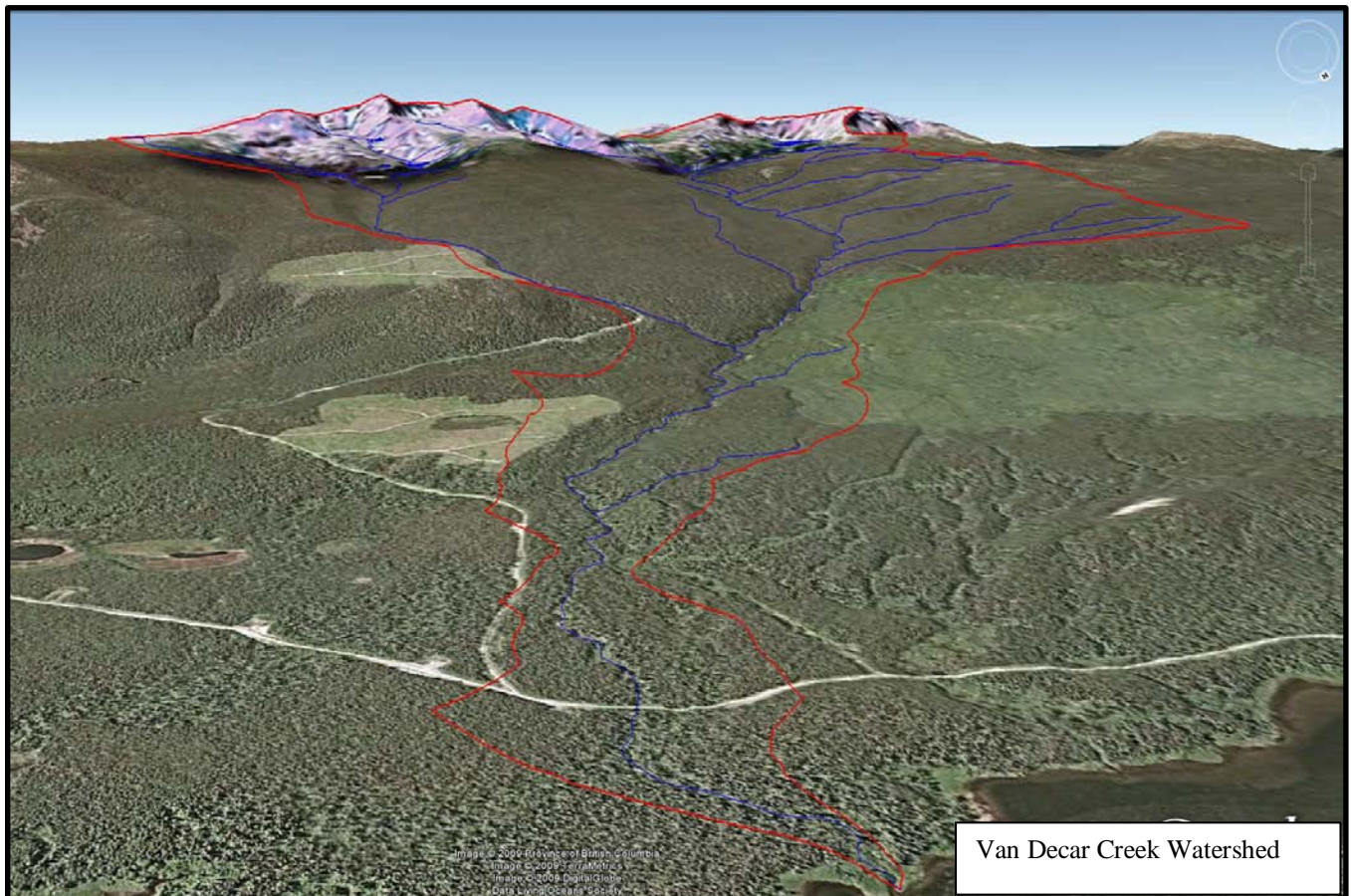


**Nine Individual Reports for the**  
**Stuart Takla Watershed**  
**Fisheries Sensitive Watershed**  
**Selection Process**



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November 22, 2011

**WATERSHED REVIEW**  
**ANKWILL CREEK WATERSHED**  
**November 22, 2011**  
 Ministry Contract No: CS12NRH-011

**BIOPHYSICAL AND LAND-USE CHARACTERISTICS OF THE WATERSHED**

Table 1. Summary Information – Watershed Characteristics – (see Figures 1 and 2)

Size (km <sup>2</sup> )	Dominant BEC Zones	Dominant NDT	Elevation Range (m)	Surficial Geology near the Mouth (i.e. sensitive area)	Stream Density (km/km <sup>2</sup> )	Biggest % of watershed in same elevation band <sup>1</sup>	Distribution of slope gradients within the watershed (% of watershed)			
							<10% slope	10 to 30% slope	30 to 60% slope	>60% slope
114.7	SBS and ESSF	NDT3	700-2104	Fine textured fluvial	2.01	27.9	19.3	29.5	36.2	15

<sup>1</sup> The entire watershed is divided into 300 m elevation bands of harvestable forest land-base. The less elevation bands there are and the more area is represented by any given single elevation band, then the greater will likely be the effect of forest harvesting on increased peak flows due to the theoretical concept of “synchronization” (i.e. the melt from the cutblocks is synchronized as much of it comes from the same elevation), and the greater sensitivity it will have.

Table 2. Rating of “Sensitivity” of Watershed to Increased Peak Flow at the lower reaches

Rosgen Stream Channel Score	Rosgen Stream Channel Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to vertical conductivity	Sensitivity score relative to climate	Sensitivity score relative to flow synchronization potential	Sensitivity score relative to NDT type	Sensitivity Score	Sensitivity Rating
C4- Stable	3.5	1	1.1	1	1.1	0.95	1	4.02	High

Table 3. Rating of “Sensitivity” of Watershed to Increased Production of Fine Sediment at lower reaches

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to climate	Sensitivity Score	Sensitivity Rating
Bull trout	5	1	1.2	1.1	6.6	Extreme

Table 4. Rating of “Sensitivity” of Watershed to a Loss In riparian Function.

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to loss of LWD	Sensitivity score relative to Aspect	Sensitivity score relative to climate	Overall watershed sensitivity to loss of riparian	Loss of Riparian Sensitivity Rating
Bull trout	5	1.25	0.8	1.1	5.50	Extreme

Table 5. Peak Flow Hazard Rating, as indexed by HEDA – current scenario (i.e. no proposed harvesting considered)

Watershed area (km <sup>2</sup> )	Total area Pine Leading (km <sup>2</sup> )	Total area Pine Mixed (km <sup>2</sup> )	Total area harvest (km <sup>2</sup> ) <sup>1</sup>	Total HEDA from Pine Beetle alone (%)	Total HEDA from logging alone (%)	Total HEDA from logging and Pine Beetle mortality (%)
114.7	1.34	0.79	9.25	0.79	4.98	5.77

<sup>1</sup>Note: This includes openings from VRI database, and non-overlapping openings from RESULTS and FTEN databases.

Table 5 (continued)

Total area in Agriculture (km <sup>2</sup> )	Total area in Agriculture (% of watershed)	Total area in Proposed Harvest (km <sup>2</sup> )	Total HEDA (%)	HEDA Hazard rating Score	HEDA Hazard Rating
0.00	0.00	0.00	5.77	0.36	Very Low

Table 6. Fine Sediment Hazard Rating, as indexed by the Stream Crossing Density

Watershed area (km <sup>2</sup> )	# of x-ings	#of fish bearing X-ings <sup>1</sup>	#of non-fish bearing X-ings	density of x-ings (#/km <sup>2</sup> )	Density of fish bearing X-ings (#/km <sup>2</sup> )	Density of non-fish bearing X-ings (#/km <sup>2</sup> )	Hazard Rating Score	Hazard Rating
114.7	15	15	0	0.1	0.1	0.00	1.1088	Very Low

<sup>1</sup>Note: The information on stream crossings was provided by MoE and was generated with a GIS model, not fieldwork.

Table 7. Loss of Riparian Function Hazard Rating (See Figures 3 to 14)

Reach Number	Rosgen Stream Type	Reach Length (m)	% riparian logged (as interpreted from air photos)	Apparent stability and other comments (as viewed from air photos)
1	C4- Stable	150	0.0	Very Stable
2	C4- Stable	320	0.0	Very Stable
3	C4- Stable	580	0.0	Stable
4	B4-Stable	1370	0.0	Very Stable
5	B4 - Unstable	420	0.0	Very Stable
6	B4-Stable	1980	0.0	Stable
7	B4-Stable	3080	0.0	Very Stable
8	B4-Stable	1210	0.0	Very Stable
Hazard Scores:			Hazard Rating Score	Hazard Rating
			0.25	Very Low

Table 8. Risk Rankings for the Different Hazards in the watershed current scenario (i.e. no proposed harvesting considered)

Watershed Hazard Types	Sensitivity Score	Sensitivity Rating	Hazard Score	Hazard Rating	Risk Score	Risk Rating
Increased Peak Flow	4.02	High	0.36	Very Low	1.4	Very Low
Increase in Production of Fine Sediment	6.60	Extreme	1.11	Very Low	7.3	Moderate
Loss of Riparian function	5.50	Extreme	0.25	Very Low	1.4	Very Low

## INTERPRETATIONS AND RECOMMENDATIONS FOR MANAGEMENT STRATEGIES FOR PROTECTION OF WATER RESOURCES IN THIS WATERSHED

### Brief Watershed Description (Table 1 and Figures 1 and 2)

This watershed flows down from the Bait Range, with a relatively large amount of steep and high elevation terrain (max elevation =2104 m). The watershed is flanked by Bait, Centre and Lovell Peaks. It flows in an easterly direction onto a relatively flat plateau and finally into the northern end of Takla Lake. The dominant biogeoclimatic zones in this watershed are an almost even split between the SBSwk3 at lower elevations and the ESSFmv3 at mid to higher elevations. Alpine Tundra (AT) can be found at the highest elevations of the watershed. About half of the watershed has slopes of 30% or less with 15% of the watershed having slopes greater than 60% (Table 1).

The mainstem of Ankwil Creek is generally deeply incised within the plateau and flows out onto a gravely fluvial fan (Figure 2 and 5). The surficial geology of this watershed is dominated by a mixture of fine and moderately coarse morainal materials, with the frequency of bedrock outcrops increasing as you move up the watershed (Figure 1). Although Ankwil Creek is incised within the morainal materials, most of the current channel flows down through a wide floodplain with active migration across this floodplain, thus creating gravel bars, mid-channel bars and active bank erosion (e.g. Figures 6 and 7). These characteristics have lead me to classify much of the stream channel as a Rosgen C4 type channel, although some of the more incised reached with narrow floodplains have been classified as B4 channels (Table 7 and Figure 4).

### Key Elements that Make this Watershed Sensitive

#### *Sensitivity to Increased Peak Flows*

The main watershed characteristics that make Ankwil Creek sensitive to the increased peak flows include the following (Table 2): 1) the C4 channel type and especially the lower part that flows across a fluvial fan, 2) the mountainous topography with localized steepness, 3) the high drainage density with very shallow soils in the upper watershed, 4) the relatively uniform elevation of the plateau area, where most of the logging disturbances occur and 5) the climate dominated by relatively deep winter snowpacks.

### *Sensitivity to Increased Delivery of Fine Sediments*

This watershed has some very sensitive fish species, including Sockeye, Dolly Varden, Kokanee and Bull Trout. The steep terrain and the high drainage density contribute significantly to the sediment sensitivity as these are significant factors in the processes of surface erosion and sediment transport to the stream network. The fine textured fluvial and lacustrine materials in the lower watershed also play an important part in classifying this watershed as sensitive to increased sediment (Table 3).

### *Sensitivity to a Reduction in Riparian Function*

The dominant stream types in this watershed are both highly dependent on the recruitment of large organic debris for the maintenance of long term channel stability and high quality fish habitat (i.e. C4 and B4). These channel types also depend on riparian vegetation and riparian forest for controlling stream temperatures and terrestrial food sources such a litter and insect drops. This dependence on the riparian forest, for the maintenance of quality fish habitat, makes them highly sensitive to riparian disturbances and losses in riparian functions (Table 4).

## **Risk Assessment for this Watershed**

### *Risk associated with Potential Increases in Peak Flows*

Currently the risks associated with potential increases in peak flows are very low (Table 8) because the extent of non-recovered disturbances in this watershed is very low, i.e. the hazard is very low. The total watershed HEDA is only at 5.77% (Table 5). Although a total area of 9.25 km<sup>2</sup> of this watershed has been harvested in the past, much of this area is either fully or partially recovered from a hydrological point of view. Also, the total amount of disturbance in the watershed, relative to the watershed size, is simply not that large (Figure 3).

### *Risk associated with Potential Increases in the Delivery of Fine Sediments to the Stream Network*

The risk associated with the potential for delivery of fine sediments have been assessed as Moderate (Table 8) based on the density of stream crossings over fish habitat and the extreme sensitivity of the watershed to increases in fine sediments (Table 3)

### *Risk associated with a Reduction in Riparian Function*

The risk associated with a loss in riparian function is very low (Table 8) because there has been no riparian logging anywhere along the mainstem of Ankwil Creek (Table 7 and Figures 4 to 9), i.e. the hazard is essentially nonexistent.

## **Suggested Management Objectives and Strategic Directions for this Sensitive Watershed**

- 1) Carefully manage the extensive flat over steep terrain found in this watershed (see Figures 8 and 10).
- 2) Maintain the peak flow risk in this watershed below a Moderate level (i.e. Low or Very Low). This means that the HEDA value for this watershed should be maintained below

20.3%, which would allow the harvesting of an additional 1660 ha of healthy stands. Use the peak flow risk calculator to determine the maximum suggested harvest of different combinations of healthy stands and mountain pine beetle affected stands in order to maintain a risk level below moderate.

- 3) Minimize as much as possibly any riparian disturbances within the riparian management zone within the areas identified as having a “fluvial fan” surficial geology, i.e. below reach break 1-2 (Figures 2 and 4).
- 4) Maintain best management erosion and sediment control practices at the stream crossing located over Reach #1 (Figure 5). In addition to being very important fish habitat at this location, the soils are easily erodible and could very easily be transported into Ankwil Creek. I suggest that the Water Quality Effectiveness Evaluation (WQEE) tool be used and that the WQEE rating be maintained below a moderate level for all crossing over Ankwil Creek (i.e. Low or Very Low). The most recent WQEE protocol can be found at the following web link:  
<http://www.for.gov.bc.ca/ftp/hfp/external/!publish/frep/indicators/Indicators-WaterQuality-Protocol-2009.pdf>
- 5) For all S4 streams wider than 0.5 m, maintain long term large woody debris (LWD) recruitment to the stream channel by retaining at least 90% of the riparian area in a state undisturbed by primary forest activities. Note that the riparian area refers to the management area measured from the closest streambank to a distance 15m upslope from the streambank.

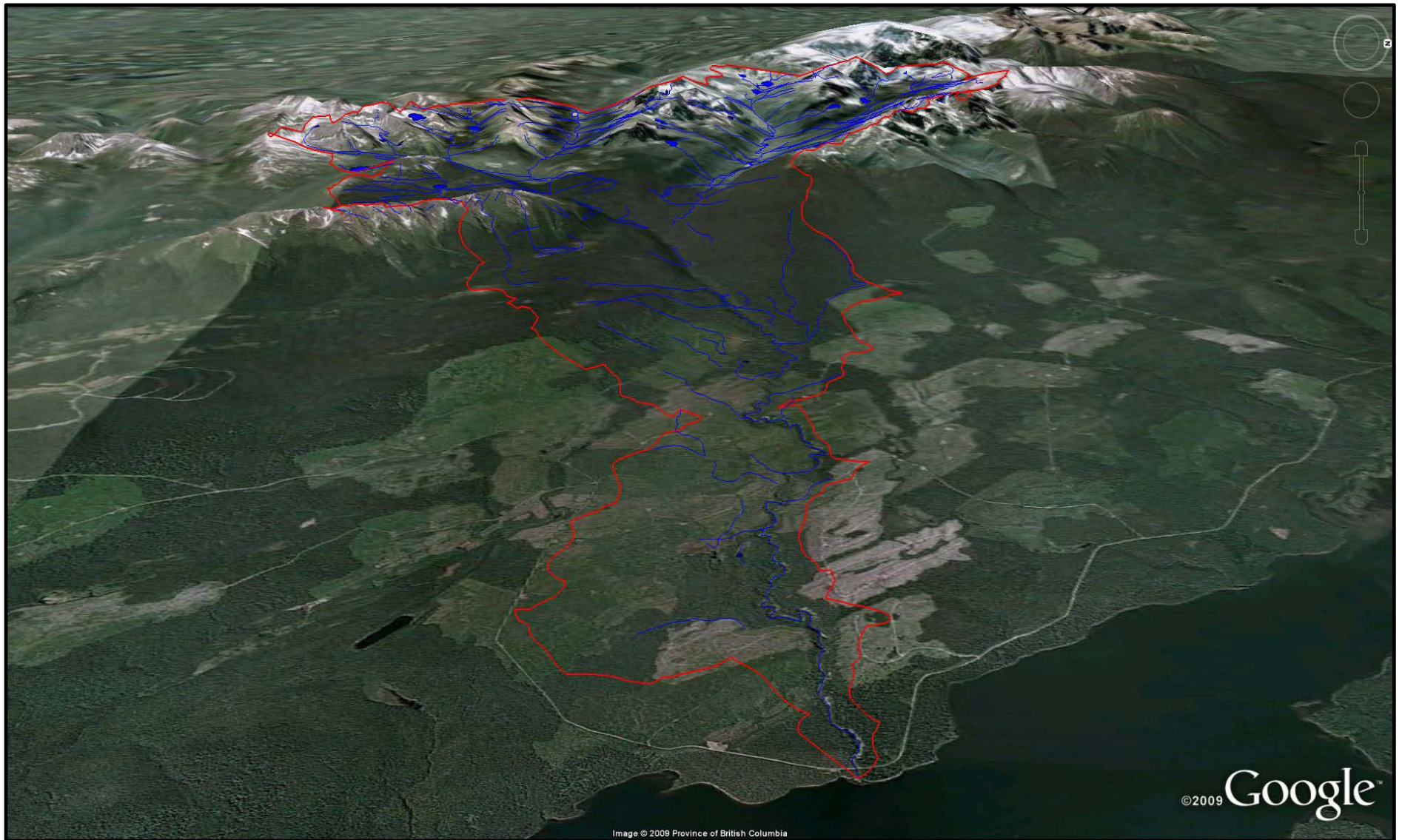


Figure 1. Google earth overview image of Ankwil Creek watershed, looking upstream into the watershed.

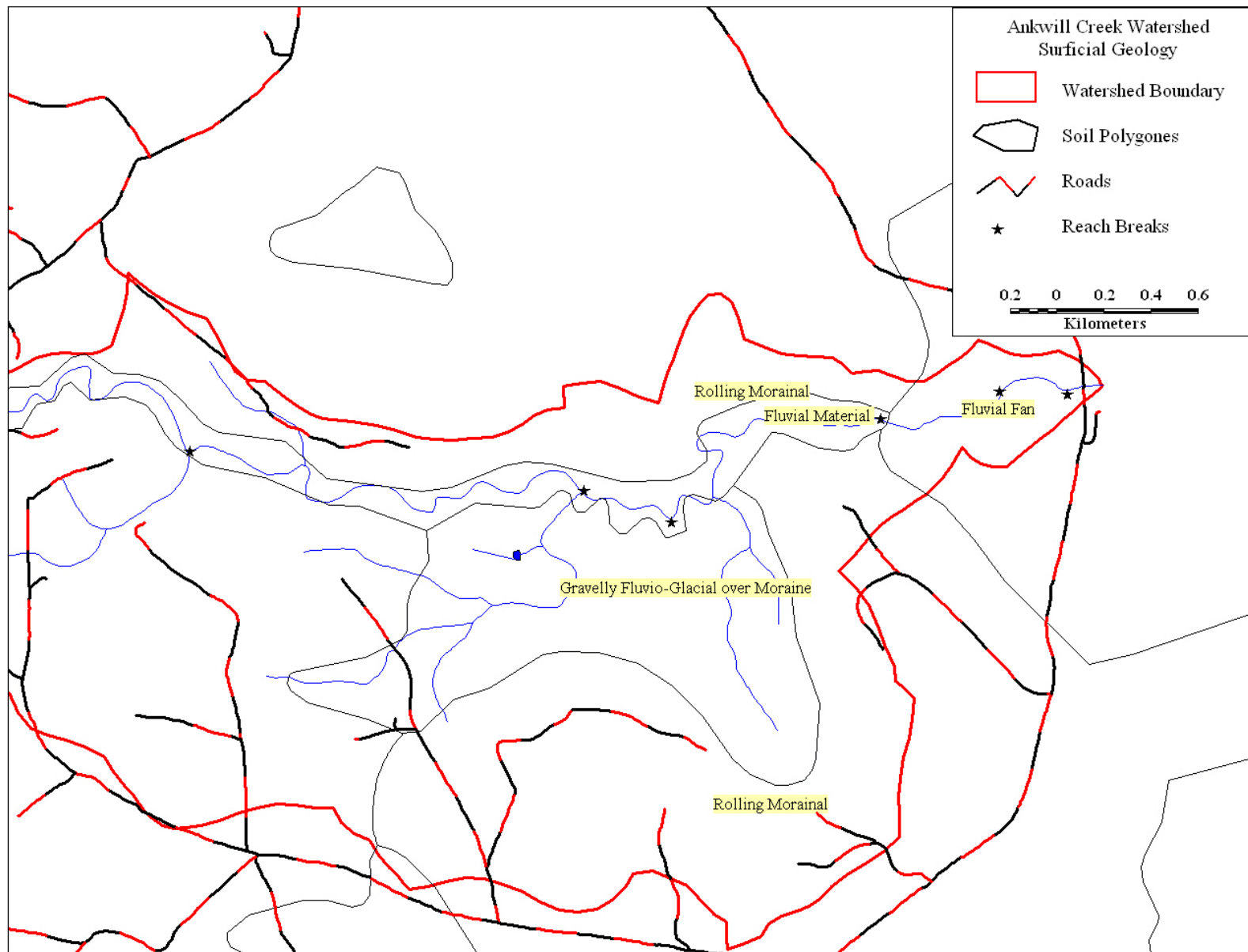


Figure 2. Distribution of surficial geology types near the mouth of Ankwil Creek.

