Cranby Creek. At the time of the field assessment, flows in Cranby Creek below Guillies Bay Road were somewhat stagnant. The channel appeared to have be relatively stable, if not slightly degraded as a result of low water flows.

Channel disturbance on upstream sections of Halley Creek (Reach 1-3) was observed. There is evidence of washout originating from an unauthorized water detention pond (see Photo 3). Diversion of the stream channel onto a constructed road/trail has caused extensive surface erosion along road cutslopes and along the road itself. However, the extent of the disturbance is limited to a short (approx. 100 m) section above a gently sloped wetland area that is not known to be fish-bearing. The Halley Creek tributary also lies outside of the Cranby Lake watershed, the location of the community water supply intake.

The distribution and abundance of aquatic vegetation within and along the shorelines of Cranby Lake were compared between 1988 and 1999 using 1:15,000 scale air photos. The comparison indicates that the shoreline shape remained virtually unchanged over this period but that there are slight changes in the abundance of shoreline vegetation. Several small vegetated "islands" visible at the south side of the lake in 1988 were no longer visible in 1999. Shoreline aquatic vegetation on the other hand appears to have slightly increased in width. This may indicate an increase in lake temperatures or in lake nutrients.

5.4 Riparian Assessment Results

The Forest Practices Code provides guidelines for riparian width, based on stream class (i.e. stream channel width and fish presence). An assessment of riparian vegetation will indicate its role in providing channel stability and structure and how this has been affected by past riparian logging. Impacts related to the loss of vegetation in the riparian zone include a loss of streambank stability, sedimentation, and a diminished supply of large woody debris for fish and wildlife. Standards for riparian width do not specifically include the need to moderate stream temperatures. However, riparian vegetation plays an important role for stream temperatures in the study area.

Approximately 0.6 km (10%) of the 5.8 km of stream in the Cranby Creek watershed (along Halley Creek) has been logged. Approximately 2.2 km (37%) of the 5.9 km of stream in the Ballpark Creek watershed has been previously logged. It should be noted that the estimated length of stream logged does not include lakeshore, nor does it include updated information on private land clearing. The loss of riparian cover along these streams does not appear to have resulted in significant channel disturbance.

Riparian stands along the lower reaches of Ballpark Creek are largely dominated by mature alder, which provide a high level of biodiversity for birds and mammals. Alder stands will adequately moderate stream temperatures during the summer months. The stands are, however, not as capable of supplying woody debris to the stream channel, the role of which is to provide long-term stability and cover for fish.

Proposed harvesting in the Ballpark Creek watershed is situated upslope from the stream. A reserve zone of approximately 60 to 140 m wide is proposed along the S3 Class stream. During detailed block engineering assessments, the reserve zone width should be confirmed and assessed for windthrow hazard.

6.0 SUMMARY OF RESULTS

6.1 Watershed Report Card

A Watershed Report Card is prepared for each watershed (Table 6.1 and 6.2). The report card summarizes some of the key measures of watershed condition and provides a summary assessment of hazard level for peak flow, sedimentation, channel impact, and riparian impact.

Table 6.1 – Cranby Creek Watershed Report Card

	Current Condition (2000)
Watershed Area (ha)	890 ha
Equivalent Clearcut Area (%)	5.4%
Length of road and total road density (km, km/km^2)	15.1 km, 1.7 km/km^2
PEAK FLOW HAZARD	**LOW**
Total number of forestry-related landslides	0
Total number of landslides, point source of sediment that have directly impacted the stream	0
Length of High Hazard Road (km)	0.25 km
Area of Class IV and V terrain (ha, %)	0
Area with high surface erosion potential (ha, %)	7.23 ha, 0.8%
SEDIMENTATION HAZARD	**LOW**
Length of mainstem stream with disturbed stream channel (km, %)	0
STREAM CHANNEL IMPACT HAZARD	**LOW**
Length of mainstem stream channel with logged riparian forest (km, %)	0.6 km, 10%
RIPARIAN IMPACT HAZARD	**LOW**

