MILNE COMMUNITY WATERSHED ASSESSMENT

Halfmoon Bay, BC

Project Number: 19-183

March 1, 2021

Client:

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EARTH WATER LAND

RECOMMENDATIONS SUMMARY

Sechelt Community Projects Inc. (SCPI), on behalf of the Sunshine Coast Community Forest (SCCF), retained Statlu Environmental Consulting Ltd. to complete a watershed assessment for Milne Community Watershed, near Halfmoon Bay, BC. The assessment was requested to evaluate the cumulative hydrologic risks from proposed harvesting and to provide recommendations to guide future forest development.

There are several water license points of diversion on Milne Creek and Trout Lake. Several fish species have been identified in Milne Creek and Trout Lake. A power transmission line and natural gas pipeline cross the watershed.

SCCF proposes to harvest Block HM50, which lies partially within the watershed. The current equivalent clearcut area (ECA) and forecast ECA (Table 7), including the proposed harvest of Block HM50, indicate that there is low likelihood of forestry affecting peak flow and overall hydrology in the watershed. The current and proposed road density presents moderate to high hydrologic risk.

ECA and Road Density Summary Table

Current ECA		ECA 2020 to 2023		ECA 2023 to 2026		Current Road Density		2020 to 2026 Road Density	
ha	%	ha	%	ha	%	km/km²	Km	km/km²	km
29.4	6.8	43.9	9.9	41.8	9.6	1.8	7.8	2.0	8.8

The moderate to high risk associated with roads can be managed and reduced by identifying unneeded roads in the watershed and deactivating them, but much of the risk results from the permanent access corridors of the transmission line, gas pipeline, and highway. This risk will not be changed by the forestry activity if planned roads are constructed as temporary roads and deactivated soon after use. The incremental risk resulting from forestry roads in the watershed is low.

If additional harvesting is planned, the watershed should be reassessed in 2026 to reevaluate ECA and to consider the effectiveness of present forest management.

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1.0 INTRODUCTION

Sechelt Community Projects Inc. (SCPI), on behalf of the Sunshine Coast Community Forest (SCCF) retained Statlu Environmental Consulting Ltd. (Statlu) to complete a watershed assessment for Milne Community Watershed, near Halfmoon Bay, BC. The SCCF tenure overlaps the Milne Community Watershed and proposed harvesting in the overlap area triggers a watershed assessment to determine the effects that harvesting might have on watershed hydrology.

The watershed assessment is a cumulative effects assessment of past, present, and planned future watershed conditions and is intended to guide future forestry activity in the watershed. The results of the assessment will help SCCF forest and land managers guide development so that planned forest practices are hydrologically sustainable and maintain a low likelihood of altering channel stability, sedimentation, timing of flows, and effects on peak and low flows in the watershed.

The normal format and methodology for a watershed assessment in coastal British Columbia is the Coastal Watershed Assessment Procedure (CWAP). The CWAP methodology considers potential effects of forest harvesting on peak and low flow magnitudes, timing of flows, water quality, riparian forest, and channel morphology. This assessment follows current best practices in evaluating the hydrologic effects of forestry, in particular using the Hudson and Horel (2007) revised methods of calculating equivalent clearcut area (ECA). In 2020, Engineers and Geoscientist BC (EGBC) and the Association of BC Forest Professionals (ABCFP) released a joint practice guideline for watershed assessments in the forest industry[1]. This assessment follows this guideline.

[1] https://www.egbc.ca/getmedia/8742bd3b-14d0-47e2-b64d-9ee81c53a81f/EGBC-ABCFP-Watershed-Assessment-V1-0.pdf.aspx

2.0 OVERVIEW AND BACKGROUND

Milne Community Watershed is on the Sunshine Coast, about 2 km east of Halfmoon Bay (Figure 1). It was legally designated as a community watershed on June 15, 1995. It includes Trout Lake, an unnamed wetland, and Milne Creek. The Sunshine Coast Highway (Highway 101) crosses the watershed on the south side of Trout Lake. A power transmission line and a natural gas pipeline cross on the north side of the lake. Mountain bike trails are present in the watershed, especially the area south of Highway 101.

The total watershed area is 435 ha (4.35 km^2) and the SCCF tenure within the watershed is 82.8 ha (0.83 km^2). The SCCF tenure is north of the power transmission line, on the east side of the watershed.

2.1 Previous Hydrological Assessments

Milne Community Watershed was last assessed in 1997[2]. The assessed 1997 Milne Community Watershed boundary is not the same as the current boundary. The modern watershed includes what was divided into Milne and Trout sub-basins in the 1997 report. The ECA for the Milne Creek basin was 2% and 8% in the Trout Creek basin. The Milne Creek road density was 0.39 km/km^2 and 0.95 km/km^2 in Trout Creek. These results did not trigger any requirements for a more detailed assessment.

2.2 Land Use

Milne Community Watershed lies in the traditional territory of the shíshálh people. The modern shíshálh Nation has a land use plan for their traditional territories that includes a brief history (shíshálh Nation, 2007). They have lived on their lands and used their resources since time immemorial. They hunted, fished, and gathered shellfish and other food, depending on the season. Salmon were the most important food, but ungulates and sea mammals were also

[2] Summit Environmental Consultants Ltd. 1997. Final Report: Halfmoon Creek, Trout Lake, and Milne Creek Watershed Assessments.

used. They preserved and stored foods near their communities, where people gathered during the winter months. The larger communities, near kálpilín (Pender Harbour) and ch'átlich (Sechelt), were occupied year round. Contemporary shíshálh Nation members harvest their reduced marine and terrestrial resources, including cedar, wild foods, and medicines, to support a resurgence of their culture.

Land use, since 1947, was described by studying historic black and white aerial photography and digital imagery (Table 1). The oldest air photos do not capture the baseline condition of the watersheds but they are the earliest record available.