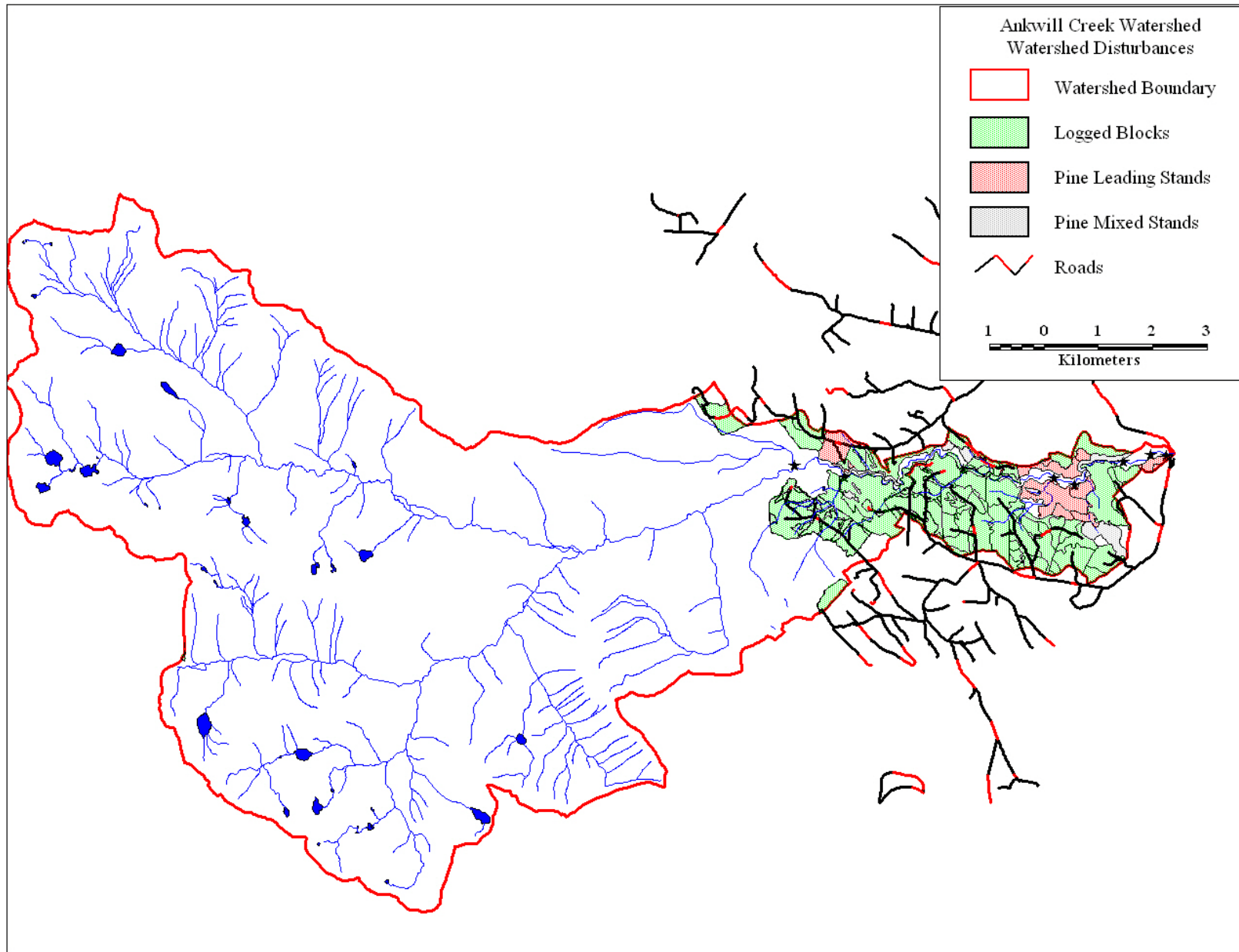


Figure 3. Land-use related and large natural disturbances in the Ankwil Creek Watershed

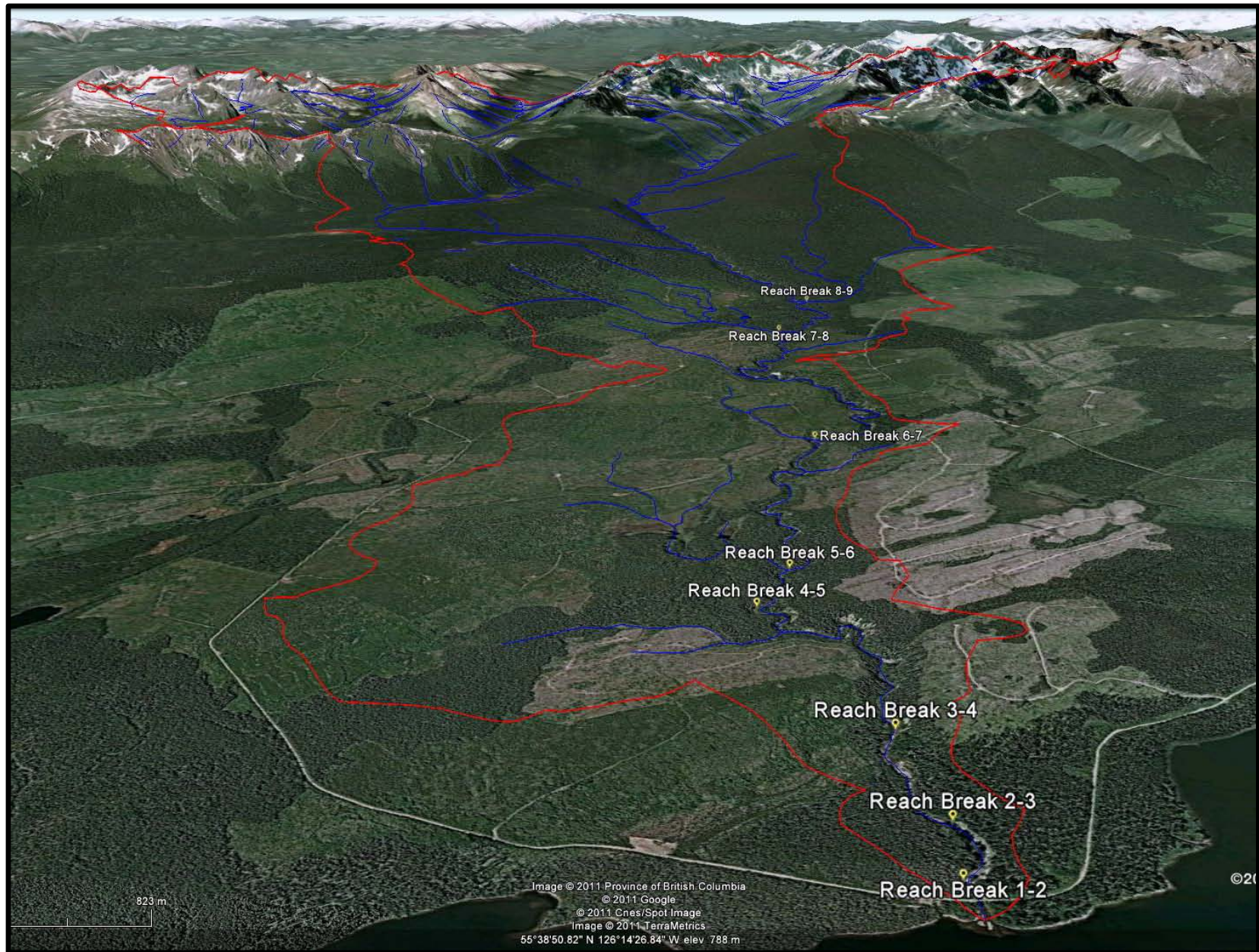


Figure 4. Identification of reach breaks along the mainstem of the lower Ankwil Creek watershed



Figure 5. Google Earth image looking upstream along Reach #1 of Ankwil Creek.



Figure 6. Google Earth image looking upstream along Reach #2 of Ankwil Creek.



Figure 7. Google Earth image looking upstream along Reach #3 of Ankwill Creek.

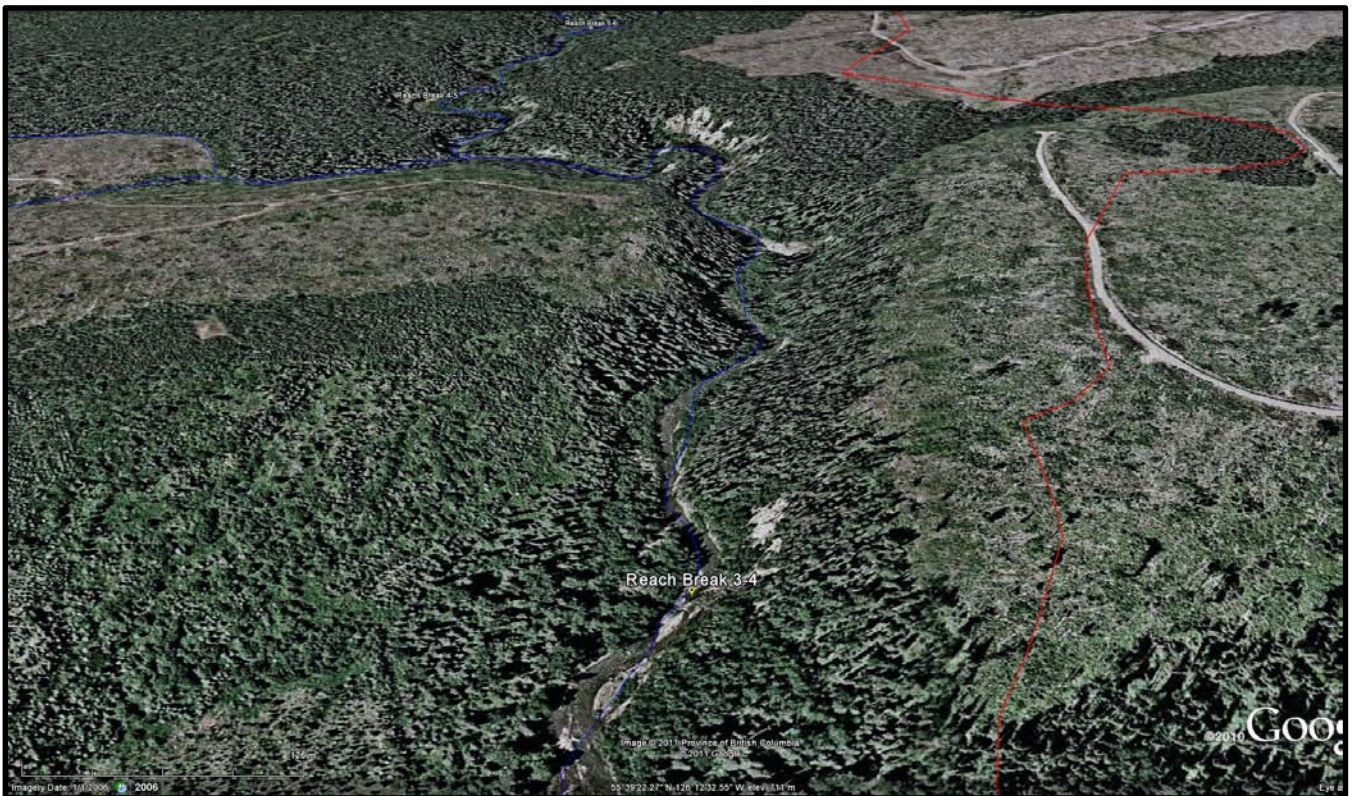


Figure 8. Google Earth image looking upstream along Reach #4 of Ankwill Creek.



Figure 9. Google Earth image looking upstream along Reaches #5 and 6 of Ankwil Creek.

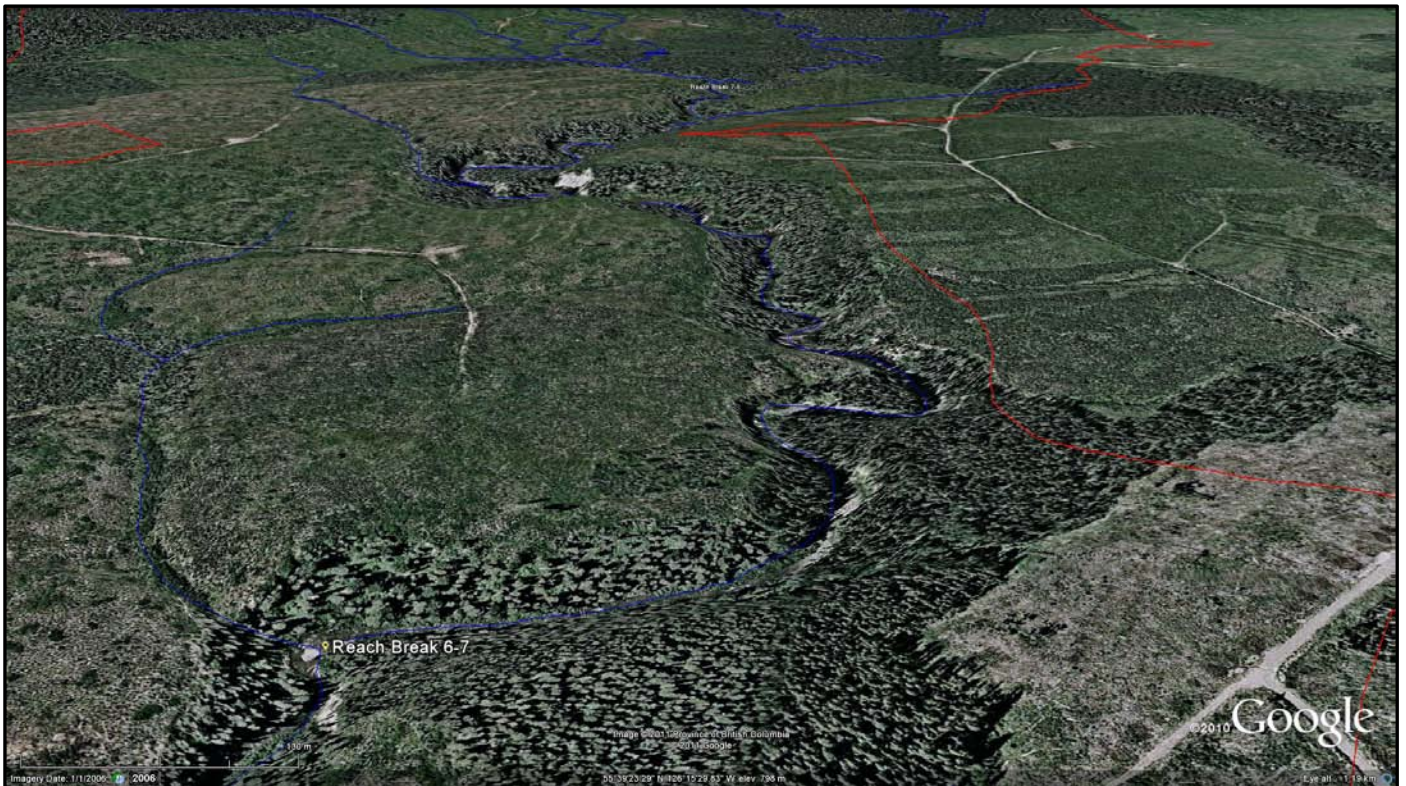


Figure 10. Google Earth image looking upstream along Reach #7 of Ankwil Creek.

## WATERSHED REVIEW FRYPAN CREEK WATERSHED

**November 22, 2011**  
Ministry Contract No: CS12NRH-011

### BIOPHYSICAL AND LAND-USE CHARACTERISTICS OF THE WATERSHED

Table 1. Summary Information – Watershed Characteristics – (see Figures 1 and 2)

Size (km <sup>2</sup> )	Dominant BEC Zones	Dominant NDT	Elevation Range (m)	Surficial Geology near the Mouth (i.e. sensitive area)	Stream Density (km/km <sup>2</sup> )	Biggest % of watershed in same elevation band <sup>1</sup>	Distribution of slope gradients within the watershed (% of watershed)			
							<10% slope	10 to 30% slope	30 to 60% slope	>60% slope
116.9	SBS	NDT3	699-1955	Fine textured fluvial	2.01	31.6	30.69	34.71	28	6.6

<sup>1</sup> The entire watershed is divided into 300 m elevation bands of harvestable forest land-base. The less elevation bands there are and the more area is represented by any given single elevation band, then the greater will likely be the effect of forest harvesting on increased peak flows due to the theoretical concept of “synchronization” (i.e. the melt from the cutblocks is synchronized as much of it comes from the same elevation), and the greater sensitivity it will have.

Table 2. Rating of “Sensitivity” of Watershed to Increased Peak Flow at the lower reaches

Rosgen Stream Channel Score	Rosgen Stream Channel Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to vertical conductivity	Sensitivity score relative to climate	Sensitivity score relative to flow synchronization potential	Sensitivity score relative to NDT type	Sensitivity Score	Sensitivity Rating
C4- Stable	3.5	1	1.1	1	1.1	1	1	4.24	High

Table 3. Rating of “Sensitivity” of Watershed to Increased Production of Fine Sediment at lower reaches

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to climate	Sensitivity Score	Sensitivity Rating
Dolly Varden	5	1	1.2	1.1	6.6	Extreme

Table 4. Rating of “Sensitivity” of Watershed to a Loss In riparian Function.

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to loss of LWD	Sensitivity score relative to Aspect	Sensitivity score relative to climate	Overall watershed sensitivity to loss of riparian	Loss of Riparian Sensitivity Rating
Dolly Varden	5	1.25	0.8	1.1	5.50	Extreme

Table 5. Peak Flow Hazard Rating, as indexed by HEDA – current scenario (i.e. no proposed harvesting considered)

Watershed area (km <sup>2</sup> )	Total area Pine Leading (km <sup>2</sup> )	Total area Pine Mixed (km <sup>2</sup> )	Total area harvest (km <sup>2</sup> ) <sup>1</sup>	Total HEDA from Pine Beetle alone (%)	Total HEDA from logging alone (%)	Total HEDA from logging and Pine Beetle mortality (%)
116.9	6.77	6.28	0	4.51	0.00	4.51

<sup>1</sup>Note: This includes openings from VRI database, and non-overlapping openings from RESULTS and FTEN databases.

Table 5 (continued)

Total area in Agriculture (km <sup>2</sup> )	Total area in Agriculture (% of watershed)	Total area in Proposed Harvest (km <sup>2</sup> )	Total HEDA (%)	HEDA Hazard rating Score	HEDA Hazard Rating
0.00	0.00	0.00	4.51	0.23	Very Low

Table 6. Fine Sediment Hazard Rating, as indexed by the Stream Crossing Density

Watershed area (km <sup>2</sup> )	# of x-ings	#of fish bearing X-ings <sup>1</sup>	#of non-fish bearing X-ings	density of x-ings (#/km <sup>2</sup> )	Density of fish bearing X-ings (#/km <sup>2</sup> )	Density of non-fish bearing X-ings (#/km <sup>2</sup> )	Hazard Rating Score	Hazard Rating
116.9	0	0	0	0.0	0.0	0.00	0	Very Low

<sup>1</sup>Note: The information on stream crossings was provided by MoE and was generated with a GIS model, not fieldwork.

Table 7. Loss of Riparian Function Hazard Rating (See Figures 3 to 14)

Reach Number	Rosgen Stream Type	Reach Length (m)	% riparian logged (as interpreted from air photos)	Apparent stability and other comments (as viewed from air photos)
1	C4- Stable	1151	0.0	Very Stable
2	B4- Stable	1487	0.0	Very Stable
3	B4- Stable	908	0.0	Very Stable
4	B4- Stable	2423	0.0	Very Stable
5	C4- Stable	2672	0.0	Very Stable
6	C4- Stable	2962	0.0	Very Stable
7	C4- Stable	1554	0.0	Very Stable
Hazard Scores:			Hazard Rating Score	Hazard Rating
			0.25	Very Low

Table 8. Risk Rankings for the Different Hazards in the watershed current scenario (i.e. no proposed harvesting considered)

Watershed Hazard Types	Sensitivity Score	Sensitivity Rating	Hazard Score	Hazard Rating	Risk Score	Risk Rating
Increased Peak Flow	4.24	High	0.23	Very Low	1.0	Very Low
Increase in Production of Fine Sediment	6.60	Extreme	0.00	Very Low	0.0	Very Low
Loss of Riparian function	5.50	Extreme	0.25	Very Low	1.4	Very Low

## **INTERPRETATIONS AND RECOMMENDATIONS FOR MANAGEMENT STRATEGIES FOR PROTECTION OF WATER RESOURCES IN THIS WATERSHED**

### **Brief Watershed Description (Table 1 and Figures 1 and 2)**

This watershed, which is adjacent to the Lovell Creek watershed, also flows down from the Bait Range, with some steep and high elevation terrain (max elevation =1955 m). The watershed is flanked, by Mounts Teegee and Frypan. It flows in an easterly direction onto a relatively flat plateau and finally into the northern end of Takla Lake. The dominant biogeoclimatic zones in this watershed are the SBSwk3 at lower elevations and the ESSFmv3 at mid to higher elevations. Alpine Tundra (AT) can be found at the highest elevations of the watershed. About 65% of the watershed has slopes of 30% or less with only 7% of the watershed having slopes greater than 60% (Table 1).

The mainstem of Frypan Creek varies between being deeply incised within the plateau (e.g. reaches 2, 3 and 4) and flowing more on the surface of the plateau (e.g. reaches 1 and 5). This stream also flows out onto a highly sensitive fluvio-glacial fan (Figure 2 and 5). The surficial geology of this watershed is dominated by a mixture of fine and moderately coarse morainal materials, with frequent pockets of coarser textured fluvio-glacial material in the lower elevations. There are bedrock outcroppings in the upper parts of the watershed and thin soils over bedrock (Figure 1). While reaches 2, 3 and 4 are more confined within a deeper canyon type topography, reaches 1 and 5 are less confined allowing them to migrate across a wider floodplain. These characteristics have lead me to classify the more confined reaches as B4 and less sensitive and the less confined reaches as C4 type channels (Table 7).

### **Key Elements that Make this Watershed Sensitive**

#### *Sensitivity to Increased Peak Flows*

Given that Frypan Creek watershed is very similar to both the Ankwil and Lovell watersheds, the main watershed characteristics that make it sensitive to the increased peak flows are similar and include the following (Table 2):

- 1) The extent of C4 channel types and particularly the lower part of the channel that flows across a fluvial fan and glacio-fluvial materials,

- 2) The mountainous topography at the back of the watershed with localized steepness,
- 3) The high drainage density with very shallow soils in the upper watershed,
- 4) The large and relatively uniform elevation of the plateau area, where most of the logging disturbances could occur and
- 5) The climate dominated by relatively deep winter snowpacks.

#### *Sensitivity to Increased Delivery of Fine Sediments*

This watershed has some very sensitive fish species, including Sockeye, Dolly Varden and Kokanee. The steep terrain, relatively wet climate, and the high drainage density contribute significantly to the sediment sensitivity as these are significant factors in the processes of surface erosion and sediment transport to the stream network. The fine textured fluvial and easily erodible glacio-fluvial materials in the lower watershed also play an important part in classifying this watershed as sensitive to the potential for increased erosion and accelerated delivery of fine sediment to the stream network (Table 3).

#### *Sensitivity to a Reduction in Riparian Function*

The dominant stream channel types in this watershed are B4 and C4, both types which are highly dependent on the recruitment of large organic debris for the maintenance of long term channel stability and high quality fish habitat. These channels also depend on riparian vegetation and riparian forest for controlling stream temperatures and terrestrial food sources such a litter and insect drops. This dependence on the riparian forest, for the maintenance of quality fish habitat, makes them highly sensitive to riparian disturbances of losses in riparian functions (Table 4).

### **Risk Assessment for this Watershed**

#### *Risk associated with Potential Increases in Peak Flows*

Currently the risk associated with potential increases in peak flows is very low (Table 8) because the extent of disturbances in this watershed is very low (i.e. the hazard is very low). The total watershed HEDA is only at 4.51% (Table 5). No commercial harvest of the forest has occurred in this watershed which means that the current peak flow hazard is non-existent (as defined for this project).

#### *Risk associated with Potential Increases in the Delivery of Fine Sediments to the Stream Network*

The risk associated with the potential for delivery of fine sediments have been assessed as Very Low (Table 8). Although the sediment sensitivity of the watershed has been assessed as Extreme (Table 3), there are no stream crossings or roads in this watershed and consequently the hazard is Very Low (Table 6).

#### *Risk associated with a Reduction in Riparian Function*

The risk associated with a loss in riparian function is Very Low (Table 8) because there has been no riparian logging anywhere along the mainstem of Frypan Creek (Table 7 and Figures 5 to 9), i.e. the hazard (as defined for this project) is essentially nonexistent.

### **Suggested Management Objectives and Strategic Directions for this Sensitive Watershed**

- 1) There are some extensive areas of flat over steep terrain in this watershed, especially along reaches 2, 3 and 4 (Figures 5 and 6). If harvesting proceeds in the vicinity of these areas, these terrain features should be carefully managed.
- 2) Maintain the peak flow risk in this watershed below a Moderate level (i.e. Low or Very Low). This means that the HEDA value for this watershed should be maintained below 19.38%, which would allow the harvesting of about 1,735 ha of healthy stands. Use the Peak Flow Risk Calculator to determine the maximum suggested harvest of different combinations of healthy stands and mountain pine beetle affected stands in order to maintain a peak flow risk level below moderate.
- 3) Minimize riparian disturbances within the riparian management zone (RMZ) within the areas identified as having a “fluvial fan” or “glacio-fluvial” surficial geology (Figure 2).
- 4) Maintain best management erosion and sediment control practices at any future stream crossing located over the mainstem river. In addition to being very important fish habitat at this location, the soils are easily erodible and could very easily be transported into Frypan Creek. I suggest that the Water Quality Effectiveness Evaluation (WQEE) tool be used and that the WQEE rating be maintained below a moderate level (i.e. Low or Very Low). The most recent WQEE protocol can be found at the following web link:  
<http://www.for.gov.bc.ca/ftp/hfp/external/!publish/frep/indicators/Indicators-WaterQuality-Protocol-2009.pdf>
- 5) For all S4 streams wider than 0.5 m, maintain long term large woody debris (LWD) recruitment to the stream channel by retaining at least 90% of the riparian area in a state undisturbed by primary forest activities. Note that the riparian area refers to the management area measured from the closest streambank to a distance 15m upslope from the streambank.

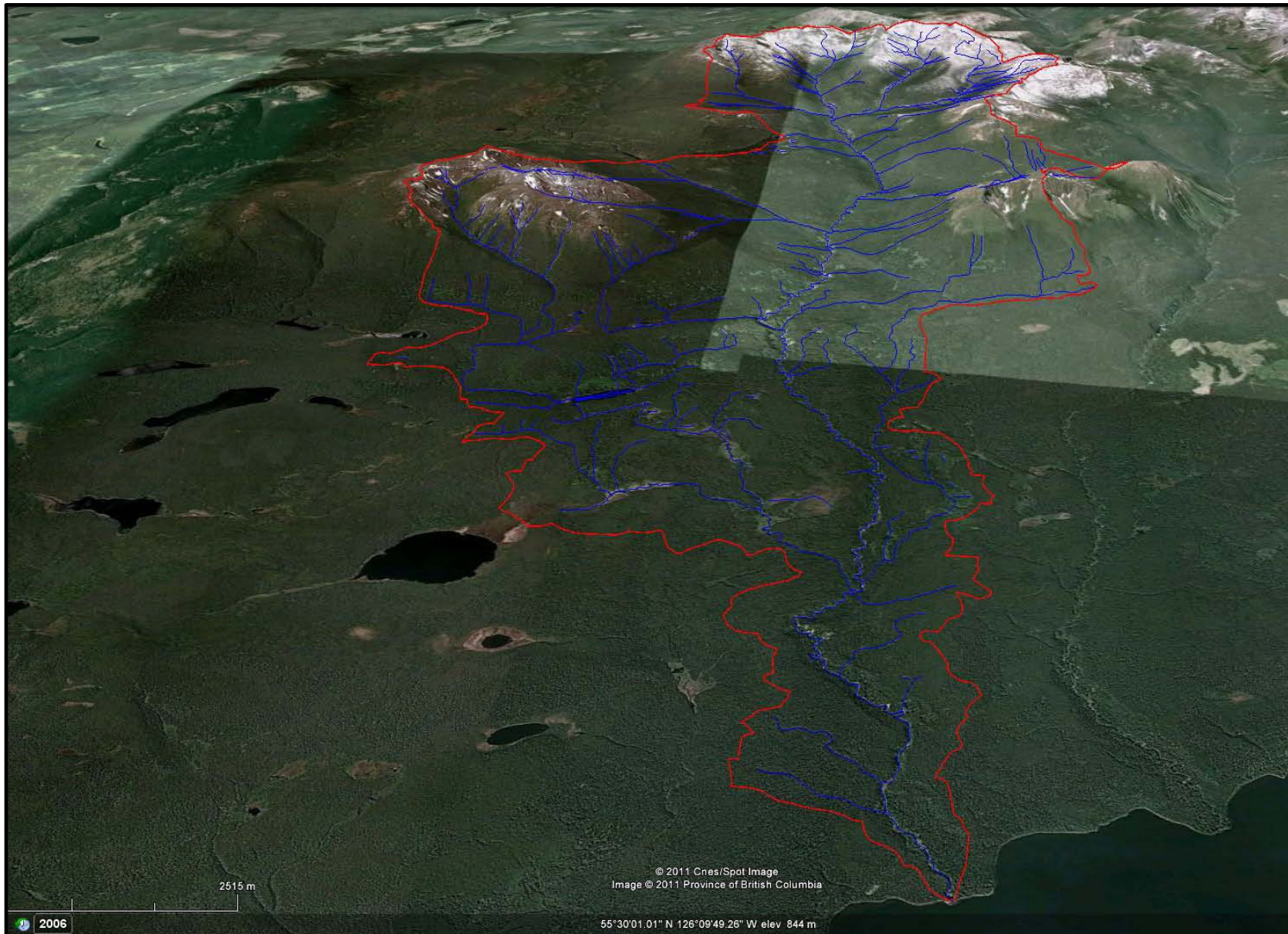


Figure 1. Google earth overview image of Frypan Creek watershed, looking upstream into the watershed.