Table 6.2 - Ballpark Creek Watershed Report Card

	Current Condition (2000)
Watershed Area (ha)	928 ha
Equivalent Clearcut Area (%)	17%
Length of road and total road density (km, km/km^2)	14.8 km, 1.6 km/km^2
PEAK FLOW HAZARD	**LOW**
Total number of forestry-related landslides	0
Total number of landslides, point source of sediment that have directly impacted the stream	0
Length of High Hazard Road	0
Area of Class IV and V terrain (ha, %)	0
Area with high surface erosion potential (ha, %)	19.6 ha, 2.1%
SEDIMENTATION HAZARD	**LOW**
Length of mainstem stream with disturbed stream channel (km, %)	0
STREAM CHANNEL IMPACT HAZARD	**LOW**
Length of mainstem stream channel with logged riparian forest (km, %)	2.2 km, 37%
RIPARIAN IMPACT HAZARD	**MODERATE**

6.2 Conclusions

Based on the results of the watershed assessment, the current level of impact associated with past harvesting activities, and the hydrologic risk of future harvesting and road construction are concluded as follows:

- there have been relatively few, and minor terrain stability and erosion hazards associated with past development.
- no harvesting activities are proposed on Crown Land portions of the Cranby Creek watershed and 8 ha of the Ballpark Creek is proposed for harvesting within the next 5 years. Cranby Lake will likely attenuate hydrologic changes in Cranby Creek, but basin size and physiography are such that there is a potential for hydrologic change in Halley Creek, or Ballpark Creek. Future forest development plans should appreciate that these two small watersheds are not able to tolerate high ECAs.
- there is a low potential for landslides, stream channel disturbance, or riparian impact as proposed blocks in the Ballpark Creek watershed are situated on relatively stable terrain. In addition, forested buffers are indicated along adjacent streams.
- Cranby Lake, the only developed source of drinking water for the Gillies Bay community, is most susceptible to changes in water quality. Parameters of concern are fecal coliform bacteria, total organic carbon, nutrients, and temperature.

Forest harvesting can take place in both the Cranby Lake and Ballpark Creek watersheds without degrading water resource characteristics. Cranby Lake watershed is relied upon to provide a minimum quality and quantity of water that meets public need for consumption as well as fish species present in the system. Proposed harvesting must be sensitive to these values. To minimize impacts, recommendations for hazard mitigation, provided below, must be followed as part of the Forest Development Plan approval process.

7.0 FOREST DEVELOPMENT PLAN RECOMMENDATIONS

7.1 Recommendations for Hazard Mitigation

Forestry activities in the watersheds are legislated by the Forest Practices Code. Based on the requirements for a clean water supply there is a necessity to adopt practices beyond that which is required under the Code. However, rationale for additional requirements should be provided.

Because a large proportion (45% and 52%) of each watershed is privately owned, much development is not regulated by the Forest Practices Code. Because of this, much responsibility for ensuring a clean and safe water supply lies with local land owners and developers. Recommendations for mitigating the hazard of impacting water characteristics in the community watersheds are summarized as follows:

Forest Harvesting

- the rate of cut in the Halley Creek sub-basin of Cranby Creek, and in the Ballpark Creek watershed, should not exceed 5% of the total Crown Land portion of each watershed over a 5 year period (approximately 1% per year).
- forest harvest activities should consider the effect of harvesting on beaver activity, which may introduce coliform bacteria and may disrupt surface water drainage. As beaver find deciduous tree species more palatable, harvested sites should be planted immediately with conifer tree species immediately after harvesting to discourage the colonization of disturbed sites by alder (deciduous) tree species. Selective removal of alder in the riparian reserve zone may enhance riparian function along streams that have been previously logged but care must be taken to ensure that stream shading is not significantly decreased.
- because the lake water supply systems are sensitive to algae blooms, special precautions should be undertaken to minimize the introduction of nutrients to streams. For example, fertilization activities should be limited to a slow-release variety and buffers should be maintained along streams, wetlands, and lakes.
- both watersheds, but Cranby Lake in particular, are sensitive to changes in temperature. To minimize the potential for summer temperature increases, streamside vegetation should be maintained within a reserve zone along all tributary streams of Cranby Lake and Ballpark Creek. The reserve zone width should also be assessed for windthrow hazard.