Table 1: Historic air photographs – Milne Community Watershed

Air Photo Numbers	Date	Observations
BC349:17-19 BC401: 29-30	1947	The road on the south side of Trout Lake is visible. It is hard to tell if it is paved, but it is most likely a gravel road because the alignment follows the modern day forestry road on the west side of the lake and the modern road is not paved. Much of the land is cleared or harvested. Cutblocks are evident because they have skid trails, yarding corridors, and roads. Some of the clearings are larger with more variable boundaries, suggesting that they are old fire scars. The area north of Trout Lake has been harvested, but is revegetating with trees that are large enough to be visible on the photos.
BC1230: 96-98	1950	The area appears very similar to the 1947 condition.
BC2097: 27-30	1957	The powerline right-of-way is visible on the north side of Trout Lake. The highway on the south side of the lake now follows the modern alignment and is paved. There is new selective harvesting on the south side of the lake with yarding corridors visible between standing trees. A clearing is visible where a landfill operated, but features in the clearing are not discernible at the photo scale. All trees and ground cover was removed from the landfill, forming a rectangular clearing with an abrupt transition from clearing to forest.
BC5102: 020-021	1964	The watershed is similar to the 1957 photos. There is more residential and urban development visible at Halfmoon Bay, west of the watershed.
BC4426: 233-235 BC4426: 193-195	1967	A narrow road or trail is visible that starts on the east side of Trout Lake on the south side of the highway. Several log booms are visible in the water near Halfmoon bay. The forest road on the west side of Trout Lake (Trout Lake FSR) is wider than in earlier images. The landfill is in use.
BC5758: 277-279	1975	The access road between the Trout Lake FSR and the landfill is hard to see despite the more detailed photos compared to the earlier sets. The forest in the watershed is noticeably taller, with an even canopy on the north side of the lake. The topography has a hummocky surface form on both sides of the lake. Older cutblocks, north of the watershed, are greening up.
30BC80060:195-195	1980	A new cutblock north of the landfill is visible. Overall watershed condition is similar to 1975.
30BC85015: 193-195 30BC85015: 218-221	1985	The photos show greater detail than earlier sets. A new cutblock clearing is visible on the south side of the watershed. There is additional clearing near the landfill that might be to improve the nearby road that heads to the north. A new logging road on the east side of the watershed is visible.

Air Photo Numbers	Date	Observations
30BC90014:185-187 30BC90014: 134-136	1990	The cutblock on the south side is still visible and is starting to green up but branch roads are still visible. The access roads near the powerline are clearly visible. The landfill is now capped and is starting to green up. A few new cutblocks are visible to the east of the watershed.
30BC94079: 57-59 30BC94079: 120-122 30BC94079: 132-133	1994	The part of the watershed south of the highway is similar to the 1990 image. Harvesting to the east of the watershed is advancing along the mainline road. There is a new block to the west of the watershed. The landfill cover is much more vegetated than on earlier images.
FFC9700: 284	1997	Blocks surrounding the watershed are greening up. No new harvest is visible in the watershed. More residential and urban development is visible outside the watershed near Halfmoon Bay.
30BCC03039:83-85 30BCC03039: 99-101	2003	Vegetation is visible in the powerline right of way. No new development is visible in the part of the watershed south of the highway. The landfill is hard to see with the vegetation growing over it. Otherwise, the image is similar to 1997 image.
Google Earth digital imagery	2014	Three new cutblocks (or openings) are adjacent to the power transmission line right of way. Each block has roads. The landfill is identifiable by its mainly deciduous forest. The remainder of the watershed appears similar to the 2003 photos.

According to the Sunshine Coast Regional District's (SCRD) Solid Waste Management Plan[3], the landfill was closed in 1987 to 1988 according to a landfill closure plan. It continues to have annual inspections and litter clean-up. Surface water near the landfill is monitored for landfill leachate. No information was provided about the status of the surface water monitoring, but it is likely that the SCRD receives water sample analysis reports that may be accessible to the SCCF.

2.3 Watershed Resources

Several species of fish are known to live in the watershed, including cutthroat trout and threespine stickleback (Habitat Wizard, 2020). Rainbow trout were observed at the mouth of Milne Creek, outside the watershed, in 1980. No barriers to fish passage are identified on the habitat mapping, but cascades on Milne Creek, near where it reaches the watershed boundary, are probable barriers.

[3] https://www.scrd.ca/files/File/Infrastructure/Solid%20Waste/SWMP%20Final%20Report%20Proofed%2010-31-11%20w%20AppB%20WEB.pdf

Milne Community Watershed is crisscrossed by a network or mountain bike trails. The trails are concentrated in the part of the watershed that lies between the ocean and Highway 101, but there are several trails north of Trout Lake. The trails are maintained by local community groups in an ad hoc manner.

There are several water license points of diversion within the watershed (Table 2 and Figure 1).

Table 2: Water License Points of Diversion

Stream Name	License Status	Purpose	Quantity	Units	Licensee
Trout Lake	Abandoned Application	Domestic	0.136	MD	Carter R and D
Trout Lake	Current	Stream storage: non-power	49339.2	MY	SCRD
Milne Creek	Current	Domestic	4.546	MD	Bowie, S
Milne Creek	Current	Waterworks: local provide	124449.214	MY	SCRD
Trout Lake	Current	Waterworks: local provide	82966.143	MY	SCRD
Milne Creek	Abandoned	Domestic	4.546	MD	Ruiter, W and L
Trout Lake	Current	Waterworks: local provide	124449.214	MY	SCRD

A power transmission line crosses the watershed on the north side of Trout Lake and a natural gas pipeline also crosses the watershed.

2.4 Physiography and Geology

Milne Community Watershed lies on the transition between the Georgia Lowland and the Pacific Ranges of the Coast Mountains (Holland, 1976). Glaciers from the Coast Mountains to the east and the Insular Mountains to the west coalesced and flowed southward along the Georgia Depression, eroding and modifying the terrain of the Georgia Lowland. The Pacific Ranges of the Coast Mountains also bear the marks of past glaciations with high mountain peaks with cirques.

There are two mapped bedrock units underlying the watershed, with the contact trending northwest to southeast on the south side or Trout Lake (iMapBC, 2020). Bedrock on the north side of the lake is Late Jurassic-aged dioritic intrusive rock, 145.3 to 157.1 million years old. On the south side of the lake, the bedrock is Early-Cretaceous-aged granodiorite intrusive rock (97 to 145.6 million years old).

Surficial materials in the watershed are a veneer of rubbly sandy till with discontinuous organic sediments in bedrock depressions. Gravelly, sandy fluvial deposit are found in stream channels. The soils are rapidly to well-drained, but runoff is controlled by the hummocky topography of the underlying bedrock.

2.5 Hydrology

The nearest gauged stream is Roberts Creek, about 21 km southeast of Milne Community Watershed. Roberts Creek drains a 32.6 km^2 watershed, which is an order of magnitude larger. However, the climate, aspect, and physiography between the two locations is similar so it is likely that stream hydrology is similar. Peak flows on Roberts Creek occur most often between November and February and the lowest flow occurs between July and September (Wateroffice, 2020).