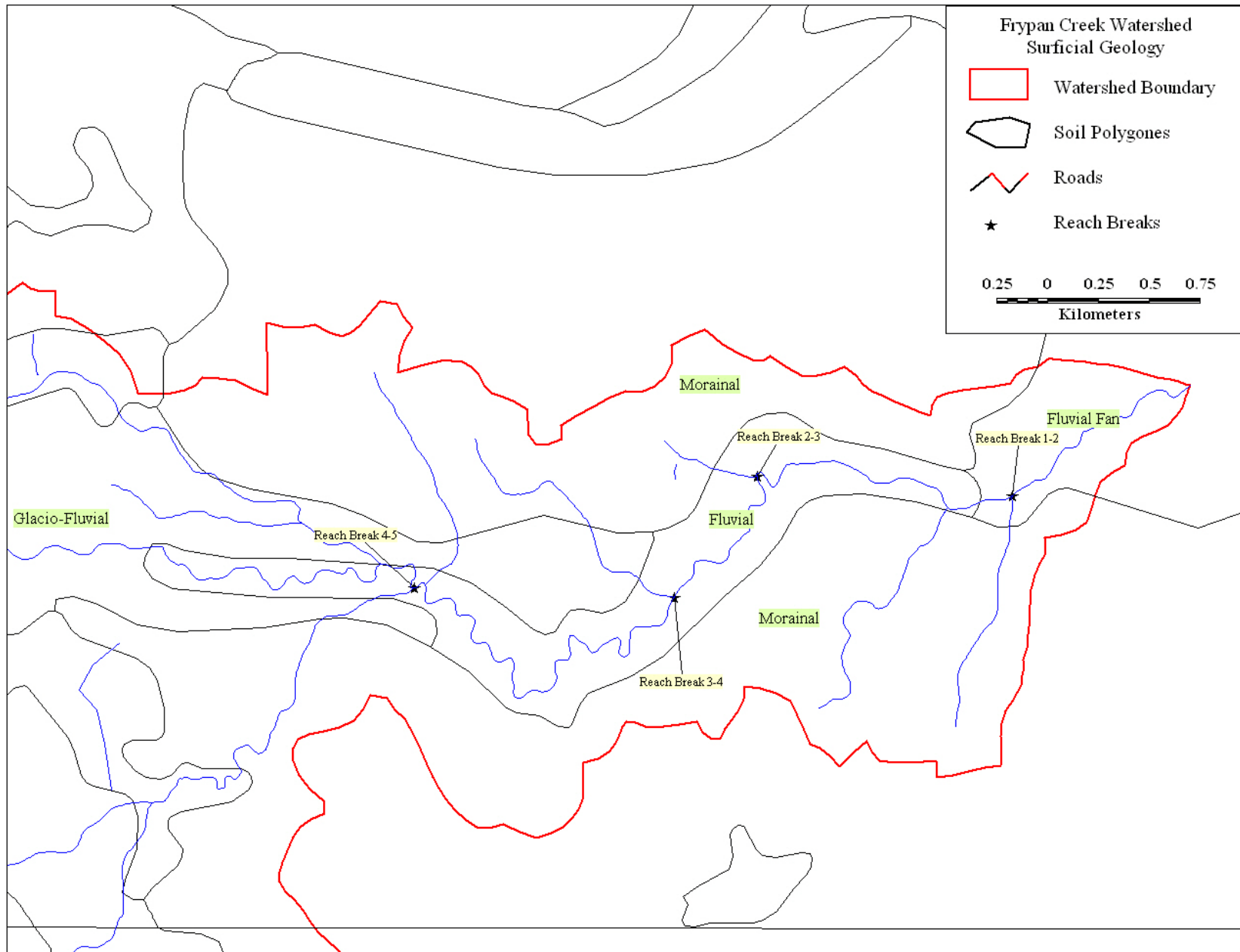


Figure 2. Distribution of surficial geology types near the mouth of Frypan Creek.

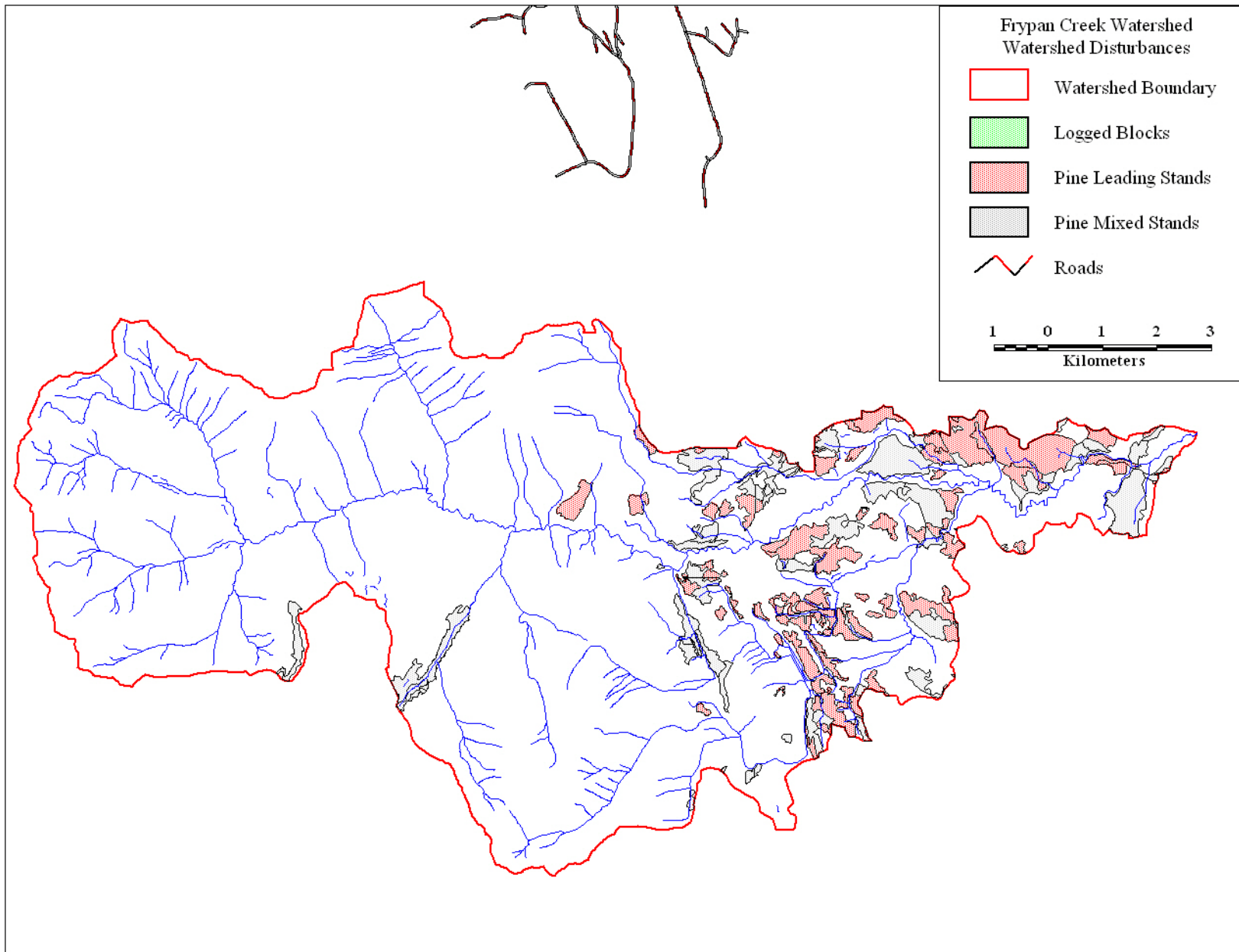


Figure 3. Land-use related and large natural disturbances in the Frypan Creek Watershed

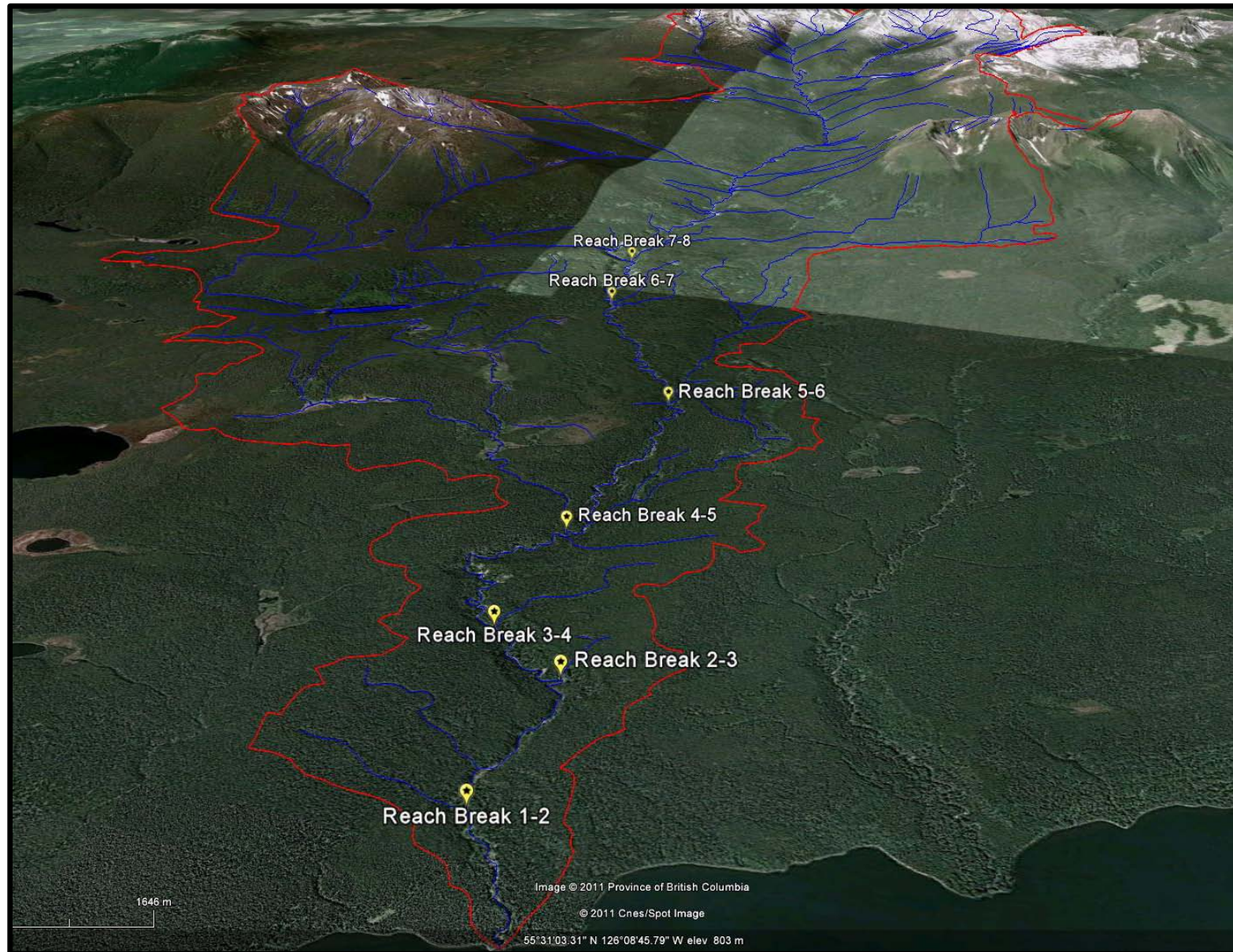


Figure 4. Identification of reach breaks along the mainstem of the lower Frypan Creek watershed

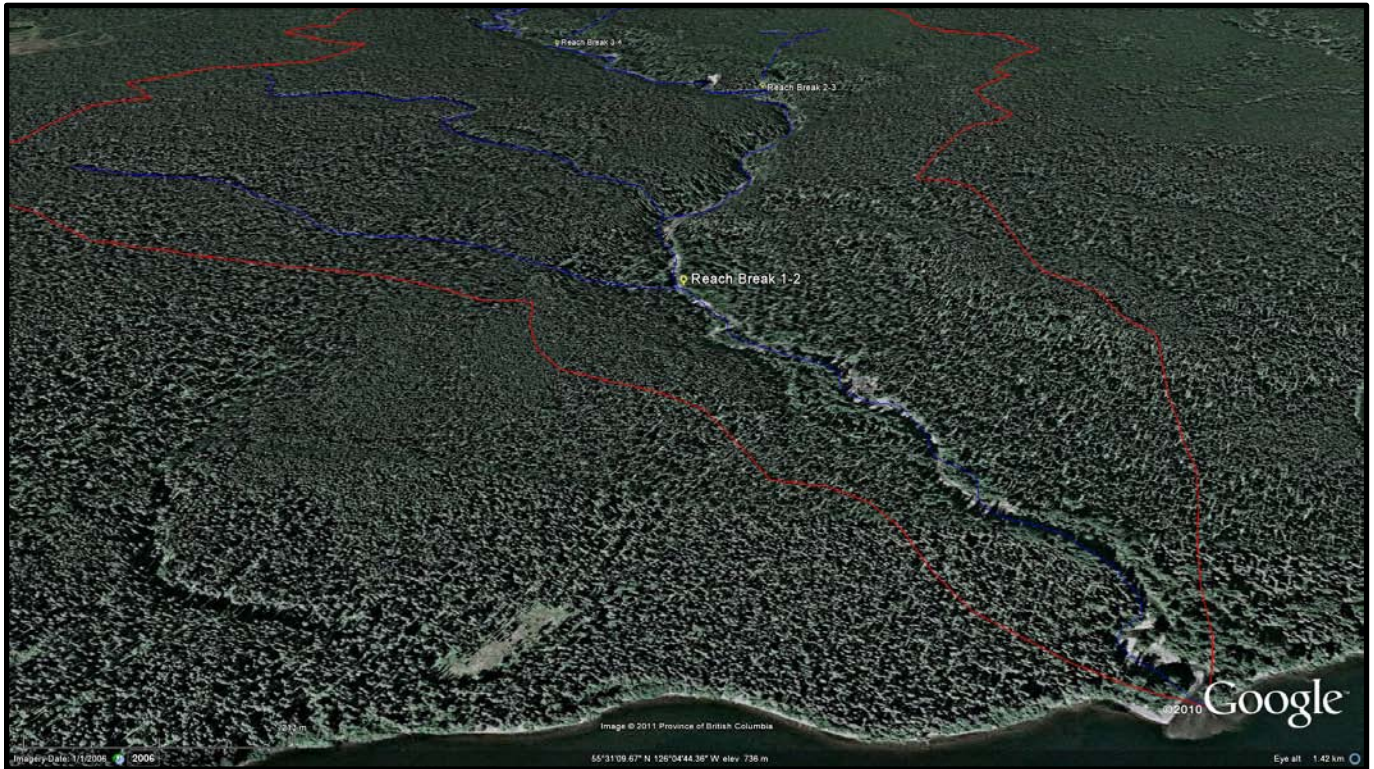


Figure 5. Google Earth image looking upstream along Reaches #1 and 2 of Frypan Creek.

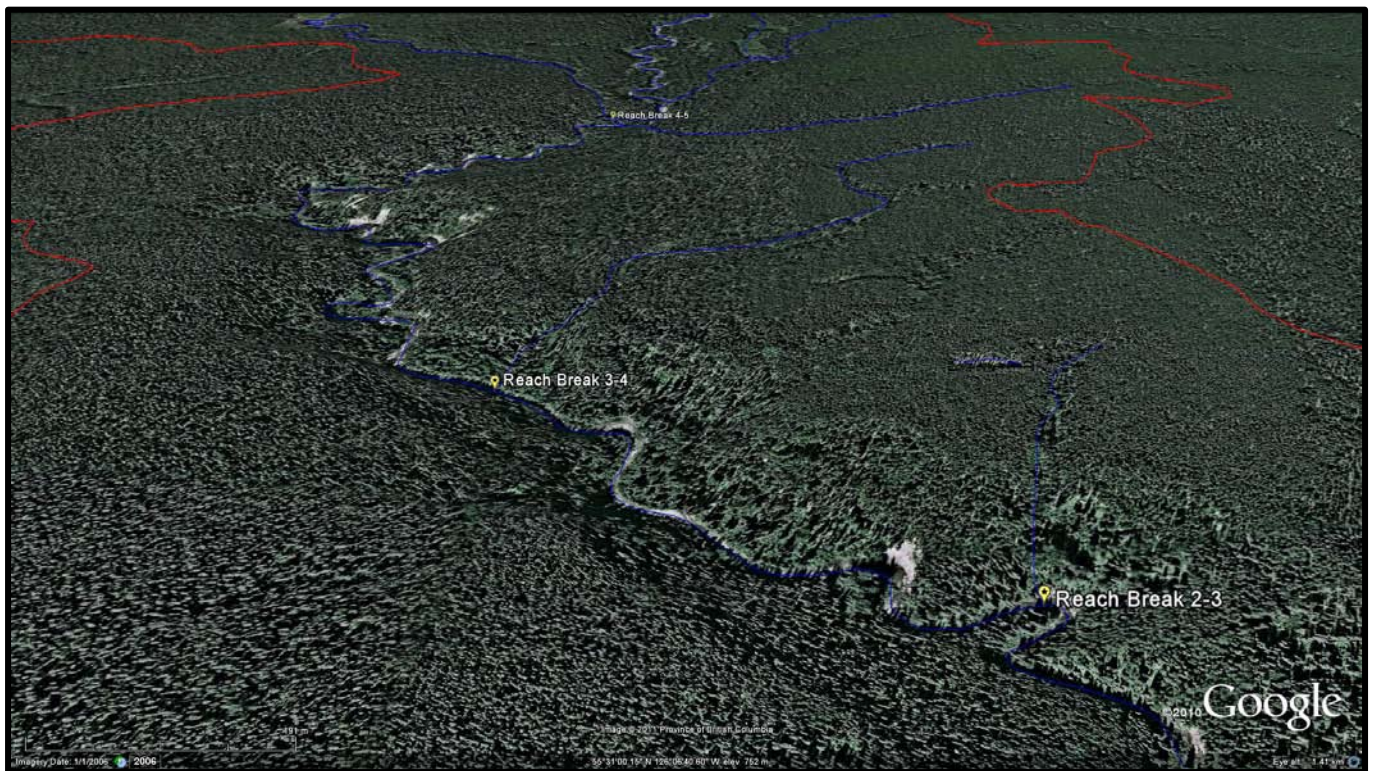


Figure 6. Google Earth image looking upstream along Reaches #3 and 4 of Frypan Creek.



Figure 7. Google Earth image looking upstream along Reach #5 of Frypan Creek.

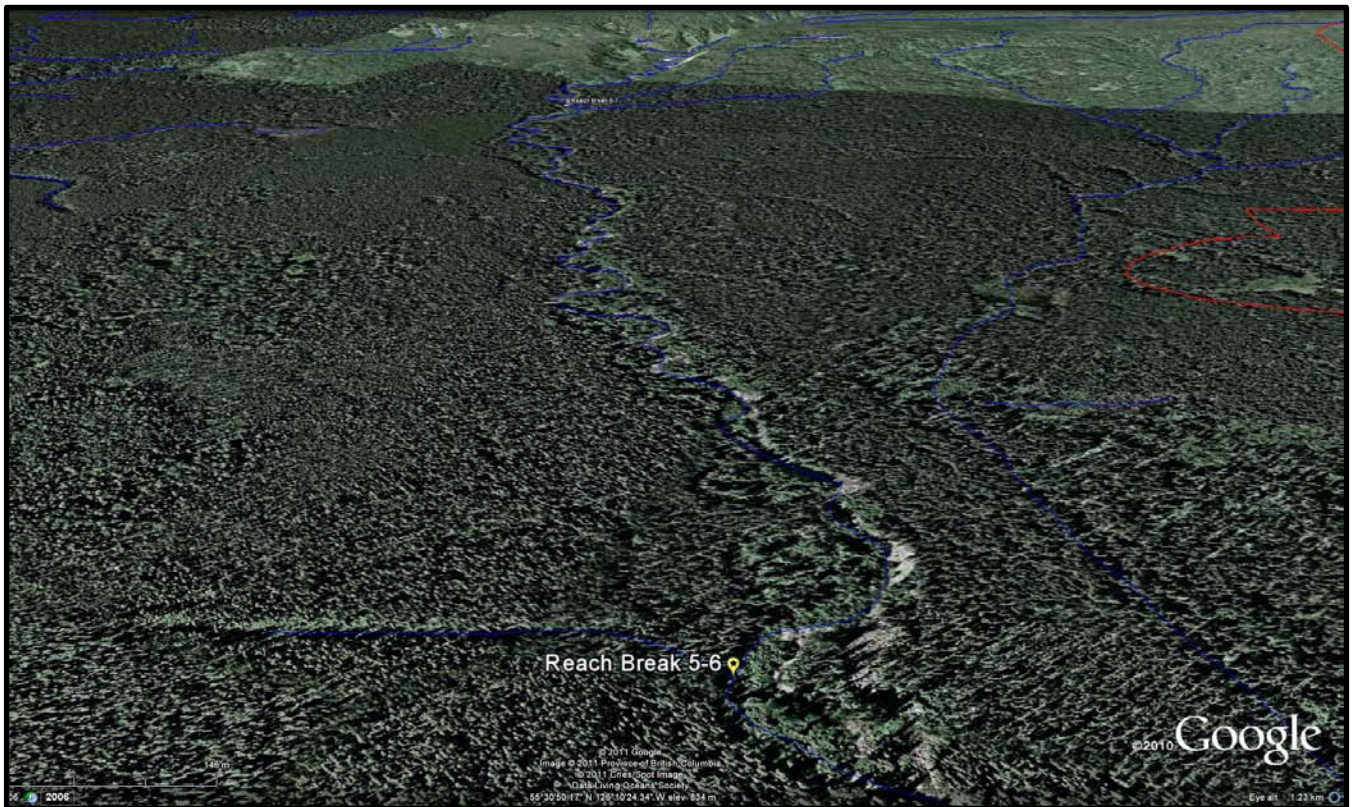


Figure 8. Google Earth image looking upstream along Reach #6 of Frypan Creek.

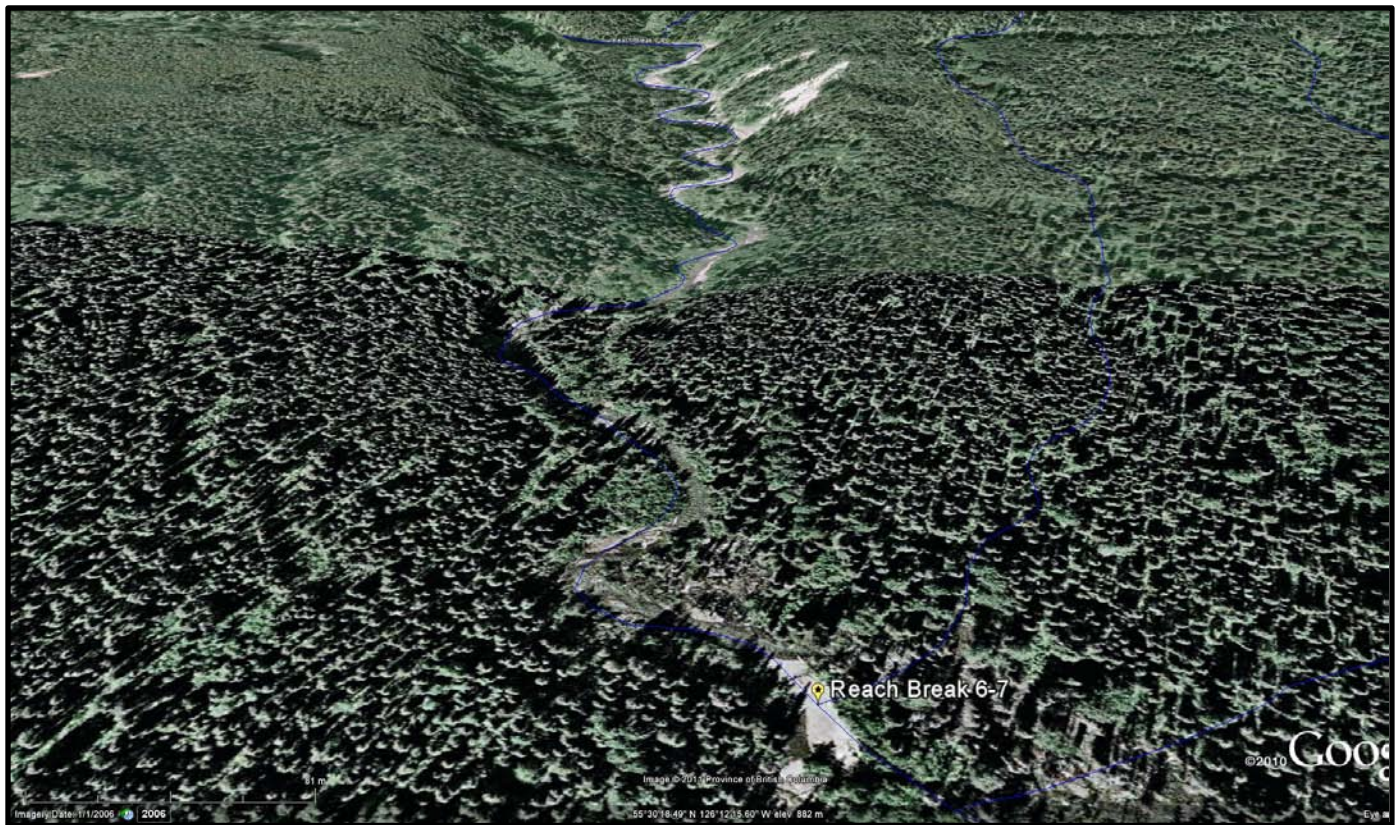


Figure 9. Google Earth image looking upstream along Reach #7 of Frypan Creek.