Roads

- as noted by the terrain mapping report, with the presence of extensive limestone deposits on Texada Island, there is the potential for the existence and development of karst and cave features (sinkholes, caves and underground drainage) that may pose safety risks and other problems during forest development. Underground cavities and channels may transport sediment directly into creeks. It is recommended that, if any karst or cave features be identified during construction, the extent of any sinkholes and potential road building and safety concerns be assessed.
- should development occur in the upper Halley Creek tributary basin, an abandoned water retention structure and washed out section of road should be rehabilitated.

Water quality monitoring, undertaken by the Gillies Bay Improvement District, should continue at sites established at Cranby Lake and on lower Ballpark Creek. Sampled parameters should include phosphate, dissolved phosphorous, nitrate, nitrite, conductivity, turbidity, total organic carbon, coliform bacteria (total and fecal) and temperature.

It is also recommended that an emergency response plan be developed in the event of a disturbance that is detrimental to the water supply. Contact names and numbers should be supplied to all contractors working in the watershed.

7.2 Recommendations for CWAP Update

Under the Forest Practices Code it is recommended that if forest development activities proceed, the CWAP should be updated every three years. If no additional development occurs within the three-year period then it is recommended that the watershed assessment be updated only when it is again proposed. The update will provide a watershed status report and will provide an opportunity to re-evaluate the potential effects of proposed development activities.

8.0 CLOSURE

Services performed by EBA for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practising under similar conditions in the jurisdiction in which the services are provided. Professional judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the results, comments, recommendations, or any other portion of this report.

Respectfully submitted,

EBA ENGINEERING CONSULTANTS LTD.

Prepared by:

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Geomorphologist/Hydrologist

Reviewed by:

PROFESSIONAL PROVINCE OF C. S. BABAKAIFF BRITISH COLUMBIA GEOSCIENTIST

31/10/00

Scott Babakaiff, M.Sc., P.Geo.
Geomorphologist/Hydrologist

Minor ravelling along road cuts constructed in glaciofluvial material and reworked morainal material was observed by Contour Geoscience Ltd. (2000).

Soil surface erosion, which refers to the detachment, entrainment and transport of mineral soil by running water, is accelerated after vegetation has been removed and mineral soil has been exposed. Factors that effect surface erosion potential are soil texture, soil moisture, soil structure, permeability, soil thickness, slope steepness, slope position, abundance of seepage and catchment area. The rate of erosion is also affected by the extent of compaction of the soil as well as the amount of cementation and alteration of the soil. Slopes overlain with compact till are generally less erodible than slopes covered with loose glaciofluvial material that may be more prone to raveling.

The soils on Texada Island area are generally fine to medium textured as they are derived from fine to medium grained (sedimentary, limestone and volcanic) or medium to coarse grained (granitic and volcanic) bedrock sources. This, combined with biogeoclimatic factors, the drainage of the soils, or abundant seepage due to soils being moist throughout most of the year results in the soils being susceptible to surface erosion. Drainage is rapid over rock controlled slopes but is imperfect to very poor in depressions, and may be more erodible.

Contour Geoscience Ltd. (2000) mapped soil susceptibility to erosion. The results indicate that, in the Cranby Creek watershed, there are 7.23 ha (0.8% of watershed) with a high surface erosion potential. In the Ballpark Creek watershed, there are 19.61 ha (2.1% of watershed). Soils with a high erosion potential are those on moderately steep to steep slopes (50-65%), overlain with finely textured materials. Areas of erodible soils are imperfectly drained to very poorly drained. As observed by Contour Geoscience Ltd. (2000), there has been erosion of trails and harvested areas along moderately steep to steep slopes in the area. Concentrating water flow in ditches, along roads and trails has increased erosion rates. Road cuts in wet, fine grained material are inherently unstable as subsurface water flow is brought to the surface, increasing runoff. Seepage zones are subject to ongoing surface erosion and raveling. Road cuts through this type of terrain should be of a minimal length and height. This may be accomplished by avoiding the areas, but should access be required across these sites road grade steepening should reduce the disturbed area.