2.6 Climate

Rainfall and rain-on-snow events cause peak streamflow in the watershed. Precipitation varies with elevation with the highest precipitation occurring at the highest elevations so two locations, one at 140 m and the other at 480 m elevation, were used to describe the climate (Table 3).

Table 3: Representative Climatic Variables from ClimateWNA from the 1981 to 2000 interval (Wang et al., 2016).

Elevation of Representative Location (m asl)	Mean Annual PPT (mm)	Rainfall (mm)	Snowfall (cm)	Total Autumn Winter PPT	Reference ET (mm)	Notional Runoff (PPT - ET) (mm)
140 m	1203	1158	45	953	612	591
480 m	1836	1692	144	1466	597	1239

Peak runoff will be driven by high precipitation events. Rain-on-snow events magnify the effect of storms and will produce the largest floods. Purely snowmelt-driven floods occur in spring, but are not as large as fall and winter rainfall- or rain-on-snow peaks.

2.7 Climate Change

The climate is changing, and this has had, and will have, an effect on watershed hydrology. Understanding these changes is necessary in order to separate and distinguish climate change from the effects of forest management on hydrologic conditions in the watersheds. Modeling climate change is useful for evaluating the direction and possible magnitude of trends in climate factors that affect streamflow in order to estimate changes in streamflow.

The Plan2Adapt tool provides a summary for of the projected climate changes for the regional districts in BC, including SCRD (Table 4) (PCIC, 2020). The tool uses a standard set of climate projection data to generate the output.

Table 4: Summary of Climate Change for Sunshine Coast in the 2050s

Climate Variable	Season	Projected Change from 1961-1990 Baseline	
		Ensemble Median	Range (10th to 90th percentile)
Mean Temperature (°C)	Annual	+1.6 °C	+1.0 °C to +2.5 °C
Precipitation (%)	Annual	+6%	-2% to +11%
	Summer	-16%	-25% to +2%
	Winter	+6%	-4% to +15%
Snowfall* (%)	Winter	-34%	-54% to -17%
	Spring	-54%	-73% to -17%

* *These values are derived from temperature and precipitation.*

ClimateWNA predicts climate change (Table 5) by using three General Circulation Models (CanESM2, CNRM-CM5, and HADGM ES-2) under different Representative Concentration Pathways (RCP 4.5 and RCP 8.5) (Wang et al., 2016). RCPs approximate greenhouse gas emissions. Under the RCP 4.5 scenario, emissions peak by 2040 and decline thereafter. Emissions continue to increase under the RCP 8.5 scenario, representing a worst case scenario or unabated climate change. The modeled predictions for 2085 from two different elevations within the watershed were averaged to estimate potential effects of climate change for the entirety of Milne Community Watershed, using RCP 8.5 to depict a business as usual (worst case) scenario.

Table 5: Predicted Climate Change to 2085 using the Climate WNA Model and RCP 8.5

Year and GCM	MAP[1] (mm)	MSP (mm)	OAP (mm)	PAS (cm)	E Ref (mm)	Runoff (mm)	MAT (°C)	FFP (days)	FFP Start
1981 to 2010 Normals	1520	310	1210	95	605	915	9	211	April 6
2085 (CanESM2)	1593	224	1369	15	777	816	15	323	Jan 21
2085 (CNRM-CM5)	1740	282	1459	25	706	1035	13	305	Feb 3

[1]MAP is mean annual precipitation, MSP is May to September (summer) precipitation, OAP is October to April (winter) precipitation, PAS is precipitation as snow and is reported as snow water equivalent with ~1 cm of snow equal to 1 mm of rainfall, E Ref is evapotranspiration, Runoff is nominal runoff (total precipitation minus predicted evapotranspiration), MAT is mean annual temperature, FFP is frost-free period, and FFP start is the first frost-free day.

The decrease of snow relative to total precipitation is not likely to alter the peak flow regime since it is dominated by precipitation at present. Total annual streamflow will likely remain similar to current conditions despite the increase in precipitation because temperature and evapotranspiration will increase. Summer low flows, however, may be lower and last longer due to the concurrent effects of decreased snowpack, earlier melt, increased temperature, and increased evapotranspiration. The most notable change will be an expected increase in water temperature due to the reduced snowpack, increased air temperatures, and lower flows that persist for longer than at present in summer.

3.0 ASSESSMENT METHODS

3.1 Rationale for Assessment

The potential for forest harvesting and road building to affect watershed hydrology were assessed using the established rationale of the Coastal Watershed Assessment Guidebook (1999) and Hudson and Horel (2007). This assessment method examines the cumulative effects of past harvesting, and evaluates the partial risk of future logging and its effects on hydrologic regimes. The assessment considers changes in forest cover, forest stand age, and forest species composition through the mechanism of equivalent clearcut area (ECA). It also considers hydrologic risk from roads, sedimentation hazards posed by road networks and landslides, changes to riparian forest, and changes in channel patterns. A detailed description of the rationale for assessment and the assessment methods used, particularly in the delineation of the transitions between rainfall and rain-on-snow zones, is presented below and Appendix 3.

3.1.1 Peak Flow Generating Hydrologic Processes

The CWAP guidebook (1995, 1999) recommends using three elevation bands (sea level to 300 m, 300 m to 800 m, and 800 m and up) for evaluating hydrologic recovery, corresponding to the rainfall, rain-on-snow, and snowmelt-dominated portions of the watershed. Hudson and Horel (2007) discriminate between warm rain-on-snow and cold rain-on-snow: warm rain liberates more water from a snowpack than cold rain does. Milne Community watershed ranges in elevation from 60 m to 520 m, so it was divided into two elevation zones. I used the standard rainfall-only zone for the terrain below 300 m elevation and a warm rain-on-snow zone for areas within the watershed above 300 m elevation.

All of the watersheds in the study area are within Snowpack Accumulation Zone 4 (Hudson 2000; Hudson and Horel 2007). I calculated expected peak snowpack depths for each elevation band within the watershed above 300 m based on the midpoint elevation of the band, as follows:

Table 6: Elevation Bands, Flood Processes, and Peak Snowpack Depths

Elevation Band (m)	Flood Generating Process	Peak Snowpack Depth (m)
0-300	Rain	0
300 -800	Warm rain-on-snow	1.6

3.1.2 Age of Full Recovery

The provincial Vegetation Resources Inventory (VRI) dataset defines tree height and age for each forest cover polygon based on field surveys added to the database over time, with a projection date of January 1, 2017. It does not include recent events, such as logging or fire. To determine present ECA, the projections were extended to January 1, 2019 and all recent cut blocks and fires were incorporated into the 2019 ECA calculations.