**WATERSHED REVIEW**  
**KUZKWA CREEK WATERSHED**  
**November 22, 2011**  
 Ministry Contract No: CS12NRH-011

**BIOPHYSICAL AND LAND-USE CHARACTERISTICS OF THE WATERSHED**

Table 1. Summary Information – Watershed Characteristics – (see Figures 1 and 2)

Size (km <sup>2</sup> )	Dominant BEC Zones	Dominant NDT	Elevation Range (m)	Surficial Geology near the Mouth (i.e. sensitive area)	Stream Density (km/km <sup>2</sup> )	Biggest % of watershed in same elevation band <sup>1</sup>	Distribution of slope gradients within the watershed (% of watershed)			
							<10% slope	10 to 30% slope	30 to 60% slope	>60% slope
1,536	SBSdw3 SBSmk1	NDT3	697-1553	Fine textured lacustrine	1.86	80.56	81.9	16.7	1.34	0.06

<sup>1</sup> The entire watershed is divided into 300 m elevation bands of harvestable forest land-base. The less elevation bands there are and the more area is represented by any given single elevation band, then the greater will likely be the effect of forest harvesting on increased peak flows due to the theoretical concept of “synchronization” (i.e. the melt from the cutblocks is synchronized as much of it comes from the same elevation), and the greater sensitivity it will have.

Table 2. Rating of “Sensitivity” of Watershed to Increased Peak Flow at the lower reaches

Rosgen Stream Channel Score	Rosgen Stream Channel Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to vertical conductivity	Sensitivity score relative to climate	Sensitivity score relative to flow synchronization potential	Sensitivity score relative to NDT type	Sensitivity Score	Sensitivity Rating
C4- Stable - Large	2.5	0.6	0.9	0.95	1.1	1.05	1	1.48	Very Low

Table 3. Rating of “Sensitivity” of Watershed to Increased Production of Fine Sediment at lower reaches

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to climate	Sensitivity Score	Sensitivity Rating
Chinook Salmon	4.4	0.8	0.9	1.1	3.5	Mod

Table 4. Rating of “Sensitivity” of Watershed to a Loss In riparian Function.

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to loss of LWD	Sensitivity score relative to Aspect	Sensitivity score relative to climate	Overall watershed sensitivity to loss of riparian	Loss of Riparian Sensitivity Rating
Chinook Salmon	4.4	1.25	0.95	1.1	5.75	Extreme

Table 5. Peak Flow Hazard Rating, as indexed by HEDA – current scenario (i.e. no proposed harvesting considered)

Watershed area (km <sup>2</sup> )	Total area Pine Leading (km <sup>2</sup> )	Total area Pine Mixed (km <sup>2</sup> )	Total area harvest (km <sup>2</sup> ) <sup>1</sup>	Total HEDA from Pine Beetle alone (%)	Total HEDA from logging alone (%)	Total HEDA from logging and Pine Beetle mortality (%)
1536	267	210.2	377.36	12.80	16.49	29.29

<sup>1</sup>Note: This includes openings from VRI database, and non-overlapping openings from RESULTS and FTEN databases.

Table 5 (continued)

Total area in Agriculture (km <sup>2</sup> )	Total area in Agriculture (% of watershed)	Total area in Proposed Harvest (km <sup>2</sup> )	Total HEDA (%)	HEDA Hazard rating Score	HEDA Hazard Rating
0.00	0.00	0.00	29.29	2.61	Mod

Table 6. Fine Sediment Hazard Rating, as indexed by the Stream Crossing Density

Watershed area (km <sup>2</sup> )	# of x-ings	#of fish bearing X-ings <sup>1</sup>	#of non-fish bearing X-ings	density of x-ings (#/km <sup>2</sup> )	Density of fish bearing X-ings (#/km <sup>2</sup> )	Density of non-fish bearing X-ings (#/km <sup>2</sup> )	Hazard Rating Score	Hazard Rating
1536.0	896	886	10	0.6	0.6	0.01	2.6	Mod

<sup>1</sup>Note: The information on stream crossings was provided by MoE and was generated with a GIS model, not fieldwork.

Table 7. Loss of Riparian Function Hazard Rating (See Figures 4 to 9)

Reach Number	Rosgen Stream Type	Reach Length (m)	% riparian logged (as interpreted from air photos)	Apparent stability and other comments (as viewed from air photos)
1	C4- Stable - Large	4485	0.0	Very Stable
2	C4- Stable - Large	2831	0.0	Very Stable
3	C4- Stable - Large	7941	0.0	Very Stable
4	C4- Stable - Large	13562	0.0	Very Stable
Hazard Scores:			Hazard Rating Score	Hazard Rating
			0.5	Very Low

Table 8. Risk Rankings for the Different Hazards in the watershed current scenario (i.e. no proposed harvesting considered)

Watershed Hazard Types	Sensitivity Score	Sensitivity Rating	Hazard Score	Hazard Rating	Risk Score	Risk Rating
Increased Peak Flow	1.48	Very Low	2.61	Mod	3.9	Low
Increase in Production of Fine Sediment	3.48	Mod	2.59	Mod	9.0	Mod
Loss of Riparian function	5.75	Extreme	0.5	Very Low	2.9	Low

**INTERPRETATIONS AND RECOMMENDATIONS FOR MANAGEMENT STRATEGIES FOR PROTECTION OF WATER RESOURCES IN THIS WATERSHED**

**Brief Watershed Description (Table 1 and Figures 1 and 2)**

The Kuzkwa Creek watershed is relatively large (1,536 km<sup>2</sup>) and is dominated by a low lying topography with numerous large lakes and wetlands spread throughout. The watershed flows in a generally north-easterly direction and empties directly into the Tachie River. At its mouth, Kuzkwa Creek is large (about 35 m wide), low gradient and has a lightly meandering plan form.

The dominant biogeoclimatic zones in this watershed are the SBSdw3 and SBSmk1. There is a small amount of ESSFmv3 at mid to higher elevations. About 81% of the watershed has slopes of 30% or less with about 0.06% of the watershed having slopes greater than 60% (Table 1). There are only two significant elevations bands in this watershed where 81% of the watershed falls between 697 and 997 m (lowest elevation band) and 18% of the watershed is between 997 and 1297m in elevation.

The mainstem of lower Kuzkwa Creek (below Tezzeron Lake) is a wide low gradient channel with a meandering plan form which has been classified as a C4/C5 Rosgen channel type (Table 7, Figure 4). Most of the watershed is dominated by a medium textured glacial till (Mm and Mv), however along the lower reaches there is an abundance of lacustrine (L) and fluvial landforms (F), which can be very sensitive to erosion when exposed (Figure 2).

The riparian ecosystems along the mainstem Kuzkwa Creek appear to have been well protected from land-use related disturbances (Figures 5 to 9), which of course serves to protect the aquatic resources.

## **Key Elements that Characterise the Sensitivity of this Watershed Sensitive**

### *Sensitivity to Increased Peak Flows*

The lower reaches of the Kuzkwa watershed have a Very Low sensitivity to increased peak flows for the following reasons (Table 2):

1. The stream channel is large and thus more robust to changes in peak flows.
2. There are numerous large lakes and wetlands in the watershed that serve to buffer peak flows.
3. The general topography of the watershed is gently rolling
4. The valley are wide and consequently more disconnected to activities in the uplands
5. Soils are generally deep glacial till that slows the vertical movement of water through the watershed

### *Sensitivity to Increased Delivery of Fine Sediments*

The following combination of watershed characteristics, along the lower reaches of the Kuzkwa watershed, generates a Moderate sensitivity to increased production of fine sediments for the following reasons (Table 3):

1. Fish species present are highly sensitive to disturbances and changes in sediment regime.
2. The topography is low gradient and thus reduces the erosion potential
3. The abundance of large lakes and wetlands serves to buffer the downstream migration of fine sediments.

### *Sensitivity to a Reduction in Riparian Function*

The lower reaches of the Kuzkwa watershed have an Extreme sensitivity to losses in riparian functions for the following reasons (Table 4):

1. Fish species present are highly dependent on a healthy riparian habitat
2. The stability of channel types of the lower reaches of Kuzkwa Creek are also very dependent on proper functioning riparian ecosystems.

## **Risk Assessment for this Watershed**

### *Risk associated with Potential Increases in Peak Flows*

This risk is Low (table 8) because of the combination of having a Very Low sensitivity to increased peak flows and only a Moderate Hazard (HEDA = 29%).

### *Risk associated with Potential Increases in the Delivery of Fine Sediments to the Stream Network*

The fine sediment risk is Moderate (Table 8) because of the combination of a Moderate sensitivity, and a Moderate hazard (896 stream crossings in this watershed). Although there are some terrain features in this watershed that are very sensitive to erosion, most of the watershed is covered by a medium to coarse textures till, which is less sensitive.

*Risk associated with a Reduction in Riparian Function*

The risks associated with a reduction in riparian function are low because the riparian ecosystems along the mainstem have been well protected from land-use disturbances.

**Suggested Management Objectives and Strategic Directions for this Watershed**

Although there are some areas in this watershed that are very sensitive to land-use disturbances, overall the characteristics of this watershed make it quite robust to land-use related disturbances that can cause increases in peak flows and increases in surface erosion. That being said however, this watershed remains very sensitive to losses in riparian functions and thus proper riparian management should remain a priority for this watershed.

Given the large size of this watershed and the very low sensitivity to increases in Peak Flows, I recommend that this watershed not be submitted as a Fisheries Sensitive Watershed (FSW) candidate.

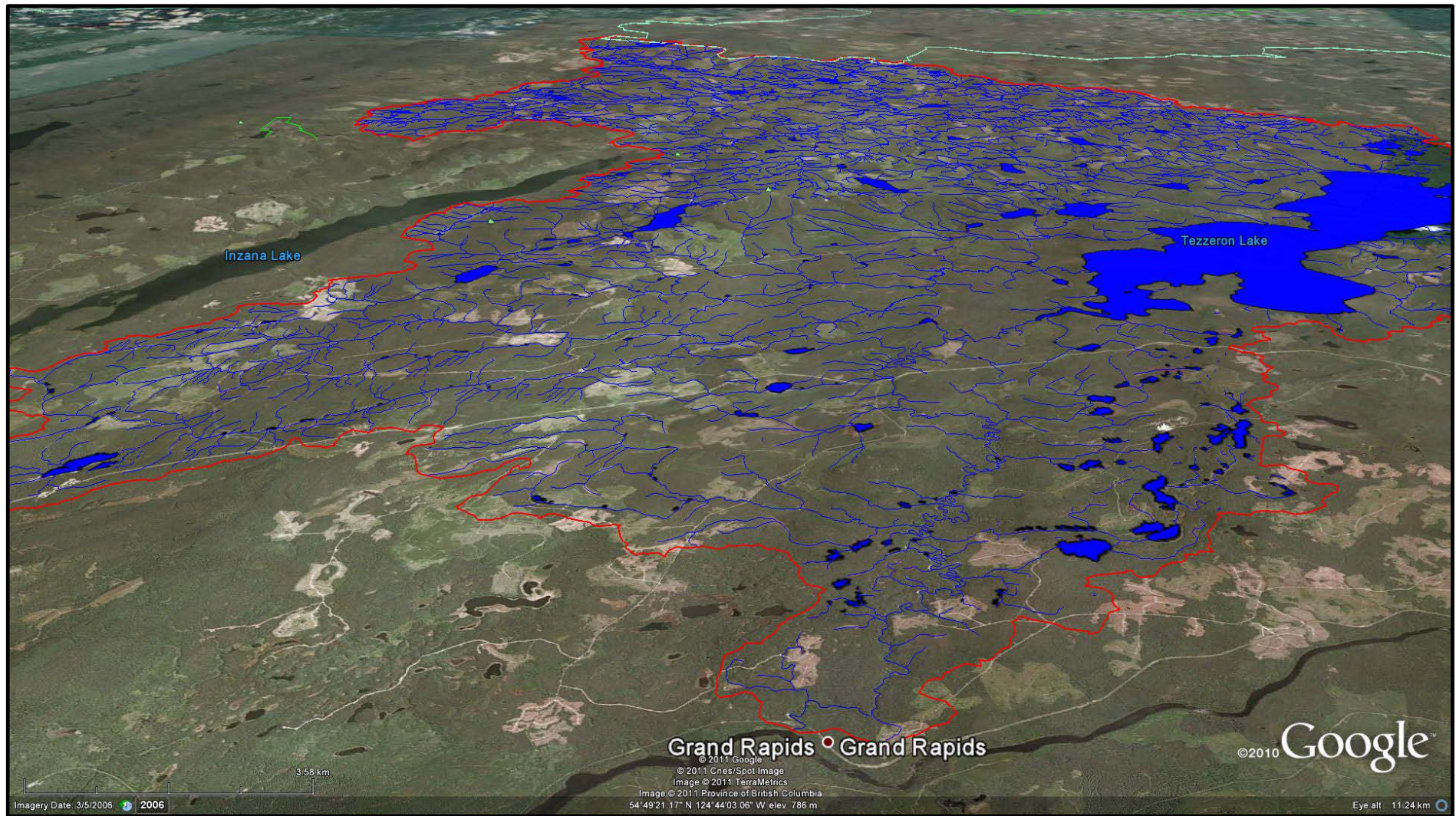


Figure 1. Google earth overview image of Kuzkwa Creek watershed, looking upstream into the watershed.



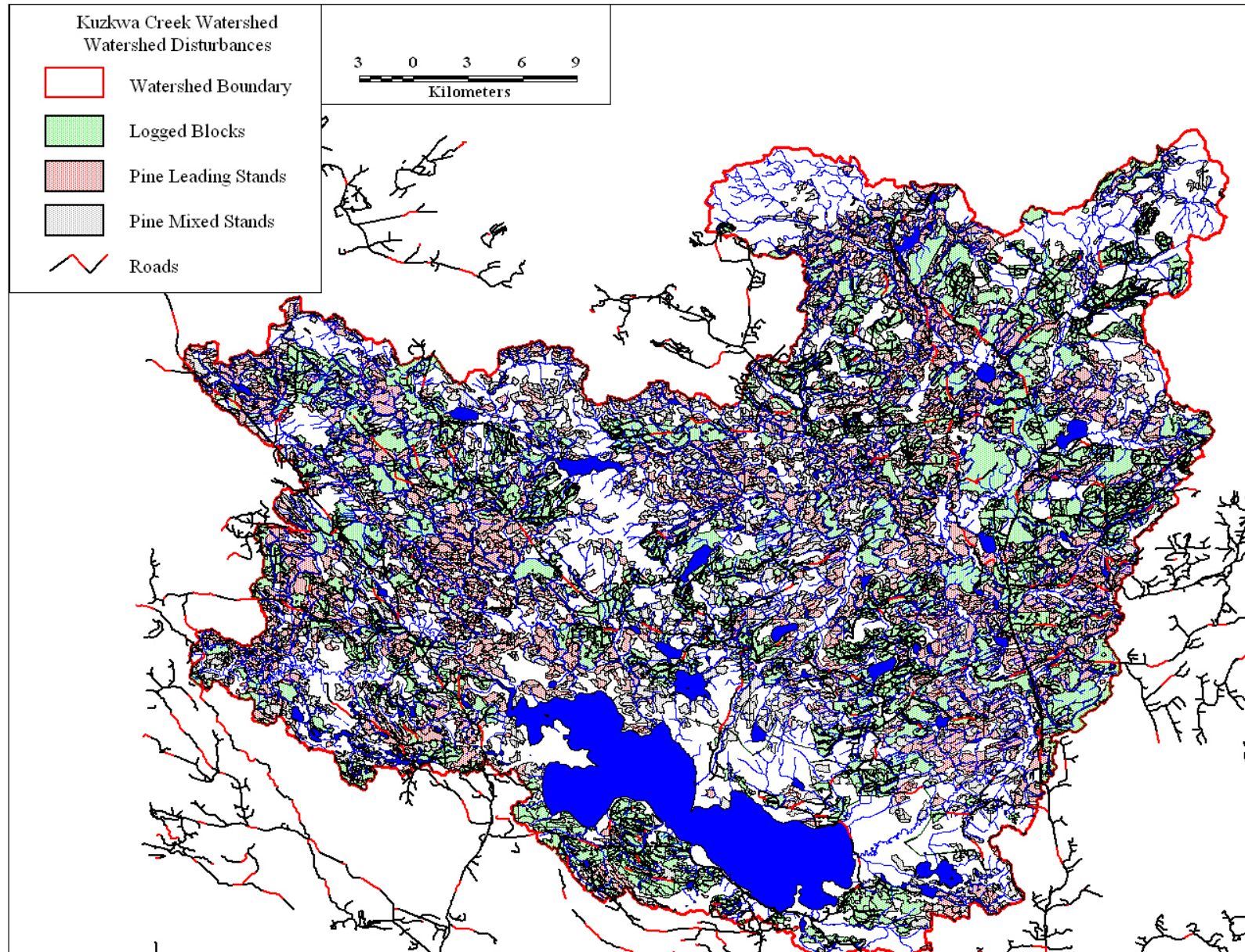


Figure 3. Land-use related and large natural disturbances in the Kuzkwa Creek Watershed

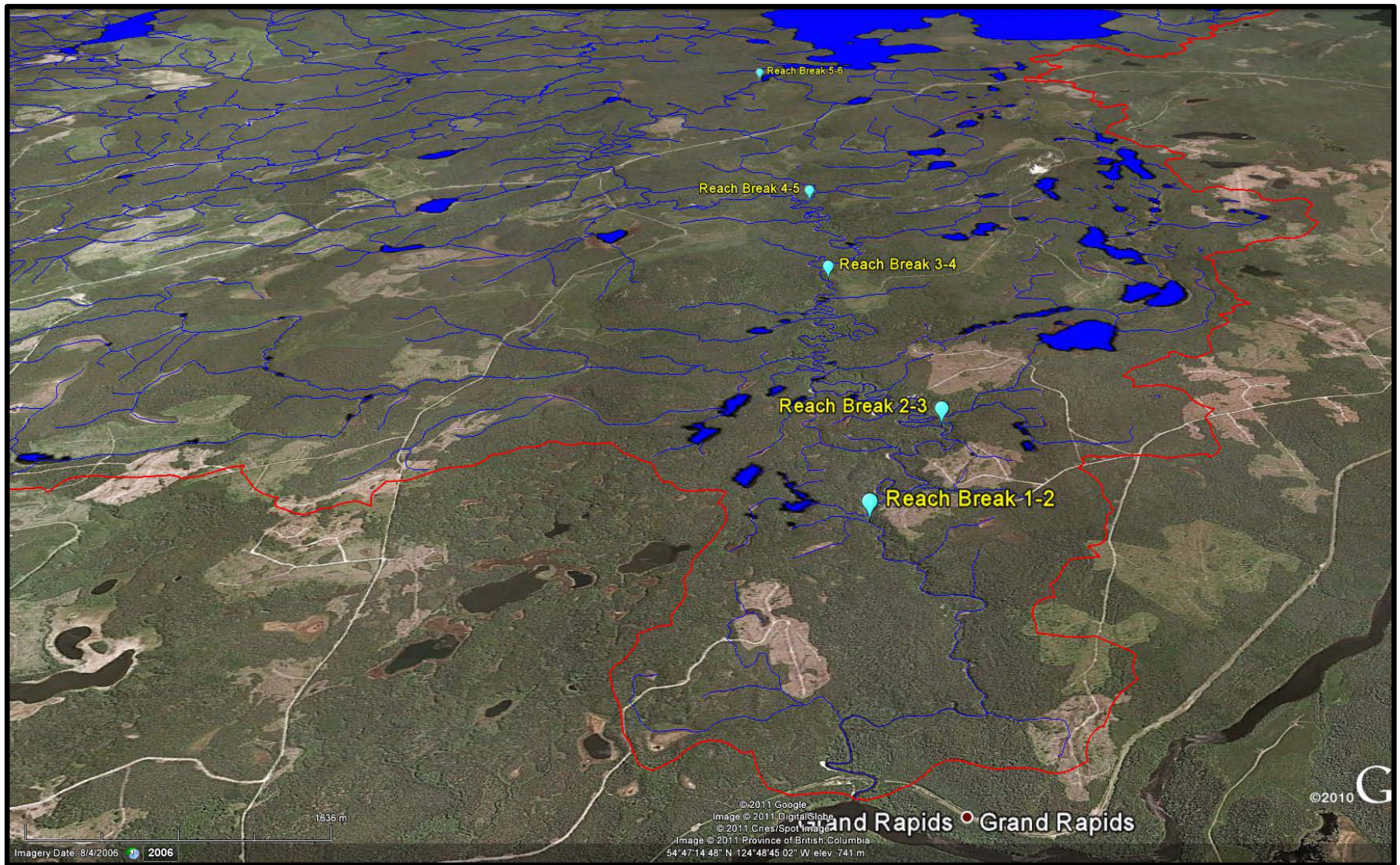


Figure 4. Identification of reach breaks along the mainstem of the lower Kuzkwa Creek watershed

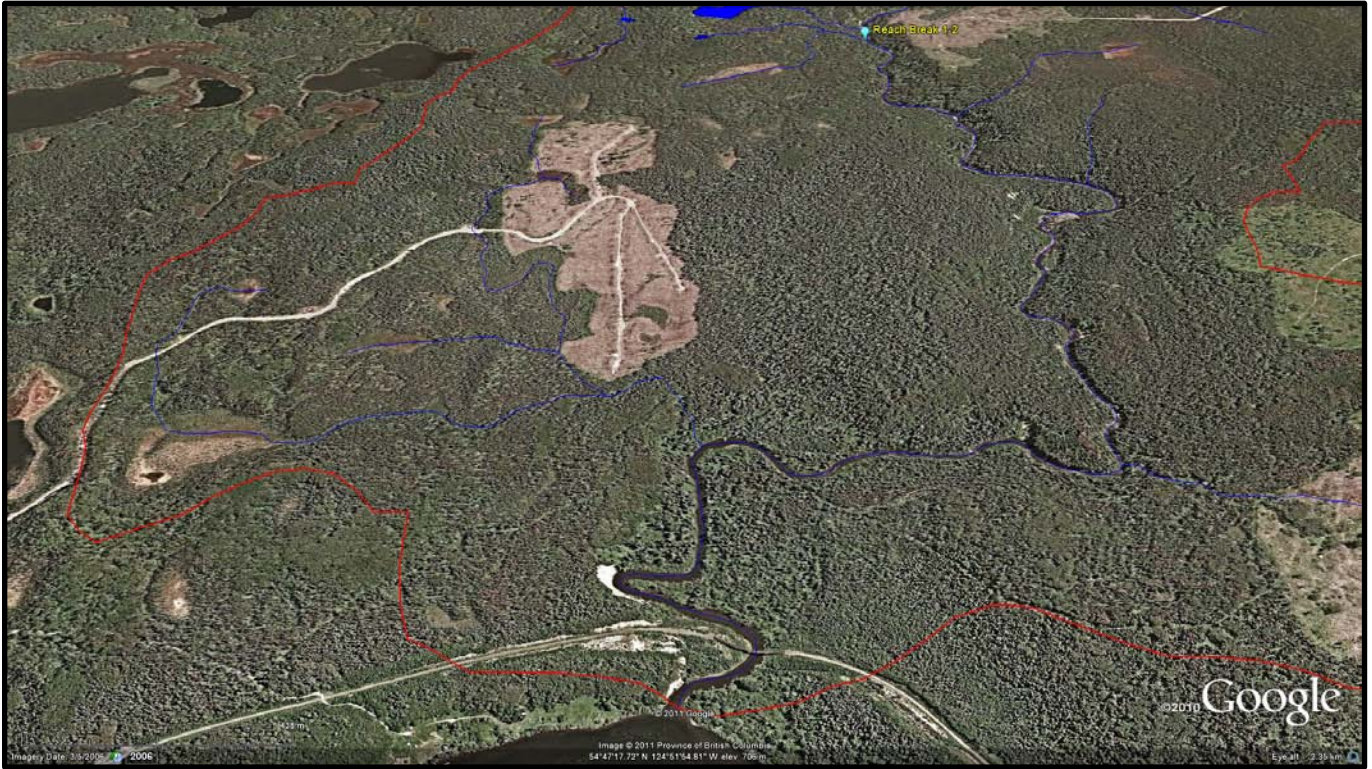


Figure 5. Google Earth image looking upstream along Reach #1 of Kuzkwa Creek.



Figure 6. Google Earth image looking upstream along Reach #2 of Kuzkwa Creek.