5.3 Channel Assessment Results

The study area watersheds are relatively small and the associated stream channels are correspondingly small. The channels do not occupy distinguishable floodplains and the hydraulic energy available to mobilize sediment stored within the channel is relatively small and limited to occasional storm-generated peak flow events.

A summary of stream channel characteristics is provided on a reach-by-reach basis for the Cranby Creek and Ballpark Creek watersheds (see Table 5.2). The results indicate

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Appendix A

Interim Report

CANTEST

CANTEST LTD.
Professional
Analytical
Services

4606 Canada Way
Burnaby, B.C.
V5G 1K5

FAX: 604 731 2386

TEL: 604 734 7276

1 800 665 8566

REPORT ON: ~~Interim Report~~

REPORTED TO: Gillies Bay Improvement
Box 102
Gillies Bay, B.C.
V0N 1W0

Att'n: Jessie Parson

CHAIN OF CUSTODY: 31699

NUMBER OF SAMPLES: 5

REPORT DATE: June 20, 2000

DATE SUBMITTED: June 7, 2000

GROUP NUMBER: 20060709

SAMPLE TYPE: Water

TEST METHODS:

Algae in Water - organisms were identified using procedures described in "Bergy's Manual of Systematic Bacteriology", Volumes 1 to 4, and "Bergy's Manual of Determinative Bacteriology", 8th Edition. This test was performed by a subcontractor. Our report lists the total number of cells and the number of types of algae. Further details are included in the enclosed subcontractor's report.

pH, Laboratory - pH analysis was performed in the laboratory using a pH meter. It must be recognized that the B.C. Ministry of Environment and other regulatory agencies recommend that pH be analyzed immediately upon sample collection. In light of this, pH measurements should be performed in the field.

Conventional Parameters - analyses were performed using procedures based on those described in "British Columbia Environmental Laboratory Manual For the Analysis of Water, Wastewater, Sediment and Biological Materi (1994 Edition), Province of British Columbia and "Standard Methods for the Examination of Water and Wastewater" 19th Edition, (1995) and 17th Edition (1989), published by the American Public Health Association.

Mercury in Water - analysis was performed using procedures based on U. S. EPA Method 1631, oxidative digestion using bromination, and analysis using Cold Vapour Atomic Fluorescence Spectroscopy.

Metals in Water - analysis was performed using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP), Inductively Coupled Plasma-Mass Spectroscopy (ICP/MS) or Graphite Furnace Atomic Absorption Spectrophotometry.

Volatile Organic Compounds in Water and Soil - analysis was performed using procedures based on U.S. EPA Methods 624/8240/8260, involving sparging with a Purge and Trap apparatus and analysis using GC/MS.

TEST RESULTS:

(See following pages)

CANTEST LTD.

Richard S. Jornitz
Supervisor, Inorganic Testing

REPORTED TO: Gillies Bay Improvement

REPORT DATE: June 20, 2000

GROUP NUMBER: 20060709

CANTEST

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		Site 1	Site 2	Site 3	Site 4	DETECTION LIMIT	UNITS
CANTEST ID:		006070019	006070032	006070033	006070034		
pH, Laboratory		7.20	7.09	7.10	7.12	-	pH units
Conductivity		97	112	111	106	1	µS/cm
True Color		20	15	13	15	5	CU
Turbidity		0.62	0.62	0.52	0.50	0.1	NTU
Hardness	CaCO3	38	40	41	40	1	mg/L
Total Dissolved Solids		66	75	81	71	10	mg/L
Total Solids		66	77	81	74	1	mg/L
Total Suspended Solids		<	<	<	<	1	mg/L
Total Alkalinity	CaCO3	46.1	46.6	42.8	42.9	0.5	mg/L
Fluoride	F	<	<	<	<	0.05	mg/L
Nitrate and Nitrite	N	0.06	0.08	0.04	0.05	0.02	mg/L
Total Organic Carbon	C	8.0	7.9	8.2	8.4	1	mg/L
Total Phosphorus	P	<	<	<	<	0.02	mg/L
Total Diss. Phosphorus	P	<	<	<	<	0.02	mg/L