The age of full recovery is determined by looking at canopy dominant tree age, height, and historic forest disturbance from fire. Any disturbance within the historic period, whether from fire, logging, etc., is considered for hydrologic effects, but effects from before the historic period are considered to be natural.

Stands older than 100 years were assumed to be fully hydrologically recovered. It is probable that much of the watershed was harvested before the air photo record began in 1947, but, judging from the appearance of the stands on the 1947 imagery, the harvesting most likely occurred between 1920 and 1947, therefore stands older than that were likely not harvested.

3.1.3 Snow Depth and Recovery Thresholds

Milne Creek is entirely within Snowpack Zone 4 as defined by Hudson (2000). I used the Snowpack Zone 4 equation from Hudson and Horel (2007) to estimate the expected peak snowpack depth within the rain-on-snow elevation band, using the median elevation of the zone (410 m) to estimate snowpack depth for the whole zone from 300 m to 520 m. The equation predicts a peak snowpack depth of 1.1 m. The height threshold for the start of recovery for young stands in rain-on-snow elevation bands is 0.5 m greater than the expected maximum snowpack depth at the same elevation (Hudson and Horel, 2007). Therefore, a threshold of 1.6 m was used to calculate the start of hydrologic recovery and resultant ECA throughout the watersheds, although the recovery equations differ between the rain-on-snow and snowmelt zones.

3.2 Identification of Hydrologic Risks

Hydrologic assessment of the risks posed by forest disturbance identifies and characterizes potential sources of disturbances (either natural or human-caused) that can potentially affect hydrologic parameters of value. These risks result from the presence of the parameters of value and the likelihood (hazard) that natural and human-caused disturbances can affect those parameters of value. Risk assessment requires identification of risks, determination of the level of risk, evaluation of means to alter or reduce the risk, and evaluation of the acceptability of the unmodified and modified levels of risk. Ultimately, determination of the acceptability of a particular level of risk is the responsibility of land managers and statutory decision-makers.

With respect to Milne Community Watershed, identified hydrologic risks include:

- Changes in the timing, duration, magnitude, or frequency of stream flows, including peak flows (floods), low flows, and mean flows, that could result in changes to the amount of usable water for water licensees, reductions in flow or water level for fish, or damage to infrastructure.
- Decreases in channel stability either due to increased sedimentation or to channel avulsion, that could result in sedimentation at water intakes or loss of riparian habitat;
- Changes in water quality as a result of increased sedimentation or changes in stream temperature that could adversely affect drinking water quality, fish or fish habitat; and
- Changes in channel pattern and riparian function that could affect fish habitat;

The primary parameters of value (elements at risk) with respect to these risks include water supply and water quality for water users. Secondary parameters of value are fish and fish habitat. Tertiary parameters of value include transportation infrastructure in the watersheds, including highways, logging roads, mountain bike trails, bridges, and culverts, that could be affected by increased peak flows. This ranking of risks is based on their identified sensitivity to potential changes and to their perceived significance. The watershed is a designated community watershed, so licensed use of water is given the highest significance. Changes to low flows will not affect transportation infrastructure, but could affect fish and fish habitat; therefore, fish habitat has a higher sensitivity to disturbance and is consequently the secondary parameter of value.

The watershed assessment method includes evaluation of the cumulative effects of past harvesting and road construction on watershed properties, and the partial risk from future logging and its effects on hydrologic regimes. The assessment considers changes in forest cover, forest stand age, and forest species composition. It also considers hydrologic risk from roads, sedimentation hazards posed by road networks and landslides, changes to riparian forest, and changes in channel patterns. A detailed description of the rationale for assessment and the assessment methods used, particularly in the delineation of the transitions between rainfall and rain-on-snow zones, is presented in Appendix 2.

3.3 GIS Analysis

GIS analysis was used to prepare the data for ECA calculation. The watershed was divided into elevation bands using TRIM contours as the input elevation. The watershed boundary and elevation bands were then intersected with the VRI data. The resultant attribute table was exported for ECA calculation using Excel. Block and road data, both existing and proposed, was intersected with the watershed boundary and the resulting attributes were also exported for further analyses. SCCF provided GIS data that showed their proposed harvest and road building in the watershed. Blocks (proposed and harvested) and roads were clipped to the watershed boundary so only those parts of each feature that lie within the watershed was considered in the ECA analysis.

3.4 Hydrologic Recovery of Unvegetated Polygons

Watersheds contain areas that will never become forested and thus do not count towards estimates of equivalent clearcut area, for example, unvegetated, unforested, or non-productive forestland with small trees such as wetlands or alpine forest. All forest cover polygons were reviewed so that all polygons describing non-vegetated and non-productive lakes, rivers, or bedrock outcrops were considered 100% hydrologically recovered. Areas temporarily deforested, even if by natural processes, such as patches with shrub vegetation, are considered to be hydrologically recovering in the same way as logged patches, and their effects are summed with logging to evaluate cumulative hydrologic effects.

4.0 RESULTS

4.1 Field Inspection

I visited the watershed on October 9, 2019, accompanied by Dave Lasser, RPF of SCCF, and Warren Hansen, RPF of Chartwell Consultants Ltd. We spent about three hours in the watershed making observations of the closed landfill, roads, mountain bike trails, the outlet of Trout Lake, and the entire length of Milne Creek's channel from the lake to the highway crossing. The weather was clear and warm, with no barriers to visibility or access, during the field inspection.

We walked to the north shore of Trout Lake and observed that the riparian area around the lake has mature timber. The primary access to the lake is from the highway that parallels the south shore.

4.2 Roads

The Sunshine Coast Highway (Highway 101) crosses the southern part of the watershed. The other roads within the watershed are all unpaved roads.

The segment of Trout Lake FSR from the highway to the closed landfill has been well maintained. Ditches are clear of debris and should be capable of conveying runoff, reducing the likelihood of erosion from the road. In addition, this segment of road crosses gentle slopes which generally have a low likelihood of erosion. The road crosses one stream in a concrete culvert. The culvert appeared to be in good condition at the time of the assessment.

We walked along the segment of Highway 101 near the outlet of Trout Lake to locate the drainage structure under the highway. We could not see a culvert or identify a clear stream channel on the opposite side of the highway from the lake. The outlet of the lake has had water control, but a valve or other structure was not located in the field.