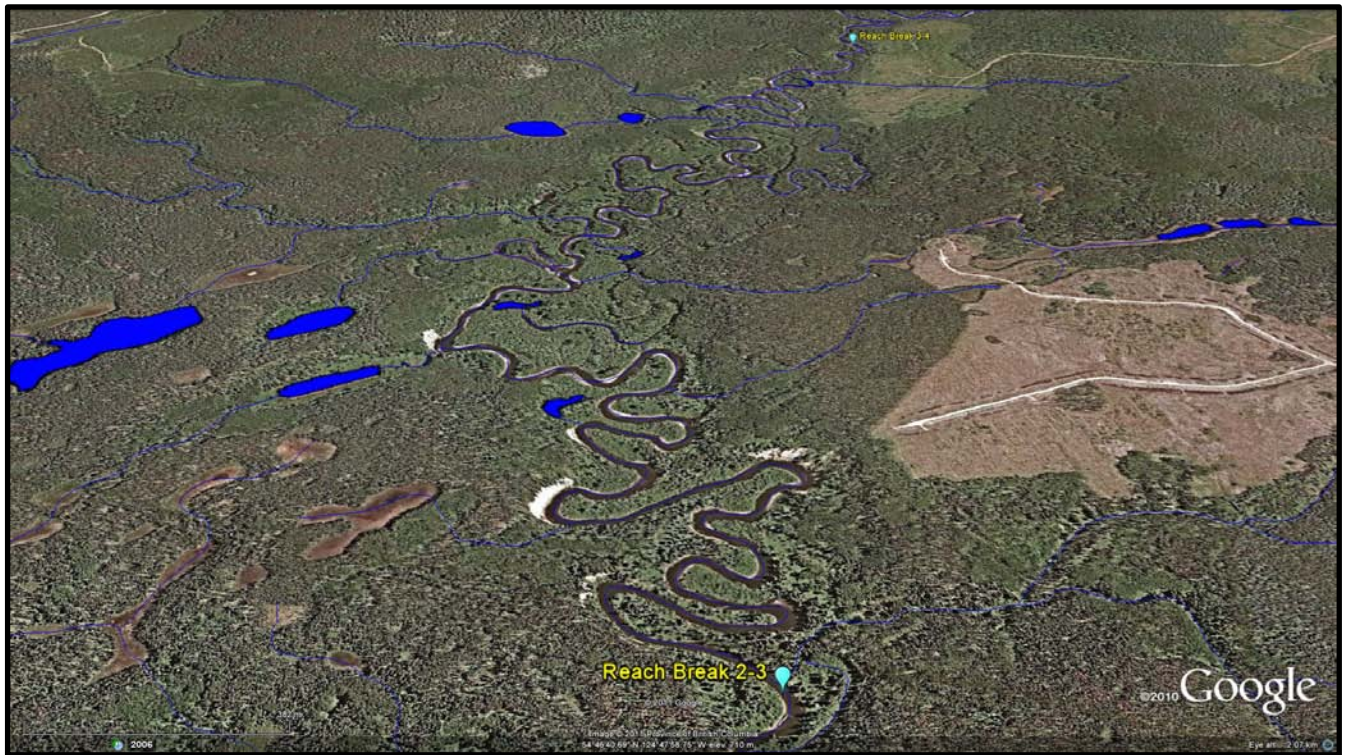


Figure 7. Google Earth image looking upstream along Reach #3 of Kuzkwa Creek.

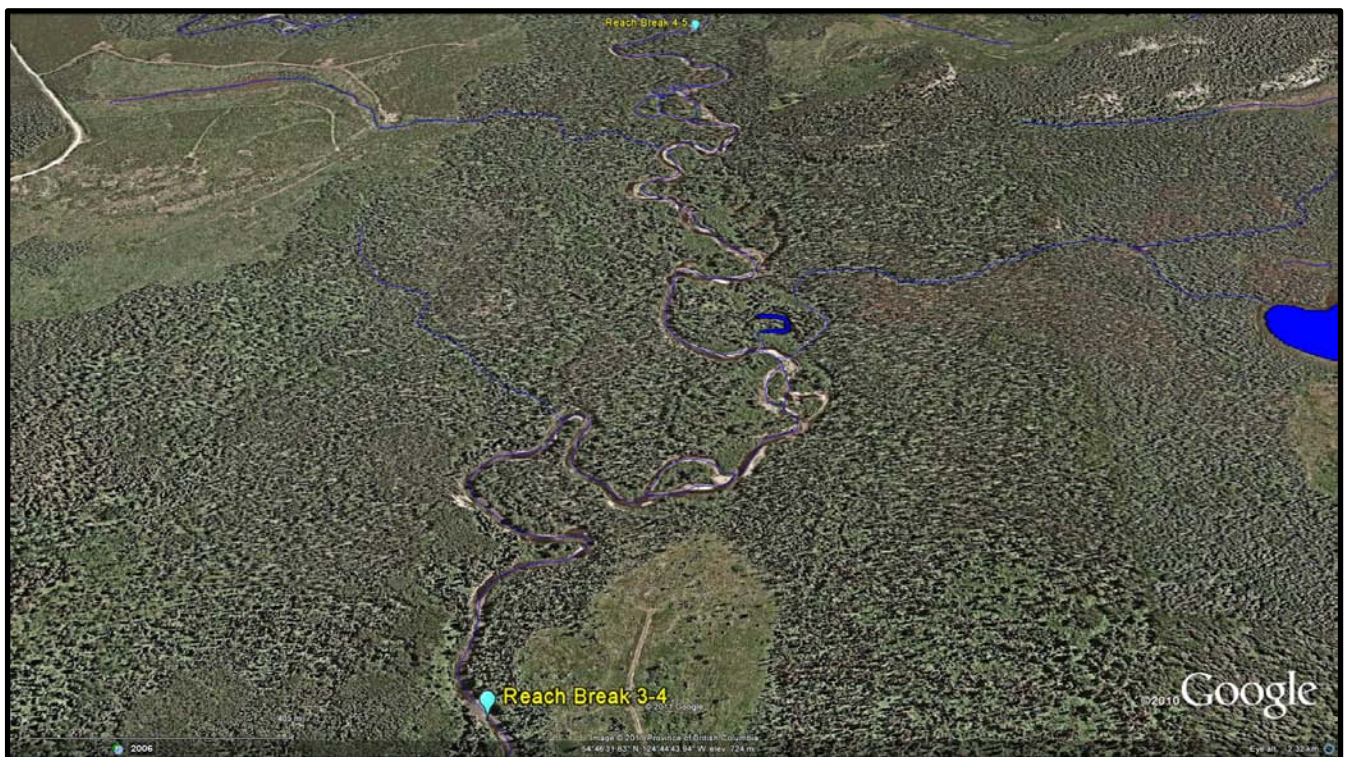


Figure 8. Google Earth image looking upstream along Reach #4 of Kuzkwa Creek.

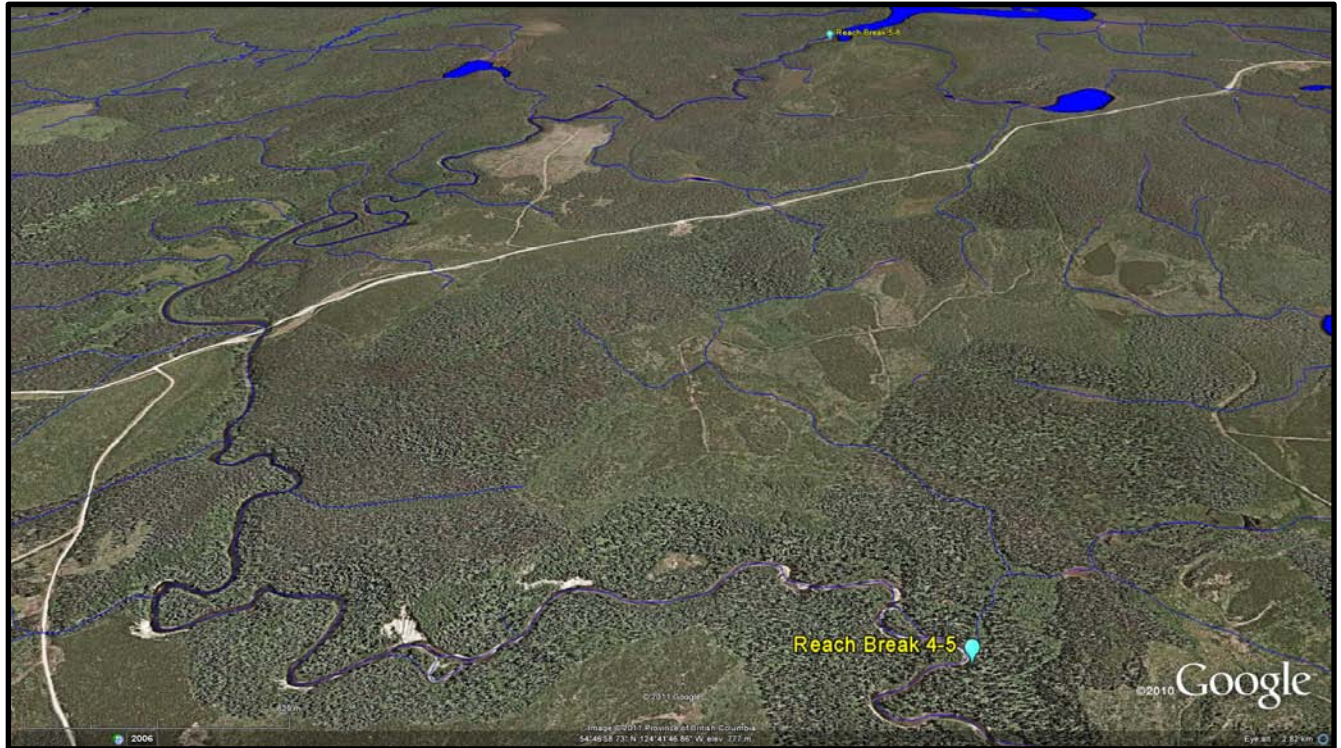


Figure 9. Google Earth image looking upstream along Reach #5 of Kuzkwa Creek.

## WATERSHED REVIEW LOVELL CREEK WATERSHED

**November 22, 2011**  
Ministry Contract No: CS12NRH-011

### BIOPHYSICAL AND LAND-USE CHARACTERISTICS OF THE WATERSHED

Table 1. Summary Information – Watershed Characteristics – (see Figures 1 and 2)

Size (km <sup>2</sup> )	Dominant BEC Zones	Dominant NDT	Elevation Range (m)	Surficial Geology near the Mouth (i.e. sensitive area)	Stream Density (km/km <sup>2</sup> )	Biggest % of watershed in same elevation band <sup>1</sup>	Distribution of slope gradients within the watershed (% of watershed)			
							<10% slope	10 to 30% slope	30 to 60% slope	>60% slope
92.5	SBS	NDT3	701-1950	Fine textured fluvial	2.26	33.3	41.3	32.4	21.5	4.8

<sup>1</sup> The entire watershed is divided into 300 m elevation bands of harvestable forest land-base. The less elevation bands there are and the more area is represented by any given single elevation band, then the greater will likely be the effect of forest harvesting on increased peak flows due to the theoretical concept of “synchronization” (i.e. the melt from the cutblocks is synchronized as much of it comes from the same elevation), and the greater sensitivity it will have.

Table 2. Rating of “Sensitivity” of Watershed to Increased Peak Flow at the lower reaches

Rosgen Stream Channel Score	Rosgen Stream Channel Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to vertical conductivity	Sensitivity score relative to climate	Sensitivity score relative to flow synchronization potential	Sensitivity score relative to NDT type	Sensitivity Score	Sensitivity Rating
C4- Stable	3.5	1	1.1	1	1.1	1	1	4.24	High

Table 3. Rating of “Sensitivity” of Watershed to Increased Production of Fine Sediment at lower reaches

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to climate	Sensitivity Score	Sensitivity Rating
Dolly Varden	5	1	1.2	1.1	6.6	Extreme

Table 4. Rating of “Sensitivity” of Watershed to a Loss In riparian Function.

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to loss of LWD	Sensitivity score relative to Aspect	Sensitivity score relative to climate	Overall watershed sensitivity to loss of riparian	Loss of Riparian Sensitivity Rating
Dolly Varden	5	1.25	0.8	1.1	5.50	Extreme

Table 5. Peak Flow Hazard Rating, as indexed by HEDA – current scenario (i.e. no proposed harvesting considered)

Watershed area (km <sup>2</sup> )	Total area Pine Leading (km <sup>2</sup> )	Total area Pine Mixed (km <sup>2</sup> )	Total area harvest (km <sup>2</sup> ) <sup>1</sup>	Total HEDA from Pine Beetle alone (%)	Total HEDA from logging alone (%)	Total HEDA from logging and Pine Beetle mortality (%)
92.5	7.47	7.09	2.91	6.34	2.77	9.10

<sup>1</sup>Note: This includes openings from VRI database, and non-overlapping openings from RESULTS and FTEN databases.

Table 5 (continued)

Total area in Agriculture (km <sup>2</sup> )	Total area in Agriculture (% of watershed)	Total area in Proposed Harvest (km <sup>2</sup> )	Total HEDA (%)	HEDA Hazard rating Score	HEDA Hazard Rating
0.00	0.00	0.00	9.10	0.68	Very Low

Table 6. Fine Sediment Hazard Rating, as indexed by the Stream Crossing Density

Watershed area (km <sup>2</sup> )	# of x-ings	#of fish bearing X-ings <sup>1</sup>	#of non-fish bearing X-ings	density of x-ings (#/km <sup>2</sup> )	Density of fish bearing X-ings (#/km <sup>2</sup> )	Density of non-fish bearing X-ings (#/km <sup>2</sup> )	Hazard Rating Score	Hazard Rating
92.5	1	1	0	0.0	0.0	0.00	0	Very Low

<sup>1</sup>Note: The information on stream crossings was provided by MoE and was generated with a GIS model, not fieldwork.

Table 7. Loss of Riparian Function Hazard Rating (See Figures 3 to 14)

Reach Number	Rosgen Stream Type	Reach Length (m)	% riparian logged (as interpreted from air photos)	Apparent stability and other comments (as viewed from air photos)
1	C4- Stable	447	0.0	Very Stable
2	C4- Stable	664	0.0	Very Stable
3	C4- Stable	330	0.0	Very Stable
4	C4- Stable	1195	0.0	Very Stable
5	C4- Stable	1472	0.0	Very Stable
6	C4- Stable	2505	0.0	Very Stable
Hazard Scores:			Hazard Rating Score	Hazard Rating
			0.25	Very Low

Table 8. Risk Rankings for the Different Hazards in the watershed current scenario (i.e. no proposed harvesting considered)

Watershed Hazard Types	Sensitivity Score	Sensitivity Rating	Hazard Score	Hazard Rating	Risk Score	Risk Rating
Increased Peak Flow	4.24	High	0.68	Very Low	2.9	Low
Increase in Production of Fine Sediment	6.60	Extreme	0.00	Very Low	0.0	Very Low
Loss of Riparian function	5.50	Extreme	0.25	Very Low	1.4	Very Low

**INTERPRETATIONS AND RECOMMENDATIONS FOR MANAGEMENT STRATEGIES FOR PROTECTION OF WATER RESOURCES IN THIS WATERSHED**

**Brief Watershed Description (Table 1 and Figures 1 and 2)**

This watershed, which is adjacent to Ankwil, also flows down from the Bait Range, with some steep and high elevation terrain (max elevation =1950 m). The watershed is flanked, by Mounts Teegee and Lovell. It flows in a generally south-easterly direction onto a relatively flat plateau and finally into the northern end of Takla Lake. The dominant biogeoclimatic zones in this watershed are an even split between the SBSwk3 at lower elevations and the ESSFmv3 at mid to higher elevations. Alpine Tundra (AT) can be found at the highest elevations of the watershed. This watershed is, on average quite a bit less steep than Ankwil. About 72% of the watershed has slopes of 30% or less with only 5% of the watershed having slopes greater than 60% (Table 1).

The mainstem of Lovell Creek varies between being deeply incised within the plateau (e.g. reach #5) and flowing more on the surface of the plateau (e.g. reach #6). This stream also flows out onto a highly sensitive fluvio-glacial fan (Figure 2 and 5). The surficial geology of this watershed is dominated by a mixture of fine and moderately coarse morainal materials, with frequent pockets of coarser textured fluvio-glacial material in the lower elevations. There are bedrock outcroppings in the upper parts of the watershed and thin soils over bedrock (Figure 1). Although some sections of Lovell Creek are incised within the morainal materials, most of the current channel flows down through a wide floodplain with active migration across this floodplain, thus creating gravel bars, mid-channel bars and active bank erosion (e.g. Figures 6, 7 and 8). These characteristics have led me to classify much of the stream channel as a Rosgen C4 type channel (Table 7).

**Key Elements that Make this Watershed Sensitive**

*Sensitivity to Increased Peak Flows*

Given that Lovell Creek watershed is very similar to the Ankwil watershed, the main watershed characteristics that make it sensitive to the increased peak flows are similar and include the following (Table 2):

- 1) The C4 channel type and especially the lower part that flow across a fluvial fan and glacio-fluvial materials,
- 2) The mountainous topography at the back of the watershed with localized steepness,

- 3) The high drainage density with very shallow soils in the upper watershed,
- 4) The large and relatively uniform elevation of the plateau area, where most of the logging disturbances occur and
- 5) The climate dominated by deep winter snowpacks.

#### *Sensitivity to Increased Delivery of Fine Sediments*

This watershed has some very sensitive fish species, including Sockeye, Dolly Varden and Kokanee. The steep terrain, relatively wet climate, and the high drainage density contribute significantly to the sediment sensitivity as these are significant factors in the processes of surface erosion and sediment transport to the stream network. The fine textured fluvial and easily erodible glacio-fluvial materials in the lower watershed also play an important part in classifying this watershed as sensitive to the potential for increased erosion and accelerated delivery of fine sediment to the stream network (Table 3).

#### *Sensitivity to a Reduction in Riparian Function*

As with the Ankwil, the dominant stream type in this watershed is C4 which is highly dependent on the recruitment of large organic debris for the maintenance of long term channel stability and high quality fish habitat. These channels also depend on riparian vegetation and riparian forest for controlling stream temperatures and terrestrial food sources such a litter and insect drops. This dependence on the riparian forest, for the maintenance of quality fish habitat, makes them highly sensitive to riparian disturbances of losses in riparian functions (Table 4).

### **Risk Assessment for this Watershed**

#### *Risk associated with Potential Increases in Peak Flows*

Currently the risk associated with potential increases in peak flows is low (Table 8) because the extent of disturbances in this watershed is very low (i.e. the hazard is very low). The total watershed HEDA is only at 9.10% (Table 5). Only a total area of 2.91 km<sup>2</sup> of this watershed has been harvested in the past (Figure 3).

#### *Risk associated with Potential Increases in the Delivery of Fine Sediments to the Stream Network*

The risk associated with the potential for delivery of fine sediments have been assessed as Very Low (Table 8). Although the sediment sensitivity of the watershed has been assessed as Extreme (Table 3), there are very few stream crossings in this watershed and consequently the hazard is Very Low (Table 6).

#### *Risk associated with a Reduction in Riparian Function*

The risk associated with a loss in riparian function is very low (Table 8) because there has been no riparian logging anywhere along the mainstem of Lovell Creek (Table 7 and Figures 4 to 8), i.e. the hazard is essentially nonexistent.

### **Suggested Management Objectives and Strategic Directions for this Sensitive Watershed**

- 1) The extent of flat over steep terrain in this watershed is much smaller than in the Ankwil watershed, however there is some present in the mid to upper watershed. If harvesting proceeds up into these areas, these terrain features should be carefully managed.
- 2) Maintain the peak flow risk in this watershed below a Moderate level (i.e. Low or Very Low). This means that the HEDA value for this watershed should be maintained below 19.4%, which would allow the harvesting of an additional 950 ha of healthy stands. Use the Peak Flow Risk Calculator to determine the maximum suggested harvest of different combinations of healthy stands and mountain pine beetle affected stands in order to maintain a peak flow risk level below moderate.
- 3) Minimize riparian disturbances within the riparian management zone within the areas identified as having a “fluvial fan” or “glacio-fluvial” surficial geology.
- 4) Maintain best management erosion and sediment control practices at any future stream crossings stream crossing located over the mainstem river. In addition to being very important fish habitat at this location, the soils are easily erodible and could very easily be transported into Lovell Creek. I suggest that the Water Quality Effectiveness Evaluation (WQEE) tool be used and that the WQEE rating be maintained below a moderate level (i.e. Low or Very Low). The most recent WQEE protocol can be found at the following web link:  
<http://www.for.gov.bc.ca/ftp/hfp/external/!publish/frep/indicators/Indicators-WaterQuality-Protocol-2009.pdf>
- 5) For all S4 streams wider than 0.5 m, maintain long term large woody debris (LWD) recruitment to the stream channel by retaining at least 90% of the riparian area in a state undisturbed by primary forest activities. Note that the riparian area refers to the management area measured from the closest streambank to a distance 15m upslope from the streambank.

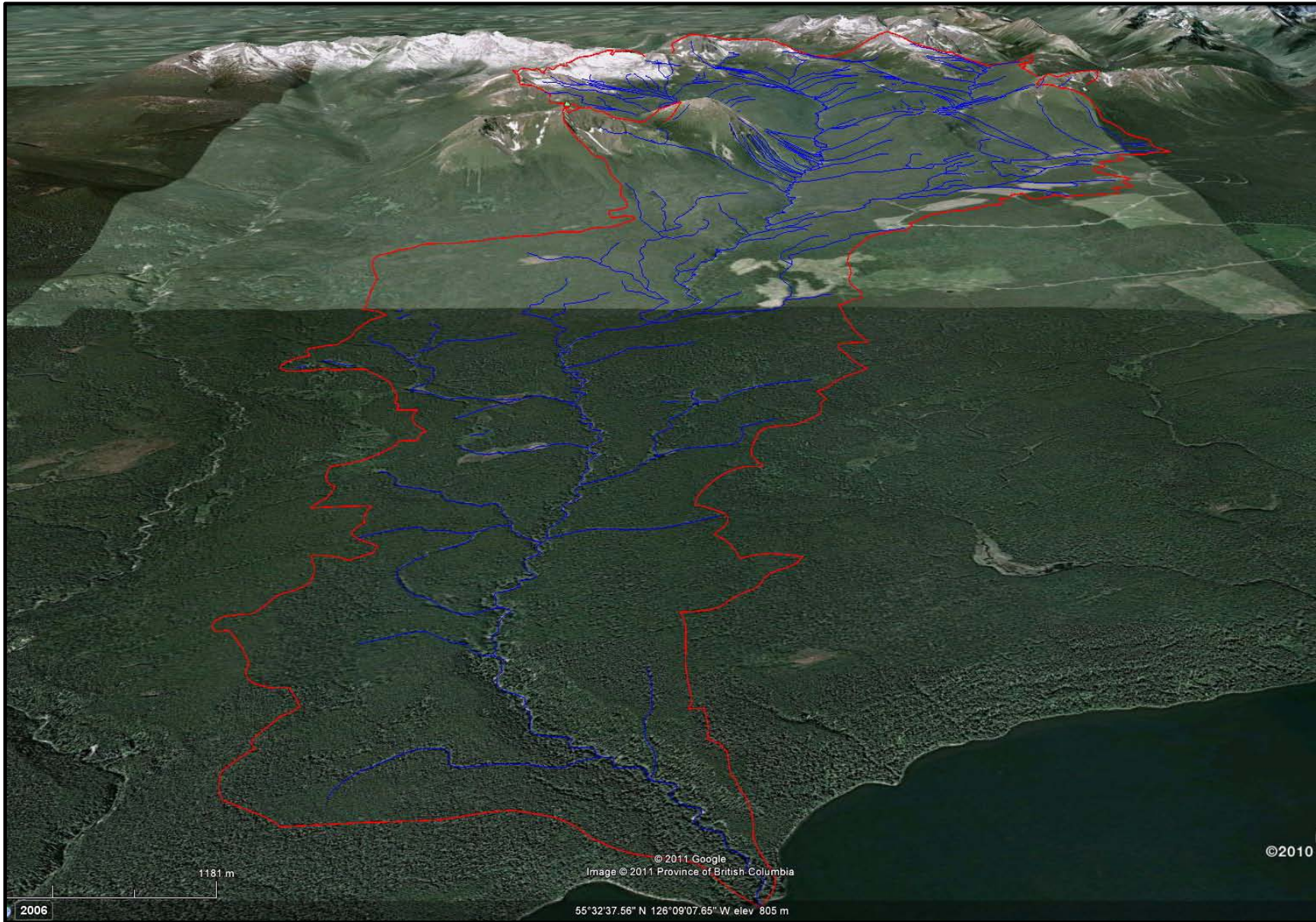


Figure 1. Google earth overview image of Lovell Creek watershed, looking upstream into the watershed.