µS/cm = microsiemens per centimeter
NTU = nephelometric turbidity units
< = Less than detection limit

CU = color units
mg/L = milligrams per liter

REPORTED TO: Gillies Bay Improvement

REPORT DATE: June 20, 2000

GROUP NUMBER: 20060709

CANTEST

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		Site 5	DETECTION LIMIT	UNITS
CANTEST ID:		006070035		
pH, Laboratory		6.98	-	pH units
Conductivity		112	1	µS/cm
True Color		15	5	CU
Turbidity		0.63	0.1	NTU
Hardness	CaCO3	42	1	mg/L
Total Dissolved Solids		81	10	mg/L
Total Solids		81	1	mg/L
Total Suspended Solids		<	1	mg/L
Total Alkalinity	CaCO3	43.4	0.5	mg/L
Fluoride	F	<	0.05	mg/L
Nitrate and Nitrite	N	0.07	0.02	mg/L
Total Organic Carbon	C	8.6	1	mg/L
Total Phosphorus	P	<	0.02	mg/L
Total Diss. Phosphorus	P	<	0.02	mg/L

µS/cm = microsiemens per centimeter
NTU = nephelometric turbidity units
< = Less than detection limit

CU = color units
mg/L = milligrams per liter

CANTEST

REPORTED TO: Gillies Bay Improvement

REPORT DATE: June 20, 2000

GROUP NUMBER: 20060709

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		Site 1	Site 2	Site 3	Site 4		
SAMPLE PREPARATION:		TOTAL	TOTAL	TOTAL	TOTAL	DETECTION LIMIT	UNITS
CANTEST ID:		006070019	006070032	006070033	006070034		
Aluminum	Al	0.007	0.010	0.010	0.008	0.005	mg/L
Antimony	Sb	<	<	<	<	0.001	mg/L
Arsenic	As	<	<	<	<	0.001	mg/L
Barium	Ba	0.003	0.004	0.003	0.004	0.001	mg/L
Boron	B	<	<	<	<	0.05	mg/L
Cadmium	Cd	<	<	<	<	0.0002	mg/L
Chromium	Cr	<	<	<	<	0.001	mg/L
Copper	Cu	0.008	0.25	0.16	0.073	0.001	mg/L
Iron	Fe	0.07	0.08	<	<	0.05	mg/L
Lead	Pb	<	0.003	0.001	<	0.001	mg/L
Magnesium	Mg	1.93	1.28	1.34	1.47	0.05	mg/L
Manganese	Mn	0.016	0.007	0.011	0.011	0.001	mg/L
Mercury	Hg	<	<	<	<	0.02	µg/L
Selenium	Se	<	<	<	<	0.002	mg/L
Silicon	SiO2	1.37	2.42	2.11	1.89	0.05	mg/L
Uranium	U	<	<	<	<	0.0005	mg/L
Zinc	Zn	0.11	0.018	0.006	<	0.005	mg/L