Several roads provide access to the power transmission line and natural gas pipeline rights-of-way. These roads cross the hummocky terrain north of Trout Lake. Some of these roads have pooling water and localized erosion. Most of the sediment from the eroded segments deposits in depressions that are not connected to the stream network. These roads are used by mountain bikers and motorized recreational vehicles (motorbikes, ATVs, or UTVs). Motorized recreational vehicles cross a ford on a natural gas pipeline road, where the access road is parallel to the FSR, leading to increased erosion at the crossing (Photo 1). I did not observe structures meant to control erosion or sedimentation on the access road.

Photo 1: Ford crossing the natural gas pipeline road, without erosion sediment and control structures and no means to prevent recreational use.

4.3 Bike Trails

There is an extensive network of recreational mountain bike trails in the watershed. Some of the trails follow the alignments of very old roads in the watershed and some have been purposefully constructed. I walked along the 250 m of the north end of the Little Knives trail and 300 m at the end (east side) of Datsun Alley trail. Both trails appeared to be constructed according to accepted trail standards[4], although I did observe erosion on a short, steep section of the Datsun Alley trail. The trails are located away from streams and watercourses so there is a very low likelihood of sediment reaching streams.

4.4 Riparian Assessment and Channel Conditions

Milne Creek, from Highway 1 to the lowest point within the watershed has a step pool morphology with a primarily bedrock channel. Fine sediments (gravels and sands) deposit in pools. Abundant coarse woody debris is present near and in the channel, with many logs shading the channel (Photo 2). There were several water intake pipes along the reach, but they had been damaged by a high flow event. It is likely that they are no longer in use because they had not been repaired.

Trout Lake has an intact riparian forest composed of a mixed coniferous forest with a mossy forest floor, except where Highway 101 parallels the lakeshore. Since the road is paved, there is little opportunity for erosion from the road. Sand, gravel and salt used by highways maintenance operators in winter might enter the lake from the highway.

[4] http://www.sitesandtrailsbc.ca/documents/mountain-bike-policy.pdf

Photo 2: Milne Creek. Note the coarse woody debris jam with wedge of fine sediment in middle of image. The stream flows under the logs, from top of photo to lower left.

4.5 Sediment Source Survey

Erosion from roads is the main sediment source in Milne Community Watershed. Most of the roads do not cross streams, so there is little opportunity for eroded sediment to reach streams. Bed and bank erosion in watercourses is a secondary source of sediment. Stream bank erosion is largely controlled by the coarse woody debris in the streams. The debris forms jams that trap mobile sediment in the channels, regulating the movement of finer-textured sediment (Photo 2). In addition, the jams create beneficial aquatic habitat.

4.6 Road Density

There are 7.8 km of existing roads in the watershed, including 1.4 km of the Sunshine Coast Highway, resulting in 1.8 km/km² road density in the watershed. An additional 1.0 km of road is proposed to be constructed in the 2020 to 2023 timeframe. Road density will increase to 2.0 km/km² when these roads are constructed.

4.7 Equivalent Clearcut Area

The ECA in the watershed is 29.41 ha, or 6.8% of watershed area. If no additional harvest occurs, the ECA will decrease to 27.0 ha (6.2% of watershed area) by 2023 and 25.9 ha (5.9% of watershed area) by 2026.

SCCF plans to harvest Block HM50 in the 2020 to 2023 interval. The block has 15.9 ha in the watershed (17.2 ha total harvest area, with 2.5 ha of that harvested with 50% retention). After harvest, the ECA is expected to be 42.90 ha (9.9% watershed area) by 2023 and 41.8 ha (9.6% watershed area) by 2026.

5.0 DISCUSSION

The likelihood of changes to watershed hydrology is a function of watershed ECA and road density. ECA values below 20% to 30% of watershed area are not likely to affect watershed hydrology. The ECA threshold for management is set according the sensitivity of the watershed, with the most sensitive watersheds managed to a 20% ECA and the least sensitive managed to a 30% ECA threshold.

The current ECA in Milne Community watershed is lower than levels that are likely to change watershed hydrology. The proposed harvesting will result in low likelihood of changes to hydrology, and low risk to downstream resources such as fish, fish habitat, and water resources.

Road density values below 1.5 km/km² indicate that the cumulative effects of roads have a low likelihood of affecting watershed hydrology, while road densities above about 2 km/km² indicate a high likelihood that roads can affect watershed hydrology.

The current road density of 1.8 km/km² and the forecast density of 2.0 km/km² are expected to affect watershed hydrology with a moderate to high likelihood of changing the timing and magnitude of peak flows. Trout Lake acts to buffer the hydrologic effects of higher road densities on peak and low flows, although the effect of that is hard to quantify within the CWAP model.

Hydrologic risk is a function of likelihood and the duration that likelihood is sustained. Permanent access structures (powerline and pipeline), together with the highway control the watershed road density and the resultant risk. They cannot be deactivated or rendered hydrologically non-functional. Therefore, for forest management, the most effective management strategy to reduce total road density and the total length of time that road density is higher than baseline is to construct temporary roads.

If new roads required for harvesting are temporary and deactivated soon after construction, then the incremental risk resulting from their construction will be minimal. The moderate to high hydrologic risk associated with roads can be managed by identifying unneeded roads in the watershed and deactivating them.

The combination of road density and ECA levels, together with the history of past watershed disturbance and watershed response, indicates a cumulative low to moderate likelihood of changing watershed hydrology in Milne Community Watershed. The timing and magnitude of peak flows should not change significantly in response to the proposed harvesting.

The watershed should be reassessed in 2026, if additional harvesting is proposed, to evaluate the effectiveness of the practices used in the 2020 to 2026 interval at maintaining ECA levels below the levels expected to affect watershed hydrology. In the meantime, site level management will be monitored SCCF staff and contractors. If indicators of changing hydrology are observed, the ECA can be re-assessed. Common indicators of changing hydrological processes include, but are not limited to, river or stream erosion or deposition, or washed out culverts or bridges, or landslides.

If the watershed experiences watershed-scale disturbance, the ECA will be affected. Forest fires, insect infestations, or harvesting in excess of what has been considered in this assessment are examples of disturbances that can rapidly change watershed ECA. If, for example, a large area of watershed burns, the ECA can be updated to determine the new ECA. The new ECA can then be used to revise management plans.

Managing resources under climate change scenarios is difficult because of the variability of future climate scenarios and challenges with scaling climatic events to specific locations. However, it is almost certain that peak streamflow will increase. The simplest means to proactively plan forest development would be to review the sizing and placement of drainage structures on the road networks. Culverts installed before climate change was taken seriously (before about 2010) are likely to be undersized.

The quality of the data used in a watershed assessment governs the quality of the results. Data quality checks do not necessarily identify all errors or inaccuracies. For example, proposed blocks are often provided as reconnaissance shapes, which are often reduced in area during layout. That difference in area leads to an overestimation in ECA. ECA accuracy can be improved by using more accurate data in the analysis.