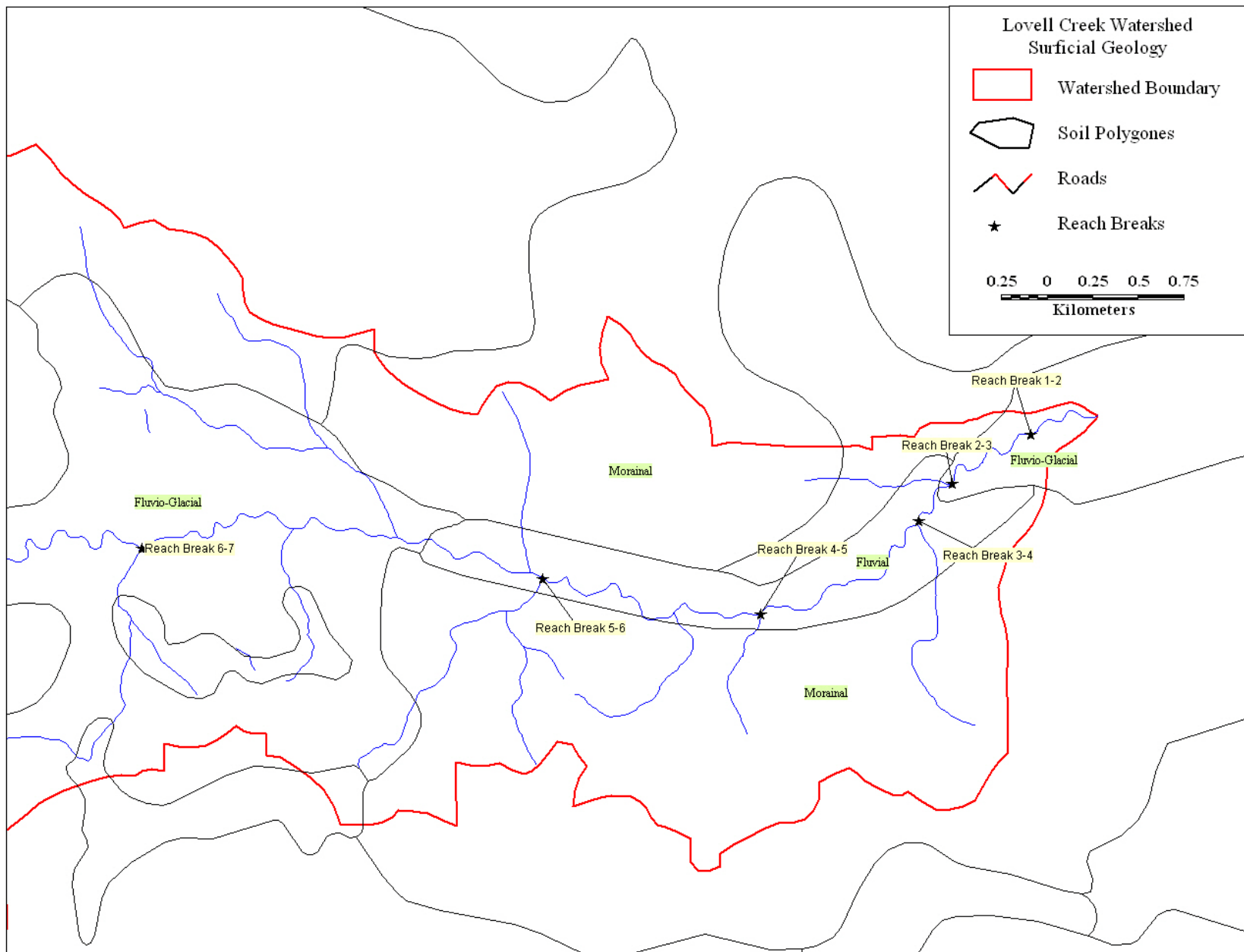


Figure 2. Distribution of surficial geology types near the mouth of Lovell Creek.

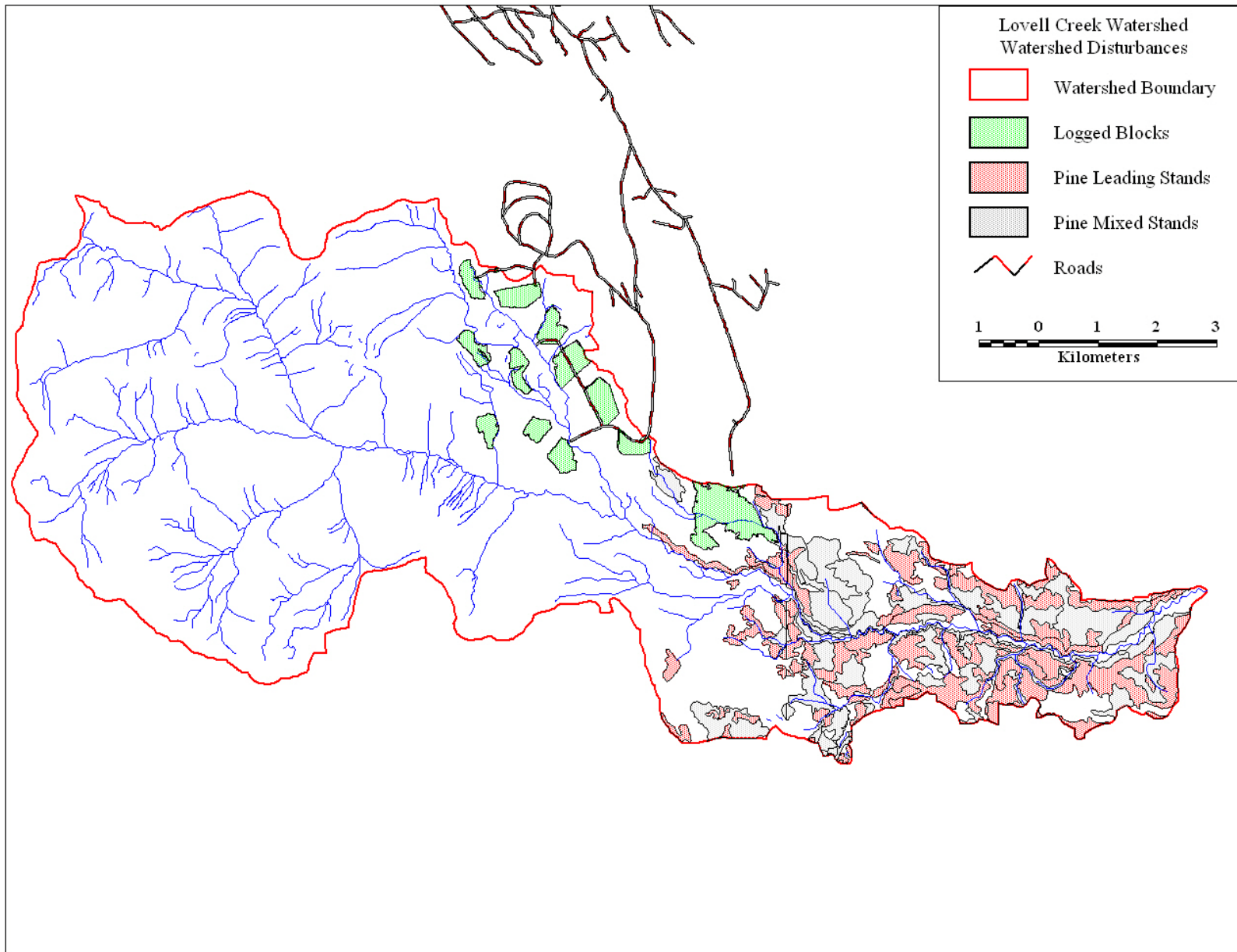


Figure 3. Land-use related and large natural disturbances in the Lovell Creek Watershed

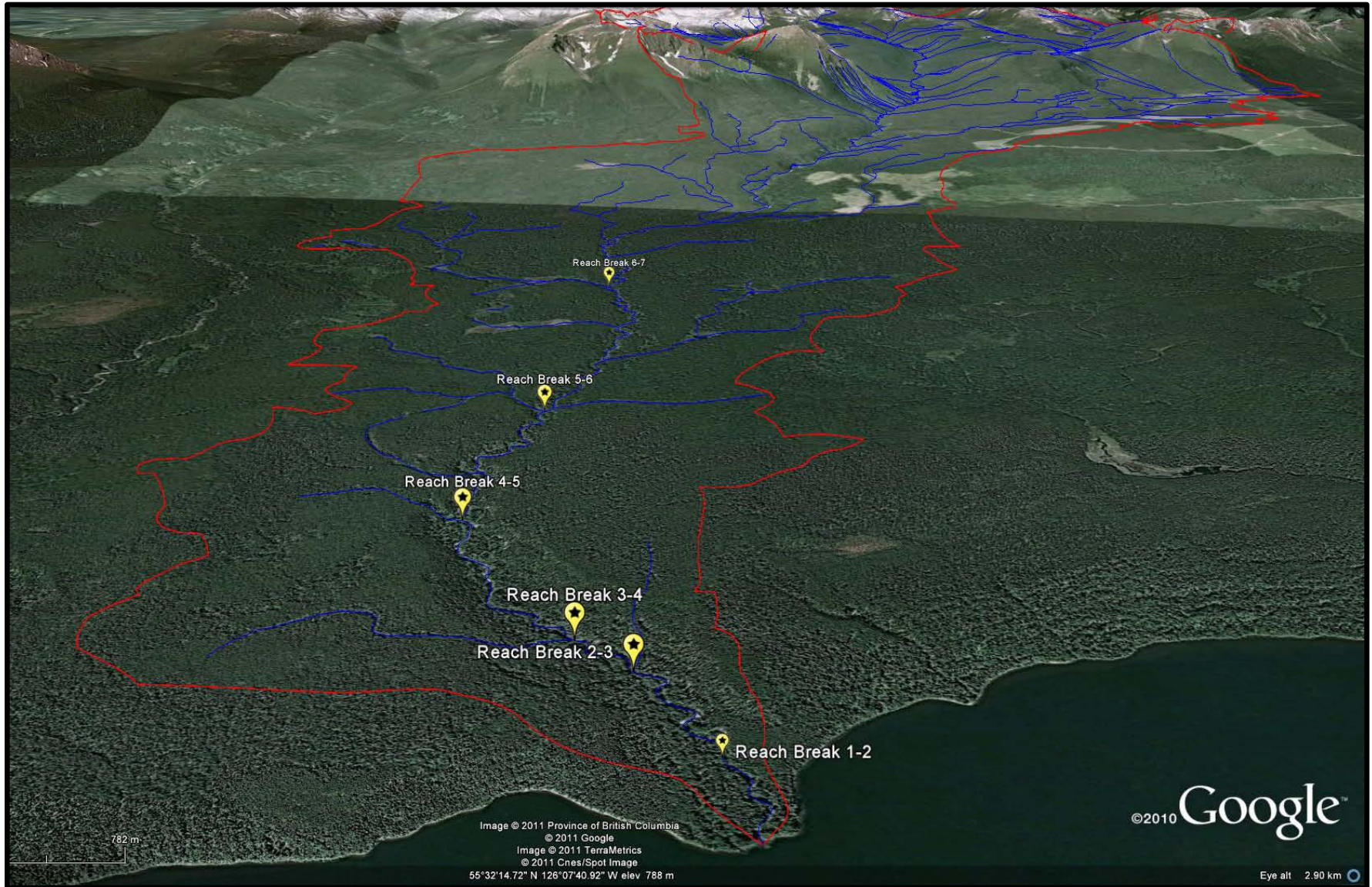


Figure 4. Identification of reach breaks along the mainstem of the lower Lovell Creek watershed



Figure 5. Google Earth image looking upstream along Reaches #1 and 2 of Lovell Creek.

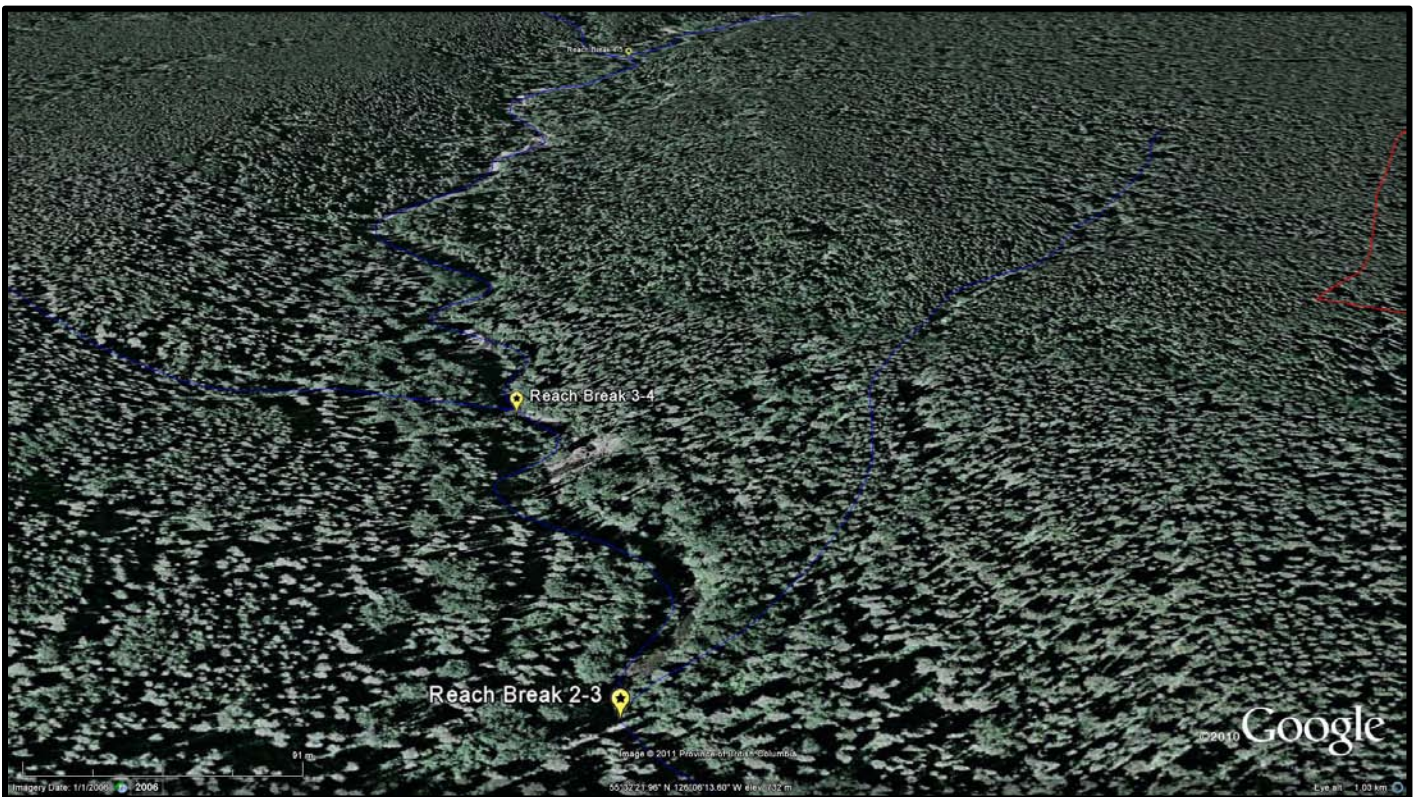


Figure 6. Google Earth image looking upstream along Reaches #3 and 4 of Lovell Creek.

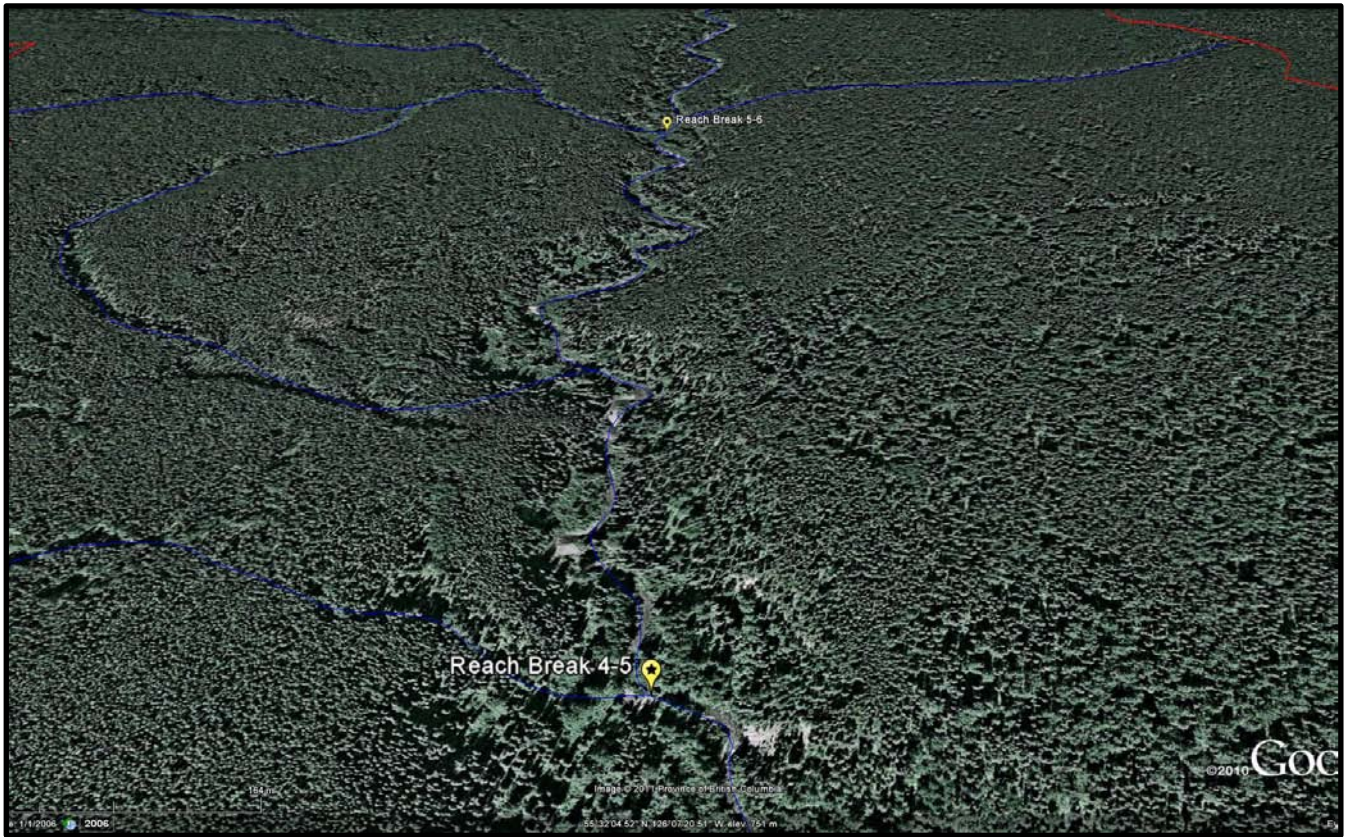


Figure 7. Google Earth image looking upstream along Reach #5 of Lovell Creek.

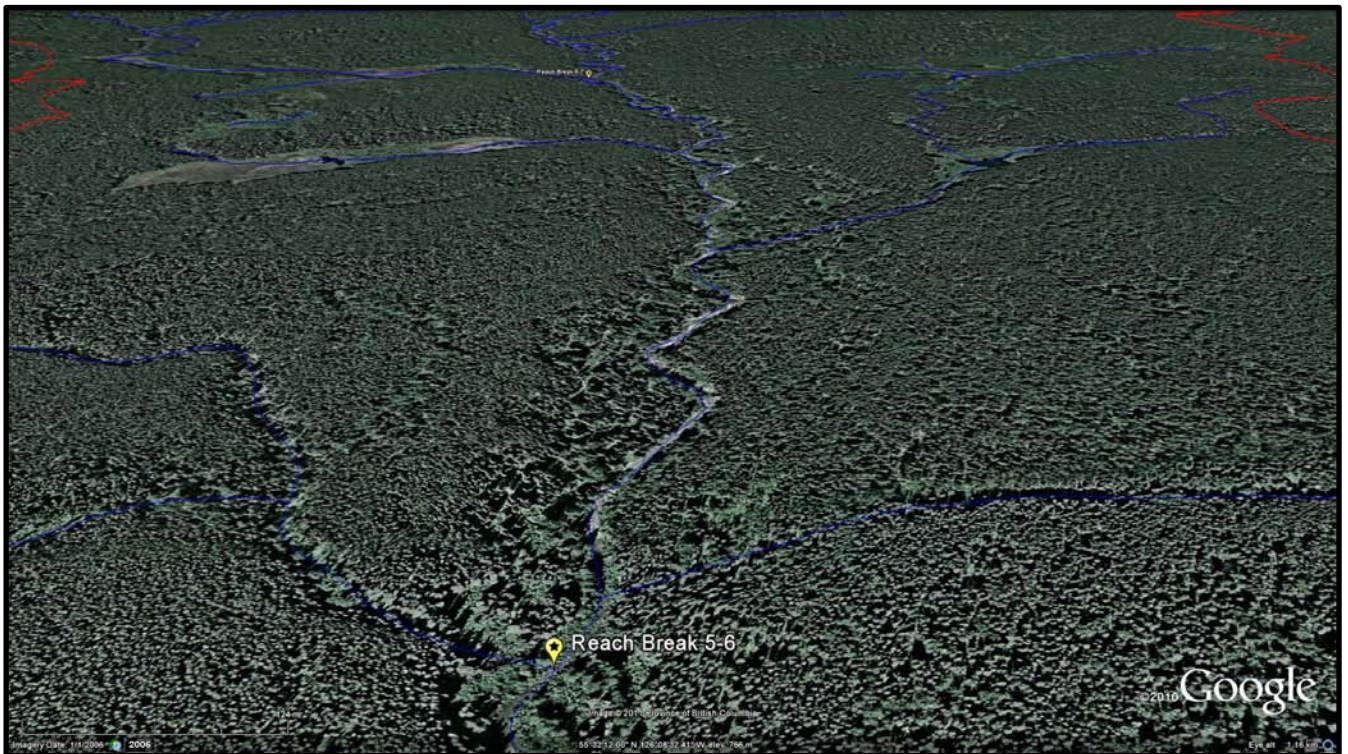


Figure 8. Google Earth image looking upstream along Reaches #6 of Lovell Creek.

## WATERSHED REVIEW NARROWS CREEK WATERSHED

**November 22, 2011**  
Ministry Contract No: CS12NRH-011

### BIOPHYSICAL AND LAND-USE CHARACTERISTICS OF THE WATERSHED

Table 1. Summary Information – Watershed Characteristics – (see Figures 1 and 2)

Size (km <sup>2</sup> )	Dominant BEC Zones	Dominant NDT	Elevation Range (m)	Surficial Geology near the Mouth (i.e. sensitive area)	Stream Density (km/km <sup>2</sup> )	Biggest % of watershed in same elevation band <sup>1</sup>	Distribution of slope gradients within the watershed (% of watershed)			
							<10% slope	10 to 30% slope	30 to 60% slope	>60% slope
64.9	ESSF and SBS	NDT2 and NDT3	698-2052	Very fine textured lacustrine	2.25	32.7	27.7	42.5	21.2	8.6

<sup>1</sup> The entire watershed is divided into 300 m elevation bands of harvestable forest land-base. The less elevation bands there are and the more area is represented by any given single elevation band, then the greater will likely be the effect of forest harvesting on increased peak flows due to the theoretical concept of “synchronization” (i.e. the melt from the cutblocks is synchronized as much of it comes from the same elevation), and the greater sensitivity it will have.

Table 2. Rating of “Sensitivity” of Watershed to Increased Peak Flow at the lower reaches

Rosgen Stream Channel Score	Rosgen Stream Channel Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to vertical conductivity	Sensitivity score relative to climate	Sensitivity score relative to flow synchronization potential	Sensitivity score relative to NDT type	Sensitivity Score	Sensitivity Rating
C4- Stable	3.5	1	1.05	1	1.1	1	1	4.04	High

Table 3. Rating of “Sensitivity” of Watershed to Increased Production of Fine Sediment at lower reaches

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to climate	Sensitivity Score	Sensitivity Rating
Bull trout	5	1	1.1	1.1	6.1	Extreme

Table 4. Rating of “Sensitivity” of Watershed to a Loss In riparian Function.

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to loss of LWD	Sensitivity score relative to Aspect	Sensitivity score relative to climate	Overall watershed sensitivity to loss of riparian	Loss of Riparian Sensitivity Rating
Bull trout	5	1.25	1.05	1.1	7.22	Extreme

Table 5. Peak Flow Hazard Rating, as indexed by HEDA – current scenario (i.e. no proposed harvesting considered)

Watershed area (km <sup>2</sup> )	Total area Pine Leading (km <sup>2</sup> )	Total area Pine Mixed (km <sup>2</sup> )	Total area harvest (km <sup>2</sup> ) <sup>1</sup>	Total HEDA from Pine Beetle alone (%)	Total HEDA from logging alone (%)	Total HEDA from logging and Pine Beetle mortality (%)
64.9	2.98	9.26	2.57	6.58	3.96	10.53

<sup>1</sup>Note: This includes openings from VRI database, and non-overlapping openings from RESULTS and FTEN databases.

Table 5 (continued)

Total area in Agriculture (km <sup>2</sup> )	Total area in Agriculture (% of watershed)	Total area in Proposed Harvest (km <sup>2</sup> )	Total HEDA (%)	HEDA Hazard rating Score	HEDA Hazard Rating
0.00	0.00	0.00	10.53	0.81	Very Low

Table 6. Fine Sediment Hazard Rating, as indexed by the Stream Crossing Density

Watershed area (km <sup>2</sup> )	# of x-ings	#of fish bearing X-ings <sup>1</sup>	#of non-fish bearing X-ings	density of x-ings (#/km <sup>2</sup> )	Density of fish bearing X-ings (#/km <sup>2</sup> )	Density of non-fish bearing X-ings (#/km <sup>2</sup> )	Hazard Rating Score	Hazard Rating
64.9	3	3	0	0.0	0.0	0.00	0.594	Very Low

<sup>1</sup>Note: The information on stream crossings was provided by MoE and was generated with a GIS model, not fieldwork.