mg/L = milligrams per liter

µg/L = micrograms per liter

< = Less than detection limit

REPORTED TO: Gillies Bay Improvement

REPORT DATE: June 20, 2000

GROUP NUMBER: 20060709

CANTEST

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		Site 5		
SAMPLE PREPARATION:		TOTAL		
CANTEST ID:		006070035	DETECTION LIMIT	UNITS
Aluminum	Al	0.009	0.005	mg/L
Antimony	Sb	<	0.001	mg/L
Arsenic	As	<	0.001	mg/L
Barium	Ba	0.004	0.001	mg/L
Boron	B	<	0.05	mg/L
Cadmium	Cd	<	0.0002	mg/L
Chromium	Cr	<	0.001	mg/L
Copper	Cu	0.79	0.001	mg/L
Iron	Fe	0.09	0.05	mg/L
Lead	Pb	0.003	0.001	mg/L
Magnesium	Mg	1.95	0.05	mg/L
Manganese	Mn	0.014	0.001	mg/L
Mercury	Hg	<	0.02	µg/L
Selenium	Se	<	0.002	mg/L
Silicon	SiO2	1.80	0.05	mg/L
Uranium	U	<	0.0005	mg/L
Zinc	Zn	0.018	0.005	mg/L

mg/L = milligrams per liter
< = Less than detection limit

µg/L = micrograms per liter

REPORTED TO: Gillies Bay Improvement

REPORT DATE: June 20, 2000

GROUP NUMBER: 20060709

CANTEST

Trihalomethanes in Water

CLIENT SAMPLE IDENTIFICATION:	Site 1	Site 2	Site 3	Site 4	
CANTEST ID:	006070019	006070032	006070033	006070034	DETECTION LIMIT
Bromodichloromethane	<	5.1	6.8	6.2	0.1
Bromoform	<	<	<	<	0.2
Chloroform	<	110	220	180	0.3
Dibromochloromethane	<	<	<	<	0.1
Surrogate Recovery					
1,2-Dichloroethane-d4	100	103	107	106	-
Toluene-d8	91	90	91	92	-
Bromofluorobenzene	96	93	98	96	-

Results expressed as micrograms per liter (μg/L)
Surrogate recoveries expressed as percent (%)
< = Less than detection limit

CANTEST

REPORTED TO: Gillies Bay Improvement

REPORT DATE: June 20, 2000

GROUP NUMBER: 20060709

Trihalomethanes in Water

CLIENT SAMPLE IDENTIFICATION:	Site 5	DETECTION LIMIT
CANTEST ID:	006070035	
Bromodichloromethane	7.0	0.1
Bromoform	<	0.2
Chloroform	180	0.3
Dibromochloromethane	<	0.1
Surrogate Recovery		
1,2-Dichloroethane-d4	120	-
Toluene-d8	93	-
Bromofluorobenzene	101	-

Results expressed as micrograms per liter (µg/L)
Surrogate recoveries expressed as percent (%)
< = Less than detection limit

REPORTED TO: Gillies Bay Improvement

REPORT DATE: June 20, 2000

GROUP NUMBER: 20060709

CANTEST

Algae Analysis in Water

CLIENT SAMPLE IDENTIFICATION:	CANTEST ID	Total Cells	Number of Algae Types
Site 1	006070019		
Site 2	006070032		
Site 3	006070033		
Site 4	006070034		
Site 5	006070035		
DETECTION LIMIT		-	-
UNITS		Cells/100 mL	

Cells/100 mL = Cells per 100 mL

REPORTED TO: Gillies Bay Improvement

REPORT DATE: June 20, 2000

GROUP NUMBER: 20060709

Microbiological Analysis in Water

CLIENT SAMPLE IDENTIFICATION:	Site 1	Site 2	Site 3	Site 4		
CANTEST ID:	006070019	006070032	006070033	006070034	DETECTION LIMIT	UNITS
Total Coliform (Confirmed)	-	<	12	134	1	Col./100 mL
Fecal Coliform	-	<	<	<	1	Col./100 mL
Total Coliform (Confirmed)	7	-	-	-	2	MPN/100mL
Fecal Coliform	<	-	-	-	2	MPN/100mL

Col./100 mL = Colonies per 100 mL
< = Less than detection limit

MPN/100mL = Most Probable Number / 100 mL

CANTEST

REPORTED TO: Gillies Bay Improvement

REPORT DATE: June 20, 2000

GROUP NUMBER: 20060709

Microbiological Analysis in Water

CLIENT SAMPLE IDENTIFICATION:	Site 5		
CANTEST ID:	006070035	DETECTION LIMIT	UNITS
Total Coliform (Confirmed)	<	1	Col./100 mL
Fecal Coliform	<	1	Col./100 mL