6.0 SUMMARY AND CONCLUSIONS

SCCF retained Statlu Environmental Consulting Ltd. to complete a watershed assessment for Milne Community Watershed, near Halfmoon Bay, BC. The assessment was requested to evaluate the cumulative hydrologic risks for proposed harvesting and to provide recommendations to guide future forest development.

There are several water license points of diversion on Milne Creek and Trout Lake. Several fish species have been identified in Milne Creek and Trout Lake. A power transmission line and natural gas pipeline cross the watershed.

SCCF proposes to harvest Block HM50, which lies partially within the watershed. The current ECA and forecast ECA (Table 7), including the proposed harvest of Block HM50, present low likelihood of affecting peak flow and overall hydrology in the watershed. The current and proposed road density has moderate to high hydrologic risk.

Table 7: ECA and Road Density Summary Table

Current ECA		ECA 2020 to 2023		ECA 2023 to 2026		Current Road Density		2020 to 2026 Road Density	
ha	%	ha	%	ha	%	km/km²	Km	km/km²	km
29.4	6.8	43.9	9.9	41.8	9.6	1.8	7.8	2.0	8.8

The moderate to high risk associated with roads can be managed and reduced by identifying unneeded roads in the watershed and deactivating them, but much of the risk results from the permanent access corridors of the transmission line, gas pipeline, and highway. This risk will not be changed by the forestry activity if planned roads are constructed as temporary roads and deactivated soon after use. The incremental risk resulting from forestry roads in the watershed is low.

If additional harvesting is planned, the watershed should be reassessed in 2026 to reevaluate ECA and to consider the effectiveness of present forest management.

7.0 LIMITATIONS

The recommendations provided in this report are based on observations made by Statlu and are supported by information Statlu gathered. Observations are inherently imprecise. Conditions other than those indicated above may exist on the site. If such conditions are observed or if additional information becomes available, Statlu should be contacted so that this report may be reviewed and amended accordingly.

This report was prepared considering circumstances applying specifically to the client. It is intended only for internal use by the client for the purposes for which it was commissioned and for use by government agencies regulating the specific activities to which it pertains. It is not reasonable for other parties to rely on the observations or conclusions contained herein.

Statlu prepared the report in a manner consistent with current provincial standards and on par or better than the level of care normally exercised by Professional Geoscientists currently practicing in the area under similar conditions and budgetary constraints. Statlu offers no other warranties, either expressed or implied.

8.0 CLOSURE

Prepared by:

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EC/DB

9.0 ASSURANCE STATEMENT – REGISTERED PROFESSIONAL

Note: This Statement is to be read and completed in conjunction with the Professional Practice Guidelines – Watershed Assessment and Management of Hydrologic and Geomorphic Risk in the Forest Sector and is to be provided for Watershed Assessments or Hydrologic Assessments.

March 1, 2021

To: Warren Hansen, RPF
Sunshine Coast Community Forest
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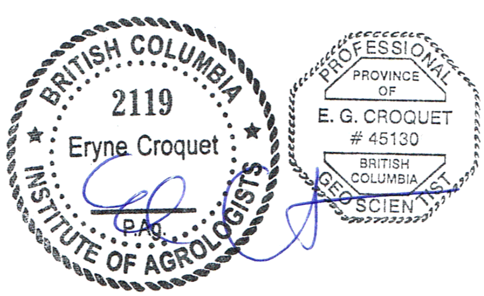
Sechelt, BC V0N 3A0

With Reference to the Milne Community Watershed, the undersigned hereby gives assurance that they are a Professional Geoscientist, registered with Engineers and Geoscientists BC, and a Professional Agrologist, registered with the BC Institute of Agrologists.

I, Eryne Croquet, M. Sc., P. Ag., P. Geo, have signed, sealed, and dated this Watershed Assessment report in general accordance with the Joint Professional Practice Guidelines - Watershed Assessment and Management of Hydrologic and Geomorphic Risk in the Forest Sector[5].



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[5] https://www.egbc.ca/getmedia/8742bd3b-14d0-47e2-b64d-9ee81c53a81f/EGBC-ABCFP-Watershed-Assessment-V1-0.pdf.aspx

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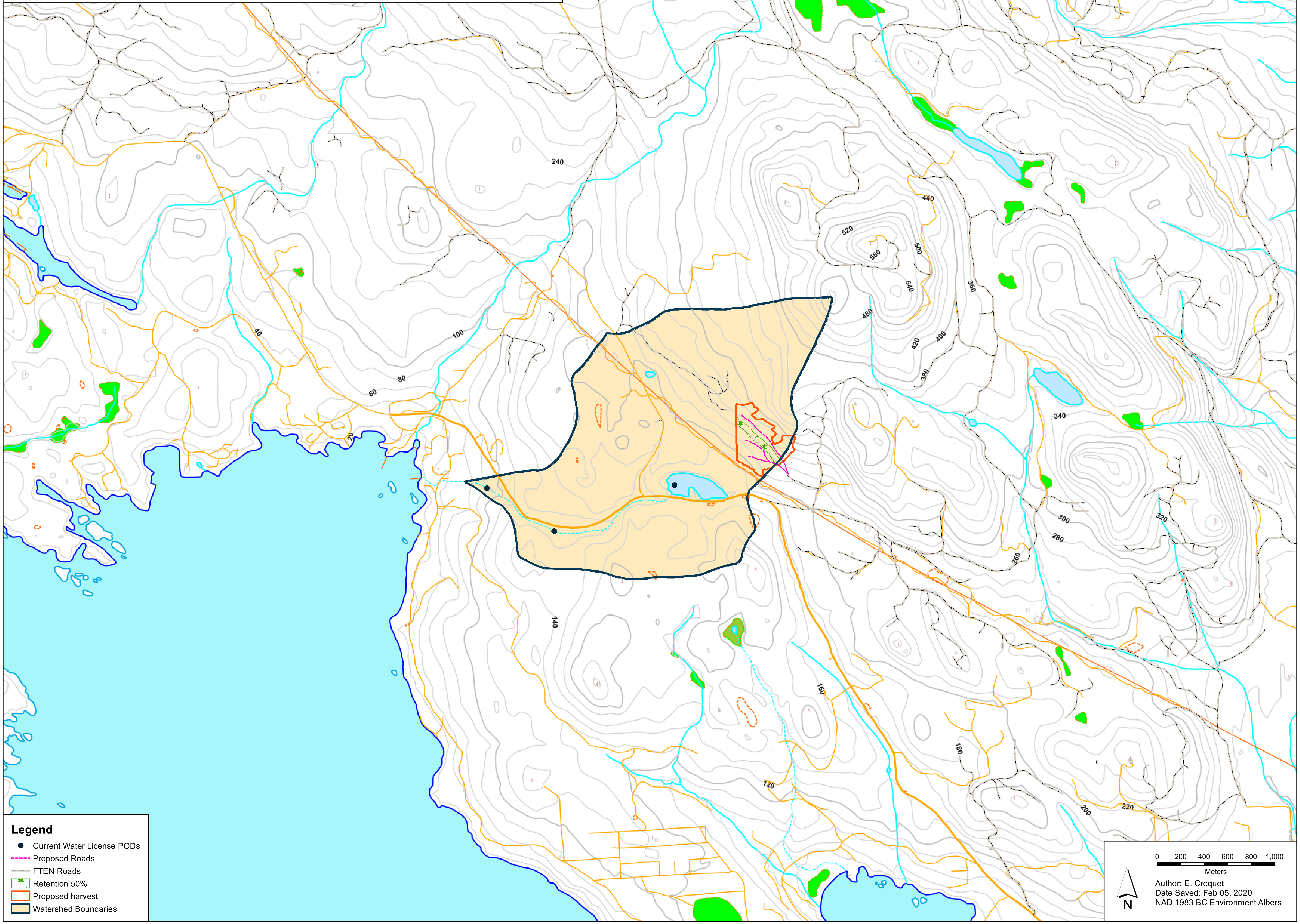
statlu ENVIRONMENTAL CONSULTING