Table 7. Loss of Riparian Function Hazard Rating (See Figures 3 to 14)

Reach Number	Rosgen Stream Type	Reach Length (m)	% riparian logged (as interpreted from air photos)	Apparent stability and other comments (as viewed from air photos)
1	E4-Stable	392	0.0	Very Stable
2	C4- Stable	336	0.0	Very Stable
3	C4- Stable	406	0.0	Very Stable
4	B4-Stable	1530	0.0	Very Stable
5	B4-Stable	514	0.0	Very Stable
6	B4-Stable	719	0.0	Very Stable
7	B4-Stable	486	0.0	Very Stable
8	B4-Stable	281	0.0	Very Stable
9	C4- Stable	320	0.0	Very Stable
10	C4- Stable	1322	0.0	Very Stable
Hazard Scores:			Hazard Rating Score	Hazard Rating
			0.25	Very Low

Table 8. Risk Rankings for the Different Hazards in the watershed current scenario (i.e. no proposed harvesting considered)

Watershed Hazard Types	Sensitivity Score	Sensitivity Rating	Hazard Score	Hazard Rating	Risk Score	Risk Rating
Increased Peak Flow	4.04	High	0.81	Very Low	3.3	Low
Increase in Production of Fine Sediment	6.05	Extreme	0.59	Very Low	3.6	Low
Loss of Riparian function	7.22	Extreme	0.25	Very Low	1.8	Very Low

## INTERPRETATIONS AND RECOMMENDATIONS FOR MANAGEMENT STRATEGIES FOR PROTECTION OF WATER RESOURCES IN THIS WATERSHED

### Brief Watershed Description (Table 1 and Figures 1 and 2)

This watershed is dominated by gently rolling topography with the set of much steeper Nesabut Peaks protruding at the back of the watershed (max elevation = 2,052 m). The watershed flows in a south westerly direction into Takla Lake at Takla Narrows. The dominant biogeoclimatic zones in this watershed are the SBSwk3 at lower elevations and the ESSFmv3 at mid to higher elevations. Alpine Tundra (AT) can be found at the highest elevations of the watershed. About 70% of the watershed has slopes of 30% or less with about 8% of the watershed having slopes greater than 60% (Table 1).

The mainstem of Narrows Creek varies between being deeply incised within the plateau (e.g. reaches 4, 5, 6 and 7) and flowing more on the surface of the plateau (e.g. reaches 1, 2, 3, 8 and 9). This stream also flows out onto a highly sensitive fluvio-glacial fan with lacustrine veneer (Figure 2 and 5). The surficial geology of the lower part of this watershed is dominated by a mixture of fluvial, lacustrine and morainal materials. There are bedrock outcroppings in the upper parts of the watershed and thin soils over bedrock (Figure 1). I have classified the mainstem stream reaches that flow through the more confined terrain as stable B4 stream types, while those that have the opportunity to flow over wider floodplains as stable C4 stream types (Table 7).

### Key Elements that Make this Watershed Sensitive

#### *Sensitivity to Increased Peak Flows*

The main watershed characteristics that make it highly sensitive to the increased peak flows include the following (Table 2):

- 1) The mixture of C4 and B4 channel types provide a mixture of sensitive and moderately sensitive types,
- 2) Although there is mountainous topography at the back of the watershed with localized steepness, most of the watershed is mountainous to rolling,
- 3) The high drainage density with very shallow soils in the upper watershed,
- 4) The large and relatively uniform elevation of the plateau area, where most of the logging disturbances could occur

- 5) One third of the watershed being located within the same 300 m elevation band (i.e. 998 m to 1298 m) and
- 6) The climate dominated by relatively deep winter snowpacks.

#### *Sensitivity to Increased Delivery of Fine Sediments*

This watershed has some very sensitive fish species, including Bull Trout and Kokanee. The mountainous terrain, relatively wet climate, and the high drainage density contribute significantly to the sediment sensitivity as these are significant factors in the processes of surface erosion and sediment transport to the stream network. The fine textured fluvial and lacustrine materials along with the easily erodible glacio-fluvial materials in the lower watershed also play an important part in classifying this watershed as sensitive to the potential for increased erosion and accelerated delivery of fine sediment to the stream network (Table 3).

#### *Sensitivity to a Reduction in Riparian Function*

The dominant stream channel types in this watershed are B4 and C4, both types which are highly dependent on the recruitment of large organic debris for the maintenance of long term channel stability and high quality fish habitat. These channels also depend on riparian vegetation and riparian forest for controlling stream temperatures and terrestrial food sources such as litter and insect drops. This dependence on the riparian forest, for the maintenance of quality fish habitat, makes them highly sensitive to riparian disturbances and losses in riparian functions (Table 4).

### **Risk Assessment for this Watershed**

#### *Risk associated with Potential Increases in Peak Flows*

The risks associated with potential increases in peak flows are Low because the hazard is very low (HEDA of only 10.5%) despite the sensitivity being classed as High.

#### *Risk associated with Potential Increases in the Delivery of Fine Sediments to the Stream Network*

The risk associated with the potential for delivery of fine sediments have been assessed as Low (Table 8). Although the sediment sensitivity of the watershed has been assessed as Extreme (Table 3), there are only a few stream crossings or roads in this watershed and consequently the hazard is Very Low (Table 6).

#### *Risk associated with a Reduction in Riparian Function*

The risk associated with a loss in riparian function is Very Low (Table 8) because there has been no riparian logging anywhere along the mainstem of Narrows Creek (Table 7 and Figures 5 to 10), i.e. the hazard (as defined for this project) is essentially nonexistent.

### **Suggested Management Objectives and Strategic Directions for this Sensitive Watershed**

- 1) Maintain the peak flow risk in this watershed below a Moderate level (i.e. Low or Very Low). This means that the HEDA value for this watershed should be maintained below 20.2%, which would allow the harvesting of about 625 ha of healthy stands. Use the Peak Flow Risk Calculator to determine the maximum suggested harvest of different combinations of healthy stands and mountain pine beetle affected stands in order to maintain a peak flow risk level below moderate.
- 2) Minimize riparian disturbances within the riparian management zone (RMZ) located within the areas identified as having a “fluvial fan”, “Lacustrine” or “glacio-fluvial” surficial geology (Figure 2).
- 3) Maintain best management erosion and sediment control practices at any future stream crossing located over the mainstem river. In addition to being very important fish habitat at this location, the soils are easily erodible and could very easily be transported into Frypan Creek. I suggest that the Water Quality Effectiveness Evaluation (WQEE) tool be used and that the WQEE rating be maintained below a moderate level (i.e. Low or Very Low). The most recent WQEE protocol can be found at the following web link: <http://www.for.gov.bc.ca/ftp/hfp/external!/publish/frep/indicators/Indicators-WaterQuality-Protocol-2009.pdf>
- 4) For all S4 streams wider than 0.5 m, maintain long term large woody debris (LWD) recruitment to the stream channel by retaining at least 90% of the riparian area in a state undisturbed by primary forest activities. Note that the riparian area refers to the management area measured from the closest streambank to a distance 15m upslope from the streambank.

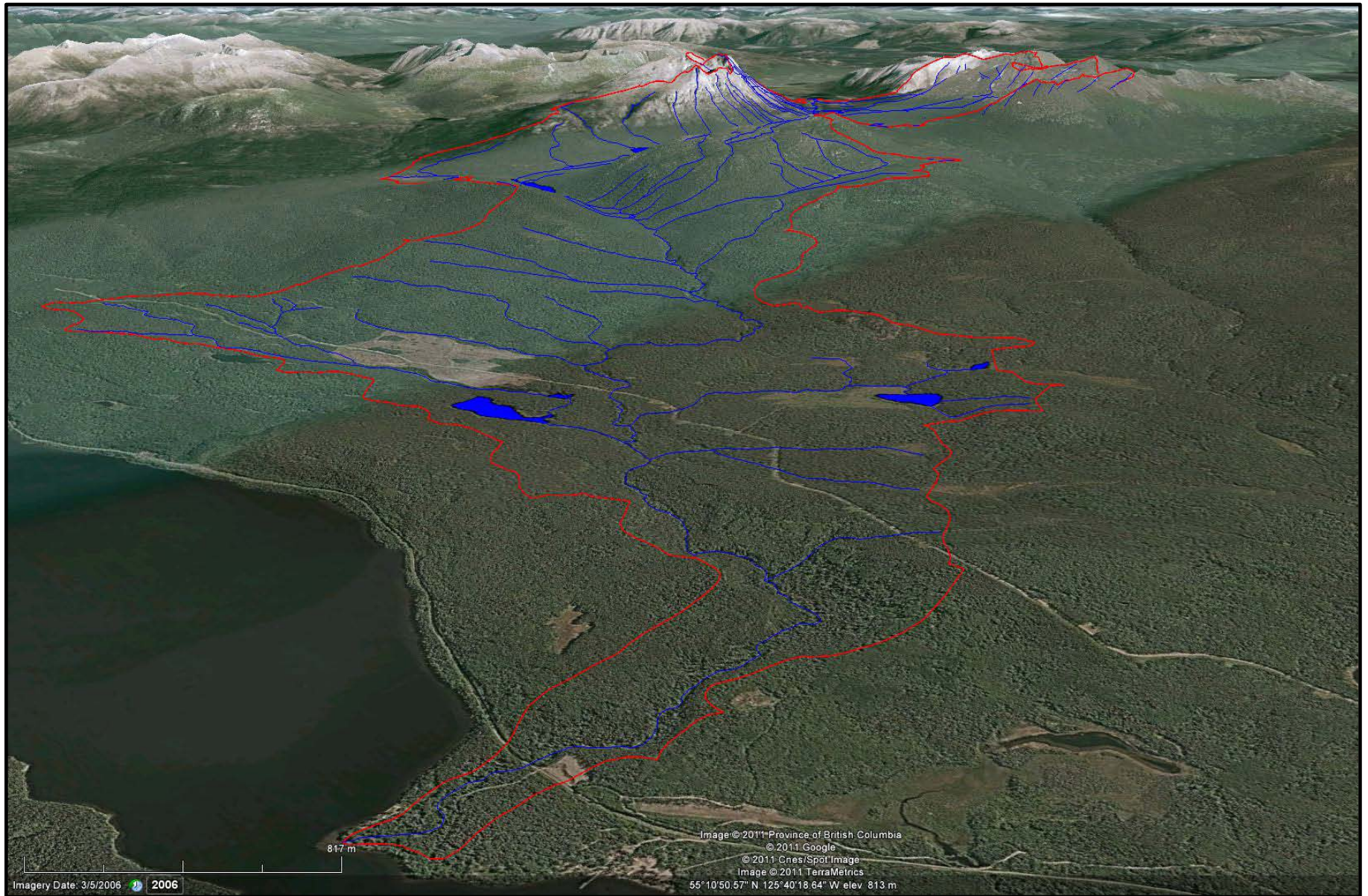


Figure 1. Google earth overview image of Narrows Creek watershed, looking upstream into the watershed.

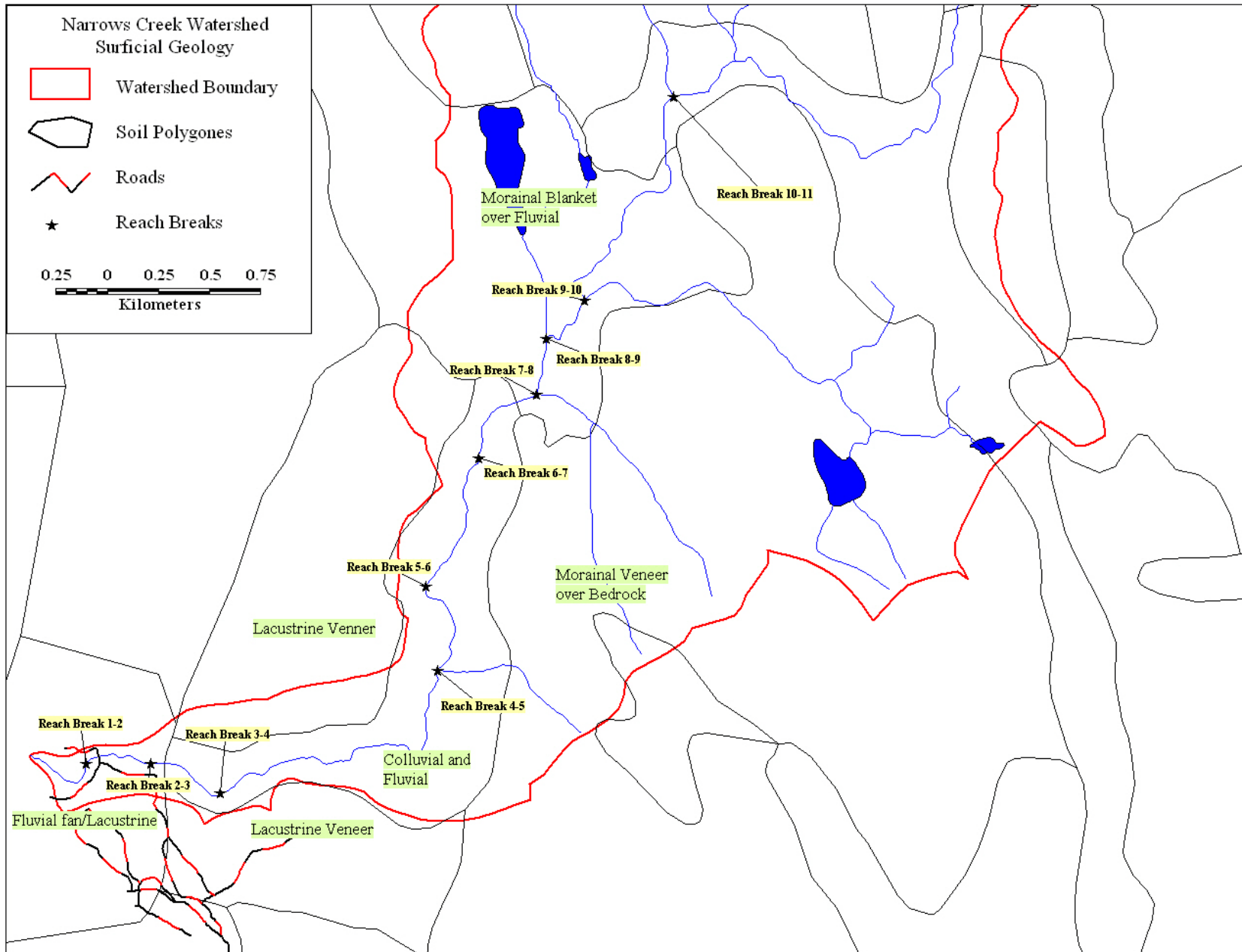


Figure 2. Distribution of surficial geology types near the mouth of Narrows Creek.

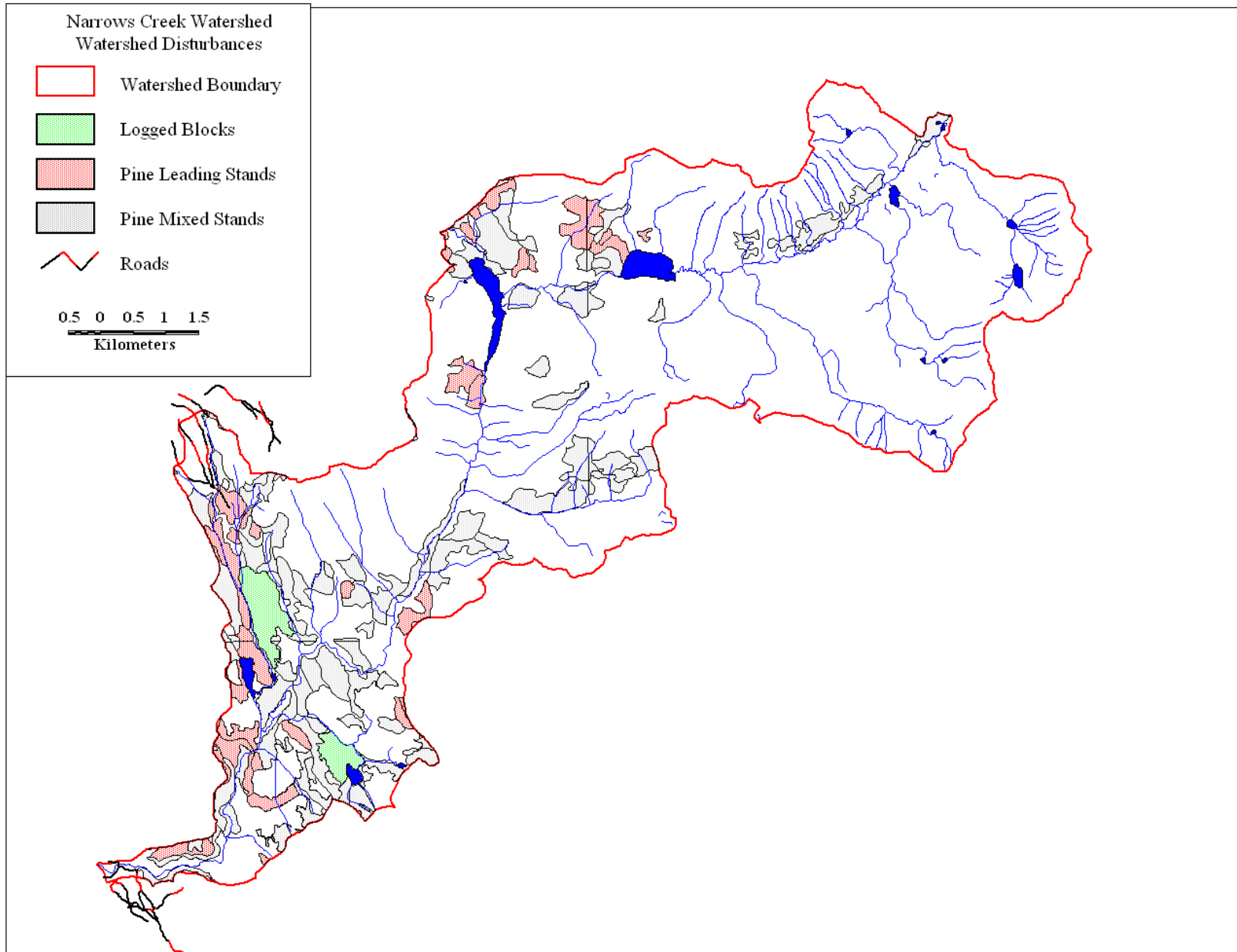


Figure 3. Land-use related and large natural disturbances in the Narrows Creek Watershed

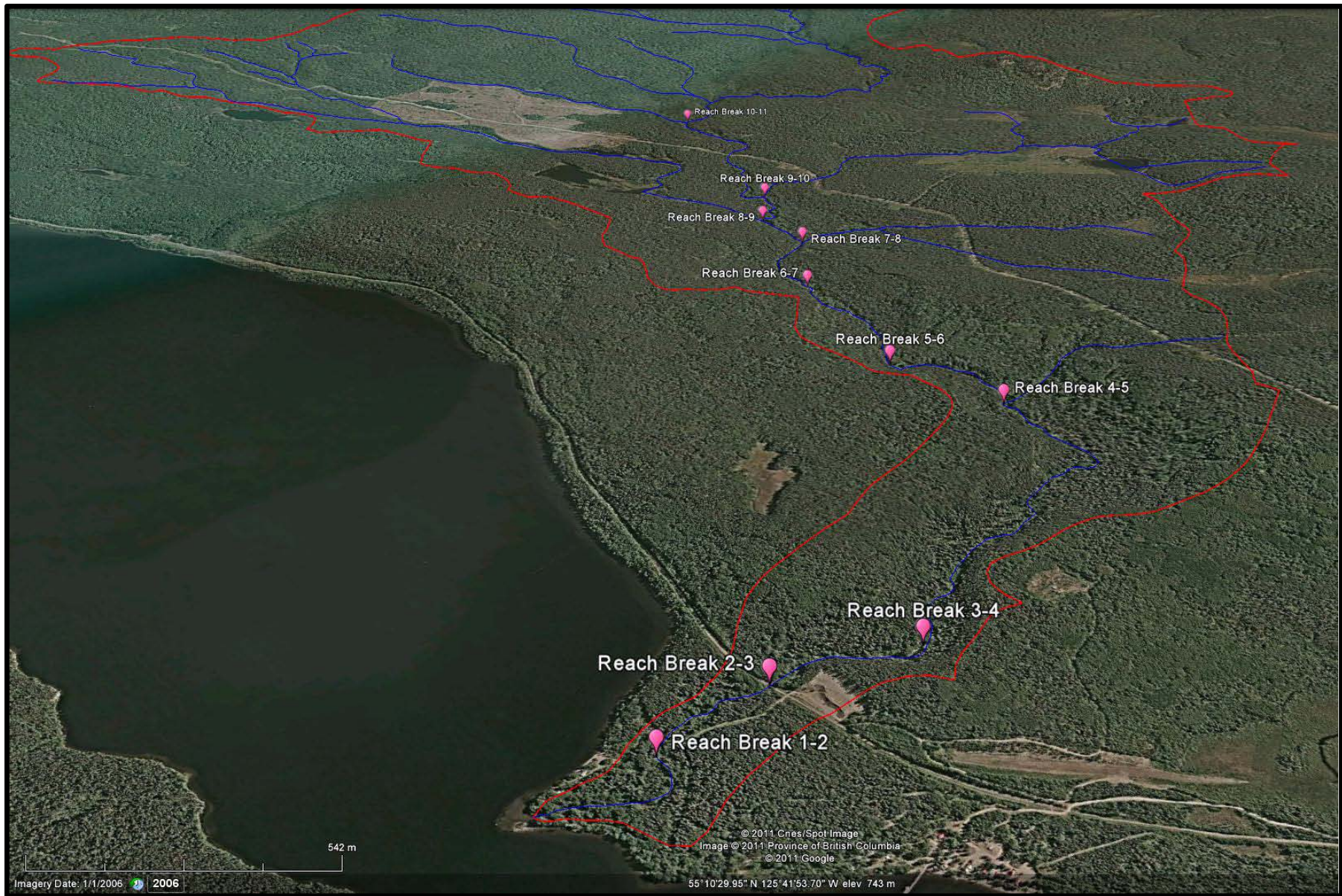


Figure 4. Identification of reach breaks along the mainstem of the lower Narrows Creek watershed



Figure 5. Google Earth image looking upstream along Reaches #1 and 2 of Narrows Creek.



Figure 6. Google Earth image looking upstream along Reach #3 of Narrows Creek.

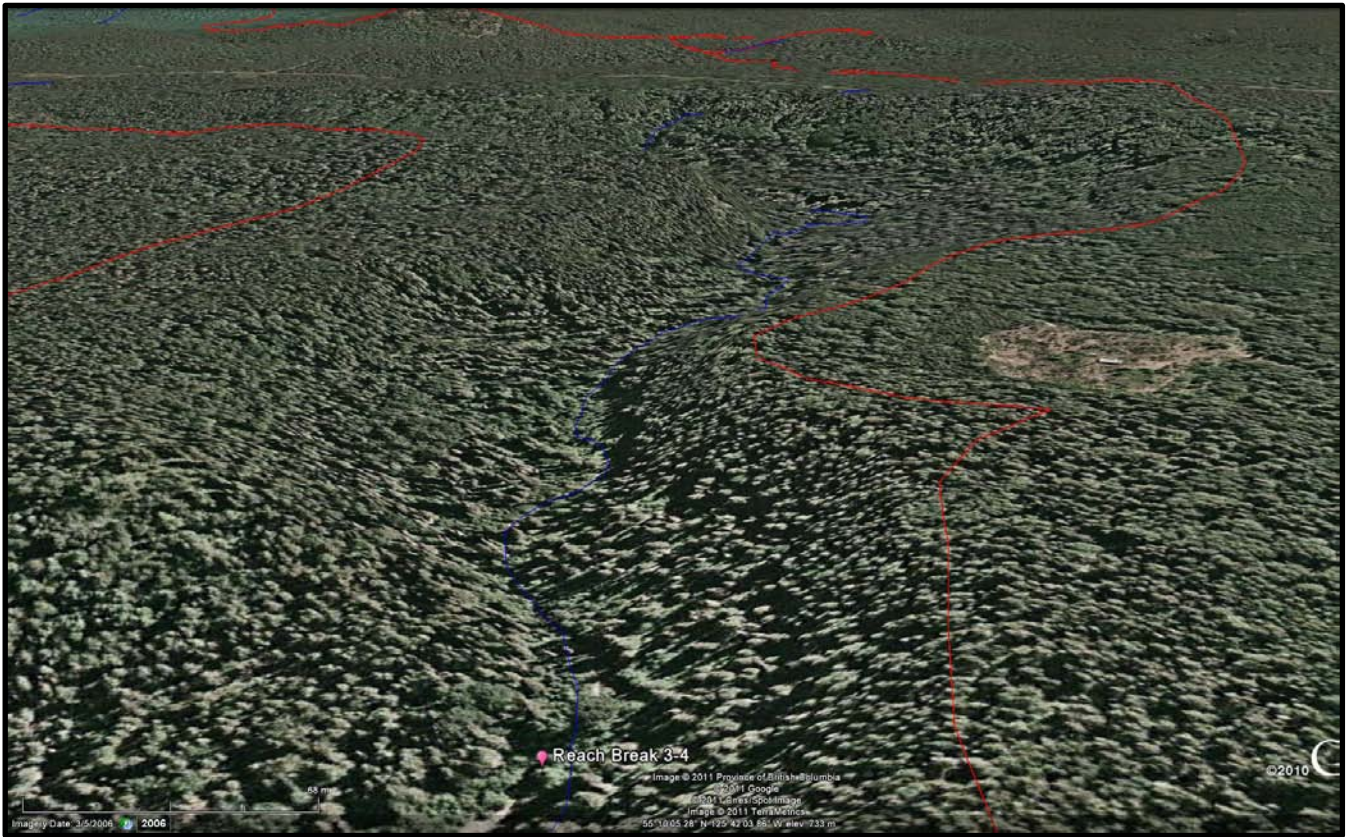


Figure 7. Google Earth image looking upstream along Reach #4 of Narrows Creek.



Figure 8. Google Earth image looking upstream along Reaches #5 and 6 of Narrows Creek.