Col./100 mL = Colonies per 100 mL
< = Less than detection limit

Appendix B

TABLE B1: LIST OF LOGGED AREAS AND CALCULATED ECAS IN THE CRANBY LAKE WATERSHED

Map Sheet No.	Polygon ID	Projected Ht. (1999)	Hydrologic Recovery (%)	Area (ha)	ECA (ha)	ECA (%)
092F078	101	19.3	90	0.51	0.05	0.01
092F078	101	19.3	90	1.86	0.19	0.02
092F078	332	19	90	3.20	0.32	0.04
092F078	101	19.3	90	1.42	0.14	0.02
092F078	101	19.3	90	19.67	1.97	0.22
092F078	309	16.6	90	0.16	0.02	0.00
092F068	16	19.3	90	65.09	6.51	0.73
092F068	184	27.8	90	17.94	1.79	0.20
092F068	182	22.3	90	15.21	1.52	0.17
092F068	153	20.7	90	11.13	1.11	0.13
092F068	202	23.3	90	0.31	0.03	0.00
092F068	181	0	0	8.86	8.86	1.00
092F068	178	0	0	1.43	1.43	0.16
092F068	166	0	0	3.95	3.95	0.44
TOTAL				**150.74 (16.9%)**	**27.89**	**3.13**

TABLE B2: LIST OF LOGGED AREAS AND CALCULATED ECAS IN THE BALLPARK CREEK WATERSHED

Map Sheet No.	Polygon ID	Projected Ht. (1999)	Hydrologic Recovery (%)	Area (ha)	ECA (ha)	ECA (%)
092F068	16	19.3	90	4.50	0.45	0.05
092F068	202	23.3	90	43.83	4.38	0.47
092F068	11	4.2	25	0.04	0.03	0.00
092F068	11	4.2	25	1.04	0.78	0.08
092F068	153	20.7	90	19.64	1.96	0.21
092F068	41	5	25	10.18	7.64	0.82
092F068	217	14.7	90	15.75	1.57	0.17
092F068	11	4.2	25	0.01	0.01	0.00
092F068	165	4	25	9.87	7.40	0.80
092F068	227	11.6	90	24.68	2.47	0.27
092F068	226	23.2	90	25.82	2.58	0.28
092F068	164	4	25	3.52	2.64	0.28
092F068	291	1.5	0	5.32	5.32	0.57
092F068	154	23.1	90	0.29	0.03	0.00
092F068	290	1.5	0	5.13	5.13	0.55
092F068	152	20.8	90	28.10	2.81	0.30
092F068	154	23.1	90	7.63	0.76	0.08
092F068	162	3.1	25	18.76	14.07	1.52
092F068	30	7.1	75	13.26	3.32	0.36
092F068	146	22.3	90	30.48	3.05	0.33
092F068	292	5	25	6.04	4.53	0.49
092F068	177	2.5	0	4.84	4.84	0.52
092F068	148	0	0	13.32	13.32	1.44
092F068	147	9.1	90	4.66	0.47	0.05
092F068	293	0.7	0	6.91	6.91	0.74
092F068	305	0.3	0	5.77	5.77	0.62
092F068	515	0.7	0	0.97	0.97	0.10
092F068	134	24.2	90	8.93	0.89	0.10
092F068	135	0	0	5.50	5.50	0.59
092F068	136	0	0	28.63	28.63	3.09
TOTAL				**353.43 (38.1%)**	**138.24**	**14.90**

Appendix C

Photo 1 – Cranby Lake, view from dam (June, 2000)

Photo 2 – Lower Ballpark Creek (June, 2000)

Photo 3 – Washed out water diversion structure on Halley Creek (June, 2000)

Photo 4 – Halley Creek, washed out section of road downstream from water diversion structure (June, 2000)