Figure 1: Milne Community Watershed

1:20,000

Client: Sunshine Coast Community Forest

Project Number: 19-183



APPENDIX 2: HYDROLOGIC RISK AND RISK ASSESSMENT METHODOLOGY

Peak flow is the maximum flow rate that occurs within a specified period, usually on an annual or event basis. Generally, melting of the snowpack in spring and/or heavy rainstorms or rain-on-snow events generate peak flows. Tree removal and road building by forestry can affect peak flow timing and volumes. By removing trees, not only is more precipitation able to reach the ground and infiltrate the soil, but the timing of the delivery may be altered. Timber harvesting reduces interception and evapotranspiration, and increases the winter snowpack. This can result in an earlier and more rapid snowmelt, and higher flow resulting from the deeper snowpack. It can also result directly in higher runoff during rainfall events and/or higher groundwater levels. By changing the longwave and shortwave radiative balance, logging can also change the timing of snowmelt, although this depends on aspect and other shading as well as forest canopy removal.

Construction of logging roads can affect the pathway and the timing in which precipitation or snowmelt reaches the stream channel. Subsurface flow may be intercepted and directed down ditches as surface flow, reaching stream channels at an accelerated rate. Compacted surfaces of roads reduce infiltration, transferring surface flow to ditches, which also means that surface water reaches stream channels at an accelerated rate.

Cumulative hydrologic effects are commonly expressed as the likelihood that logging will result in increases to peak flow magnitude or frequency. Cumulative hydrologic effects are evaluated by considering the net area logged over time and determining the equivalent clearcut area (ECA) for each logged area, which consists of the initially clearcut area modified by a recovery term that accounts for the restoration of forest canopy, root structures, transpiration, and interception as new trees grow. For instance, an area of 10 ha, originally clearcut, fully restocked, and with vigorous new growth 20 years old, might be calculated to have recovered 30% of the original hydrological effectiveness of the previous forest in terms of rainfall and snowfall interception and ground shading. The ECA is calculated as clearcut area times the recovery factor (percent clearcut minus percent recovered). In this example, the ECA is 10 ha * (100%-30%) = 7 ha. Therefore the 10 ha, 20-year-old block would be determined to be hydrologically equivalent to a 7 ha fresh clearcut. ECA is summed for each past block harvested in a watershed to determine cumulative hydrologic effects. Intermediate categories (such as very low to low) are included in the table to indicate the range of watershed sensitivities, which depend on woody debris abundance, channel substrate, geology, hydrograph type (snowmelt or rainfall dominated) and other factors.

In addition to peak flow changes, cumulative hydrologic effects can result in changes to mean annual or low flow, and to changes in the timing and duration of flow. Flow might become less variable if melt from different aspects and elevations is synchronized. The timing of low flow might be altered, and its duration lengthened, if snowmelt occurs earlier in the year. Conversely, by reducing transpiration, forest harvesting might increase low flow levels or decrease the duration of summer low flows.

ECA Range (percent of total watershed area)	Hydrologic Risk	Qualitative Interpretation
0% to 15%	Very low	Detectable changes to peak, mean and low flow will not occur
15% to 20%	Very low to low	
20% to 25%	Low	Detectable changes to peak or flow are unlikely to occur. Small variations might be detectable using statistical analysis.
25% to 30%	Low to moderate	
30% to 35%	Moderate	Detectable changes to peak flow might occur for some flow magnitudes and return periods. Flow durations might be altered.
35% to 40%	Moderate to high	
40% to 45%	High	Detectable changes to peak flow frequency and magnitude will occur. Floods will become larger and more frequent. Low flows might increase or decrease. Mean annual flow might change.
45% to 50%	High to very high	
50% or higher	Very high	Watershed hydrology will be significantly changed. Peak flow frequency and magnitude will undergo large changes. Floods will be much larger and much more frequent. Low flow and mean annual flow frequency and duration will change.

Risk is a function the likelihood of an event occurring and the exposure of downslope or downstream resources to the event, and vulnerability of the downslope resources, which together determine the consequences should the event occur. Land Management Handbook 56 (Wise et al. 2004) and the BC Ministry of Forests Forest Road Engineering Guidebook (2002) define risk as the product of the probability of hazard (likelihood of occurrence) and consequence. Consequence further depends on the nature of the element(s) at risk, exposure, and vulnerability.

Statlu recognizes that the evaluation of the exposure and vulnerability of elements at risk is difficult and may require specialized skills or additional information not available to professional geoscientists. Since the information is available or potentially available to land managers and statutory decision makers, we have concentrated on identifying and describing the geomorphic components of the consequences, specifically their likelihood of reaching downstream identified elements and resources at risk. This is a partial risk analysis since it identifies the geomorphic components of a risk analysis without addressing the vulnerability of the elements at risk.

As an example, consider a theoretical watershed of 1000 ha. The existing ECA is 150 ha, and another 100 ha are planned for logging, with associated road construction, which will raise the watershed ECA to 25%. The main stream in the watershed flows into a lake and has built a fan at its mouth; there are cabins on the lake, with a community water license intake near the head of the fan, and fish present in stream reaches on and near the fan, while higher stream reaches are too steep for fish habitat. Statlu estimates that the post-harvest likelihood of peak flow changes is low, and that if changes to peak flow regimes do occur they are likely to be transient and persist for less than five years. Small changes to the timing of flow are likely: spring snowmelt may occur up to a week earlier, and the summer low flow period may be extended by a similar length of time, but summer low flows may be slightly higher for up to ten years due to reduced evapotranspiration. Changes to channel pattern in the stream and on the fan are unlikely and changes to water quality are unlikely if all roads are built as planned and incorporate site-specific erosion and sediment control measures, and if old roads are deactivated.

To extend this hydrogeomorphic analysis to a full evaluation of the consequence of the potential harvesting and road building and the resultant risk, requires information on the frequency of use, and designated flood construction level and flood control measures incorporated into the design of the cabins on the fan, the nature and frequency of use of the forest service roads by industrial and recreational traffic, the quality of riparian habitat, species present and seasonality of use of the fish stream by those species, the water diversion and treatment methods used at the water intake, and other information beyond the purview of geoscience but available or potentially available to land managers and statutory decision makers.

Broadly speaking, the qualitative estimations of probability determined by Statlu correspond to the following classes of consequence from the Forest Road Engineering Guidebook (Table A2). These correspondences are approximate and are provided only to help with decision-making.

Qualitative Probability of Consequence	Range of Quantitative Probabilities of Occurrence	Approximate Qualitative Consequence Class
Certain; Will Occur	>50%	Very High
Likely to Occur	25-50%	High
Probable; Could Occur	10-25%	Moderate
Unlikely to Occur	1-10%	Low
Remote or Will not Occur	<1%	Very Low

APPENDIX 3: RATIONALE FOR HYDROLOGIC ASSESSMENT

Rationale for Assessment

Forest harvesting can affect hydrology in many ways. The assessment of hydrologic impacts in a CWAP focuses on the potential for:

- Changes to peak stream flows,
- Accelerated surface soil erosion,
- Accelerated landslide activity,
- Changes to riparian zones; and,
- Changes to channel morphology.

The following section describes the potential effects of changes to these five indicators resulting from forestry and forestry-related activities.

Changes to Peak Stream Flow

Peak flow is the maximum flow rate that occurs within a specified period, usually on an annual or event basis. Generally, melting of the snowpack in spring and/or heavy rainstorms or rain-on-snow events generate peak flows. Tree removal and road building by forestry can affect peak flow timing and volumes. By removing trees, not only is more precipitation able to reach the ground and infiltrate the soil, but the timing of the delivery may be altered. Timber harvesting reduces interception and evapotranspiration, and increases the winter snowpack. This can result in an earlier and more rapid snowmelt, and higher flow resulting from the deeper snowpack. It can also result directly in higher runoff during rainfall events and/or higher groundwater levels.

Construction of logging roads can affect the pathway and the timing in which precipitation reaches the stream channel. Subsurface flow may be intercepted and directed down ditchlines as surface flow, reaching stream channels at an accelerated rate. Compacted surfaces of roads reduce infiltration, transferring surface flow to ditches, which also means that surface water reaches stream channels at an accelerated rate.

Accelerated Surface Soil Erosion

Surface soil erosion is defined as the detachment, entrainment, and transport of individual sediment particles due to falling or running water, or wind. It is a function of surface cover, mineral soil type, slope gradient, slope length and shape, and rainfall intensity.

The principal effect of forest practices on surface soil erosion results from road building. Sediment generated from ditches, cut and fill slopes, and road surfaces is introduced to stream channels through ditches and at stream crossings. Higher road densities indicate higher potential for sediment delivery to streams. High quantities of sediment can clog ditches and stream channels, accelerate stream bank erosion, deposit fine sediments in reservoirs, cover fish spawning grounds, and reduce downstream water quality. Timber harvesting can also cause accelerated surface soil erosion due to exposing soil as a byproduct of removal of vegetation. However, roads, particularly old pre-*Forest Practices Code* roads that have not been deactivated, pipeline and powerline access roads, and other similar roads, are a far greater potential source of sediment than conventional harvesting done to current *Forest and Range Practices Act* (FRPA) standards.

Landslide Activity

Landslides are a natural process on steep terrain, and occur over time at a natural rate. Forest practices can accelerate this natural rate through road construction and logging on unstable or potentially unstable terrain.

The alteration of natural drainage patterns through road building can lead to unusual concentrations of water on hillslopes, road fillslopes, and road beds, leading to a higher likelihood of landsliding. Timber harvesting can alter slope hydrology. Removal of forest cover results in a reduction of transpiration and interception losses, leading to increased soil saturation, subsurface flow, and surface runoff. In addition, when trees are harvested, the roots of the stumps decay and begin to lose their soil binding strength, reducing their reinforcing capacity. This makes slopes more susceptible to landsliding until new growth re-establishes deep root systems.

The harvesting method can also lead to slope instability. Log yarding can disrupt natural pathways for water drainage, and create new pathways. Yarding logs across slopes and using heavy machinery can damage the soil surface and the roots that help hold the soil.

FRPA requires that logging not cause landslides, adverse gully processes, or fan destabilization. The frequency of landsliding from logged terrain has been reduced by identifying and avoiding harvesting on unstable slopes, and by applying mitigation measures that promote stability on harvested slopes.

Changes to Riparian Zone

The riparian area, or land adjacent to the high water line in watercourses and standing bodies of water, is important to stream ecosystems and stream morphology. Riparian areas help maintain water quality by controlling sedimentation, supplying nutrients and large woody debris, and maintaining stream channel morphology. Excessive harvesting within riparian areas can destabilize stream banks, increase bank erosion and stream sedimentation, diminish the supply of woody debris to the channel, and increase the size of sediment wedges of some stream reaches.

Changes to Stream Channel Pattern

Analysis of stream channel patterns can indicate that changes to sediment supply, riparian vegetation, or peak flow indices may have influenced a watershed because these variables influence changes to stream channel pattern. For instance, increased flooding can lead to increased bank erosion or overbank deposition as well as changes in bed material texture. Increased sediment supply can result in increased sediment deposition in-channel and a consequent widening of the channel or changes in the texture and composition of channel bedforms. Changes to riparian vegetation can change coarse woody debris inputs to the channel, altering the frequency and size of logjams as well as the bed texture.