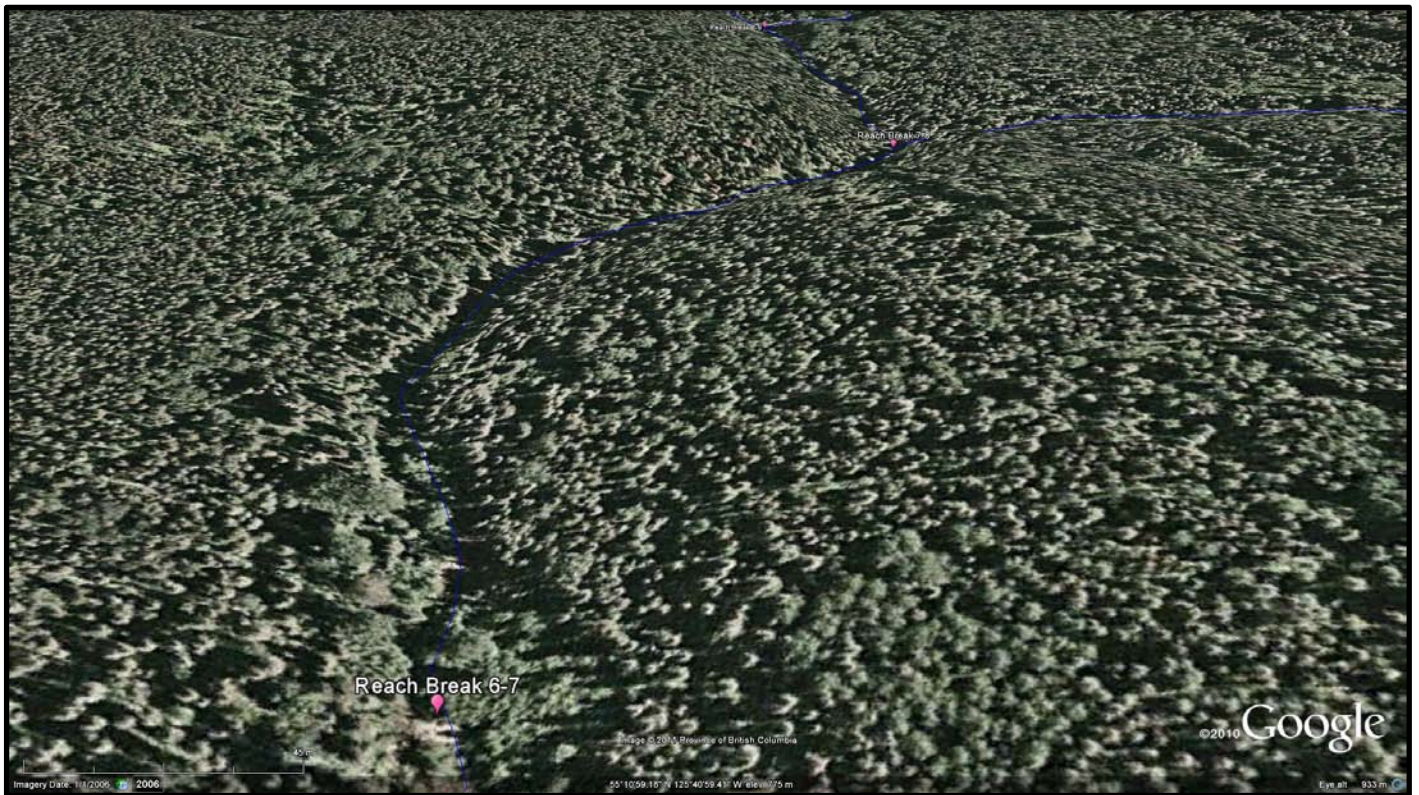


Figure 9. Google Earth image looking upstream along Reaches #7 and 8 of Narrows Creek.

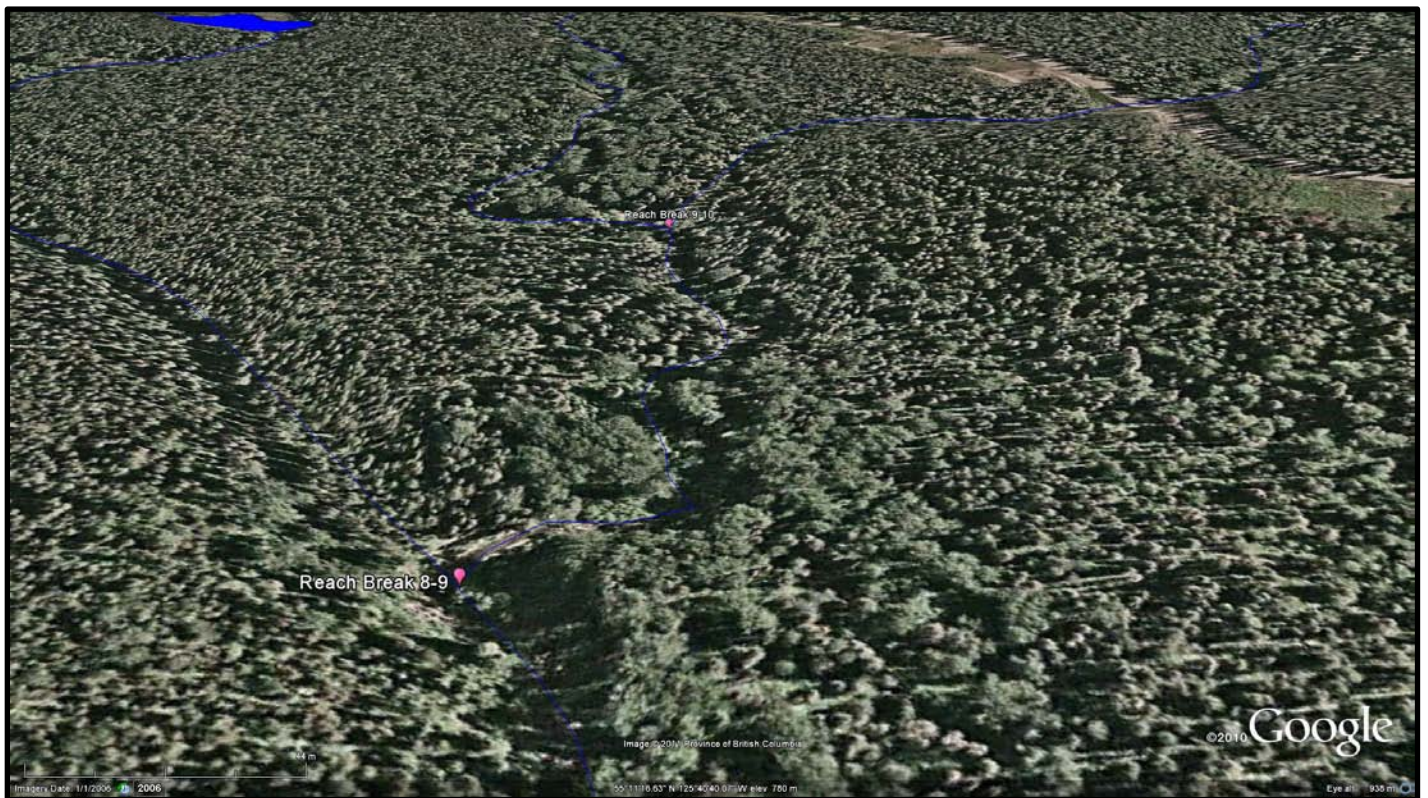


Figure 10. Google Earth image looking upstream along Reaches #9 and 10 of Narrows Creek.

**WATERSHED REVIEW**  
**PAULA CREEK WATERSHED**  
**November 22, 2011**  
 Ministry Contract No: CS12NRH-011

**BIOPHYSICAL AND LAND-USE CHARACTERISTICS OF THE WATERSHED**

Table 1. Summary Information – Watershed Characteristics – (see Figures 1 and 2)

Size (km <sup>2</sup> )	Dominant BEC Zones	Dominant NDT	Elevation Range (m)	Surficial Geology near the Mouth (i.e. sensitive area)	Stream Density (km/km <sup>2</sup> )	Biggest % of watershed in same elevation band <sup>1</sup>	Distribution of slope gradients within the watershed (% of watershed)			
							<10% slope	10 to 30% slope	30 to 60% slope	>60% slope
45.4	SBS	NDT3	700-1912	Fine textured fluvial	1.97	37.9	30.6	52.8	16.3	0.3

<sup>1</sup> The entire watershed is divided into 300 m elevation bands of harvestable forest land-base. The less elevation bands there are and the more area is represented by any given single elevation band, then the greater will likely be the effect of forest harvesting on increased peak flows due to the theoretical concept of “synchronization” (i.e. the melt from the cutblocks is synchronized as much of it comes from the same elevation), and the greater sensitivity it will have.

Table 2. Rating of “Sensitivity” of Watershed to Increased Peak Flow at the lower reaches

Rosgen Stream Channel Score	Rosgen Stream Channel Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to vertical conductivity	Sensitivity score relative to climate	Sensitivity score relative to flow synchronization potential	Sensitivity score relative to NDT type	Sensitivity Score	Sensitivity Rating
C4- Lightly unstable/disturbed	4	1	1.1	1	1.1	1	1	4.84	Very High

Table 3. Rating of “Sensitivity” of Watershed to Increased Production of Fine Sediment at lower reaches

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to climate	Sensitivity Score	Sensitivity Rating
Dolly Varden	5	0.8	1.2	1.1	5.3	Very High

Table 4. Rating of “Sensitivity” of Watershed to a Loss In riparian Function.

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to loss of LWD	Sensitivity score relative to Aspect	Sensitivity score relative to climate	Overall watershed sensitivity to loss of riparian	Loss of Riparian Sensitivity Rating
Dolly Varden	5	1.25	1.1	1.1	7.56	Extreme

Table 5. Peak Flow Hazard Rating, as indexed by HEDA – current scenario (i.e. no proposed harvesting considered)

Watershed area (km <sup>2</sup> )	Total area Pine Leading (km <sup>2</sup> )	Total area Pine Mixed (km <sup>2</sup> )	Total area harvest (km <sup>2</sup> ) <sup>1</sup>	Total HEDA from Pine Beetle alone (%)	Total HEDA from logging alone (%)	Total HEDA from logging and Pine Beetle mortality (%)
45.4	3.12	0.94	9.85	4.06	19.32	23.37

<sup>1</sup>Note: This includes openings from VRI database, and non-overlapping openings from RESULTS and FTEN databases.

Table 5 (continued)

Total area in Agriculture (km <sup>2</sup> )	Total area in Agriculture (% of watershed)	Total area in Proposed Harvest (km <sup>2</sup> )	Total HEDA (%)	HEDA Hazard rating Score	HEDA Hazard Rating
0.00	0.00	0.00	23.37	2.04	Low

Table 6. Fine Sediment Hazard Rating, as indexed by the Stream Crossing Density

Watershed area (km <sup>2</sup> )	# of x-ings	#of fish bearing X-ings <sup>1</sup>	#of non-fish bearing X-ings	density of x-ings (#/km <sup>2</sup> )	Density of fish bearing X-ings (#/km <sup>2</sup> )	Density of non-fish bearing X-ings (#/km <sup>2</sup> )	Hazard Rating Score	Hazard Rating
45.4	21	21	0	0.5	0.5	0.00	2.2176	Low

<sup>1</sup>Note: The information on stream crossings was provided by MoE and was generated with a GIS model, not fieldwork.

Table 7. Loss of Riparian Function Hazard Rating (See Figures 3 to 14)

Reach Number	Rosgen Stream Type	Reach Length (m)	% riparian logged (as interpreted from air photos)	Apparent stability and other comments (as viewed from air photos)
1	C5- Stable	239.3	0.0	Stable
2	C4- Stable	176.7	0.0	Stable
3	C4- Stable	358	0.0	Stable
4	C4- Stable	402.3	0.0	Stable
5	C4- Stable	780.9	0.0	Stable
6	B4-Stable	1276.6	0.0	Stable
7	C4- Stable	1568.4	0.0	Stable
8	C4- Stable	1469.3	0.0	Stable
9	B4-Stable	1271.8	0.0	Stable
10	C4- Stable	791.9	0.0	Stable
11	B4-Stable	1357.4	0.0	Stable
12	B3-Stable	974.4	0.0	Stable
Hazard Scores:			Hazard Rating Score	Hazard Rating
			0.5	Very Low

Table 8. Risk Rankings for the Different Hazards in the watershed current scenario (i.e. no proposed harvesting considered)

Watershed Hazard Types	Sensitivity Score	Sensitivity Rating	Hazard Score	Hazard Rating	Risk Score	Risk Rating
Increased Peak Flow	4.84	Very High	2.04	Low	9.9	Mod
Increase in Production of Fine Sediment	5.28	Very High	2.22	Low	11.7	Mod
Loss of Riparian function	7.56	Extreme	0.5	Very Low	3.8	Low

## **INTERPRETATIONS AND RECOMMENDATIONS FOR MANAGEMENT STRATEGIES FOR PROTECTION OF WATER RESOURCES IN THIS WATERSHED**

### **Brief Watershed Description (Table 1 and Figures 1 and 2)**

The Paula Creek watershed is immediately adjacent to the Sidney watershed and also flows down from the Mt Sidney Williams group of mountains and flows into the West end of Trembleur Lake. Elevations range between 700 and 1912 m for this watershed. Most of the watershed has a topography that is rolling to mountainous with a limited amount of steep terrain and exposed bedrock at the back end of the watershed. The watershed flows in a south-easterly direction, with much of the lower part of the watershed being located in a protected area (Figures 1 and 3).

The dominant biogeoclimatic zones in this watershed are the SBSmc2 and SBSwk3 at lower elevations and the ESSFmv3 at mid to higher elevations. Alpine Tundra (AT) can be found at the highest elevations of the watershed. About 83% of the watershed has slopes of 30% or less with 0.3% of the watershed having slopes greater than 60% (Table 1).

The lower reaches of Paula Creek flow through lacustrine soils and an alluvial fan near its mouth (Figures 2, 4 and 5). All of the lower reaches are a Rosgen C4 stream type, and given the importance of the fish habitat there, this contributes very significantly to the sensitivity of this watershed (Table 7). As you go up into the watershed, from Reach 6, the channel very slowly becomes steeper and in some places more incised and thus gradually less sensitive (i.e. reaches 9, 11 and 12 are B4 types) (Table 7 and Figure 4).

### **Key Elements that Make this Watershed Sensitive**

#### *Sensitivity to Increased Peak Flows*

This watershed is considered to be very sensitive to increased peak flows for the following reasons (Table 2):

1. Sensitive stream reach types in the lower parts of the watershed (C4). These lower reaches appear to be slightly disturbed and unstable, likely due to some past natural disturbance event.
2. Although much of the topography is rolling, there are some areas of steep topography in this watershed.

3. There are no lakes in the lower part of the watershed to buffer peak flows and the drainage density is relatively high.
4. Most of the soils are deep morainal tills, but much of the upper watershed has thin soils and exposed bedrock.
5. This is a relatively wet climate with deep snowpacks.
6. There is a large portion of the watershed that is within the same elevation band (38%).

#### *Sensitivity to Increased Delivery of Fine Sediments*

This watershed is considered to be very sensitive to erosion processes and delivery of fine sediments for the following reasons (Table 3):

1. The watershed has fish species that are very sensitive to disturbances and increases in fine sediments
2. The watershed has enough slopes and channel connectivity to effectively transport eroded sediments to the stream network.
3. The climate is wet with heavy spring snowmelt which can contribute to the effectiveness of surface erosion and downslope transport of fine sediments.
4. There is an abundance of highly erodible soils in the lower part of this watershed (Fluvial fan and lacustrine materials).

#### *Sensitivity to a Reduction in Riparian Function*

This watershed is considered to be sensitive to a reduction in riparian function for the following reasons (Table 4):

1. The watershed has fish species that are very sensitive to disturbances and loss of riparian function
2. The stream channel types in this watershed are highly dependent on the recruitment of large woody debris to maintain stability and proper ecological functioning.
3. The south aspect of this watershed makes it sensitive to a loss of riparian vegetation and possible effects on water temperatures.

### **Risk Assessment for this Watershed**

#### *Risk associated with Potential Increases in Peak Flows*

The peak flow risks are considered Moderate because of the combination of a very high sensitivity score and a low to moderate hazard score (HEDA = 23.4%, Table 5).

#### *Risk associated with Potential Increases in the Delivery of Fine Sediments to the Stream Network*

The fine sediment risks are considered as Moderate because of the sensitive characteristics of the watershed and the number of stream crossing hazards in the watershed (21 crossings in the watershed) (Table 6).

*Risk associated with a Reduction in Riparian Function*

The risks associated with a reduction in riparian function are Low because the riparian forest along the mainstem of Paula Creek has been minimally disturbed by land-use activities, i.e. the hazard is very low (Table 7).

**Suggested Management Objectives and Strategic Directions for this Sensitive Watershed**

- 1) Currently the peak flow risk in this watershed is at a Moderate level and should be maintained at a Low level or lower. This means that the HEDA value for this watershed needs to be lowered and then maintained below 17.2% (it is currently at 23.4). Thus a total of about 280 ha of recently harvested forest needs to reach hydrological recovery before logging can resume in this watershed. Use the Peak Flow Risk Calculator to determine the maximum suggested harvest of different combinations of healthy stands and mountain pine beetle affected stands in order to maintain a peak flow risk level below moderate.
- 2) For all future logging, minimize riparian disturbances within the riparian management zone (RMZ) located within the areas identified as having a “fluvial fan”, “Lacustrine” or “glacio-fluvial” surficial geology (Figure 2).
- 3) Maintain best management erosion and sediment control practices at all stream crossings located over the mainstem river and significant tributaries. I suggest that the Water Quality Effectiveness Evaluation (WQEE) tool be used and that the WQEE rating be maintained below a moderate level for each crossing (i.e. Low or Very Low). The most recent WQEE protocol can be found at the following web link:  
<http://www.for.gov.bc.ca/ftp/hfp/external!/publish/frep/indicators/Indicators-WaterQuality-Protocol-2009.pdf>
- 4) For all S4 streams wider than 0.5 m, maintain long term large woody debris (LWD) recruitment to the stream channel by retaining at least 90% of the riparian area in a state undisturbed by primary forest activities. Note that the riparian area refers to the management area measured from the closest streambank to a distance 15m upslope from the streambank.



Figure 1. Google earth overview image of Paula Creek watershed, looking upstream into the watershed.

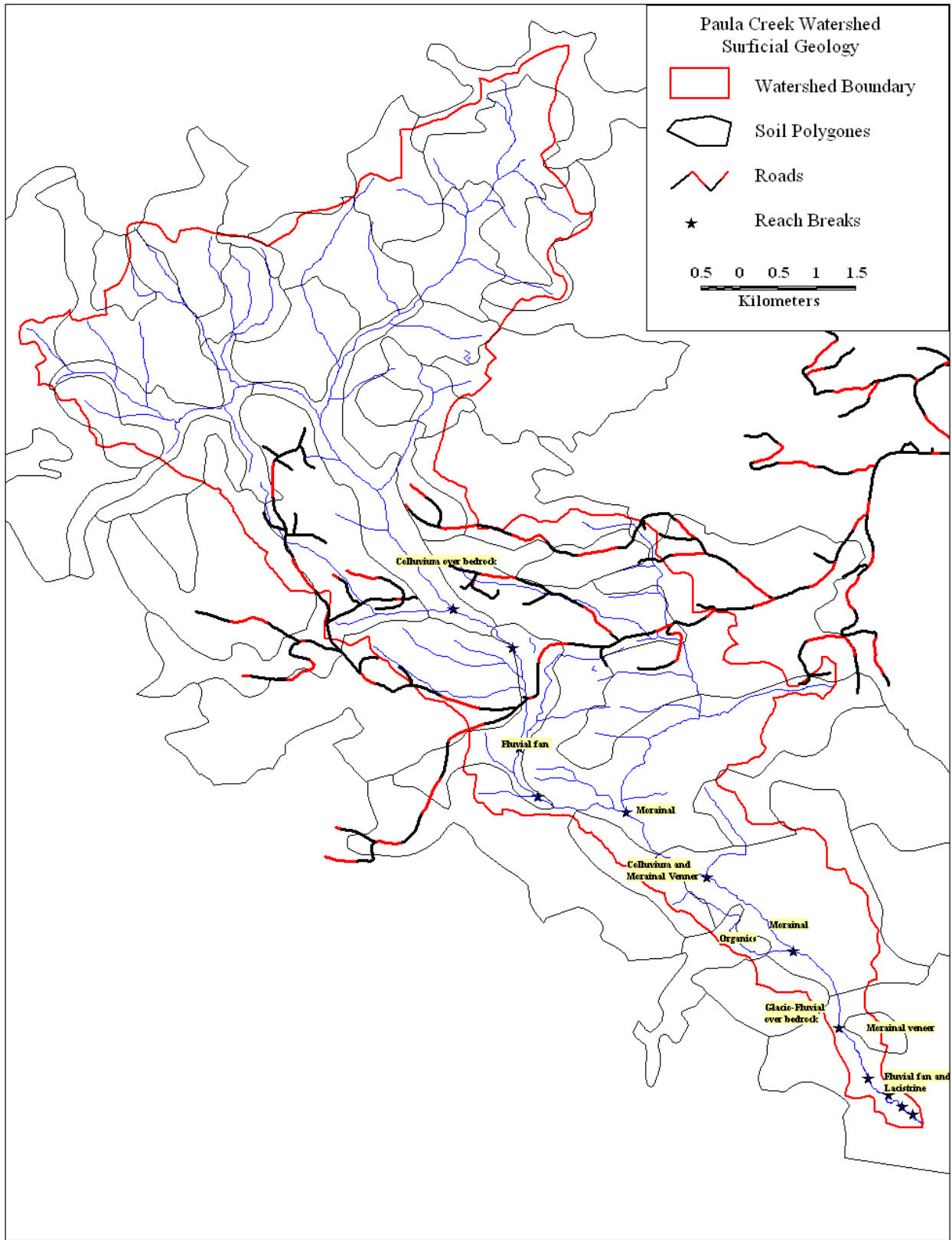


Figure 2. Distribution of surficial geology types near the mouth of Paula Creek.

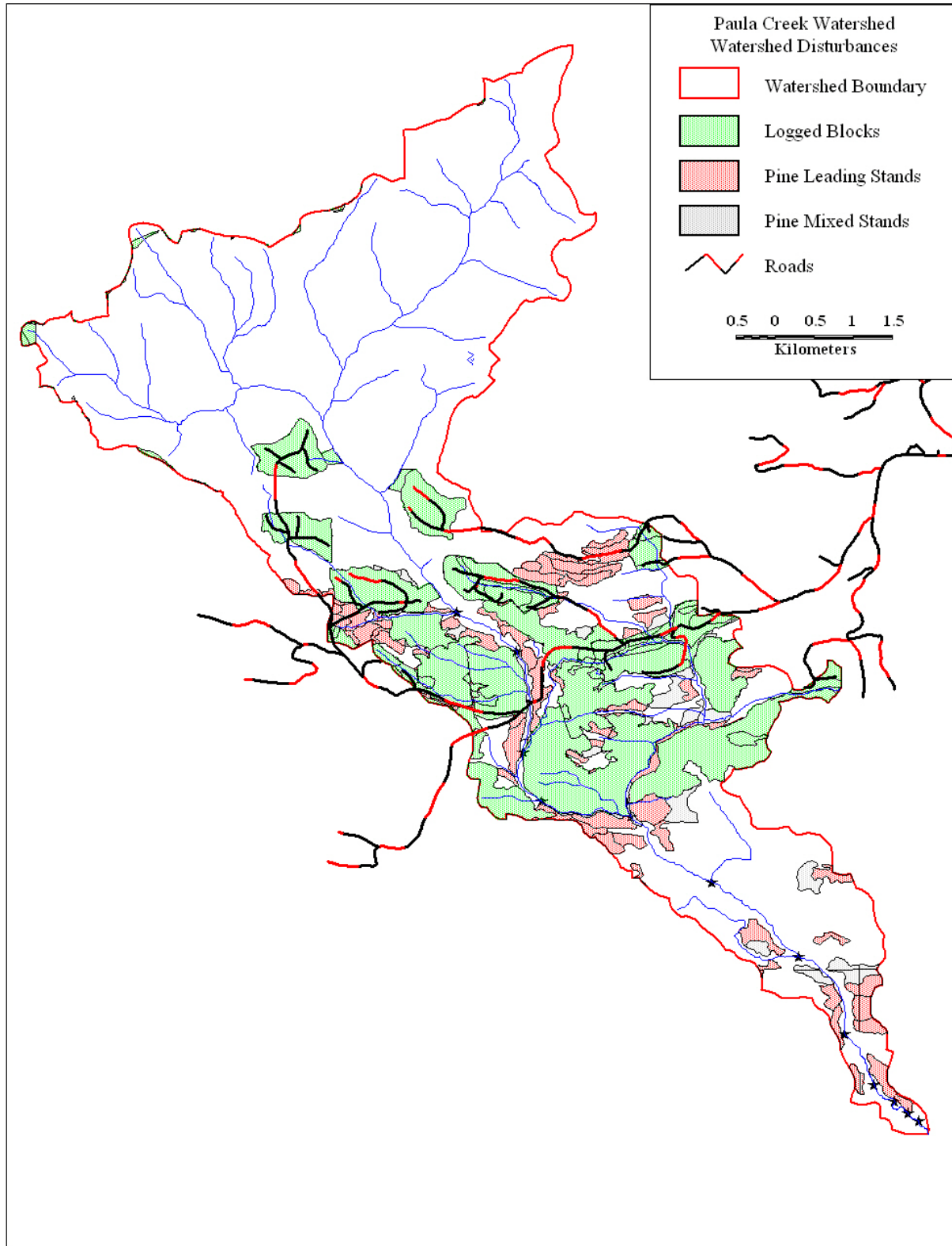


Figure 3. Land-use related and large natural disturbances in the Paula Creek Watershed



Figure 4. Identification of reach breaks along the mainstem of the lower Paula Creek watershed



Figure 5. Google Earth image looking upstream along Reaches #1 and 2 of Paula Creek.

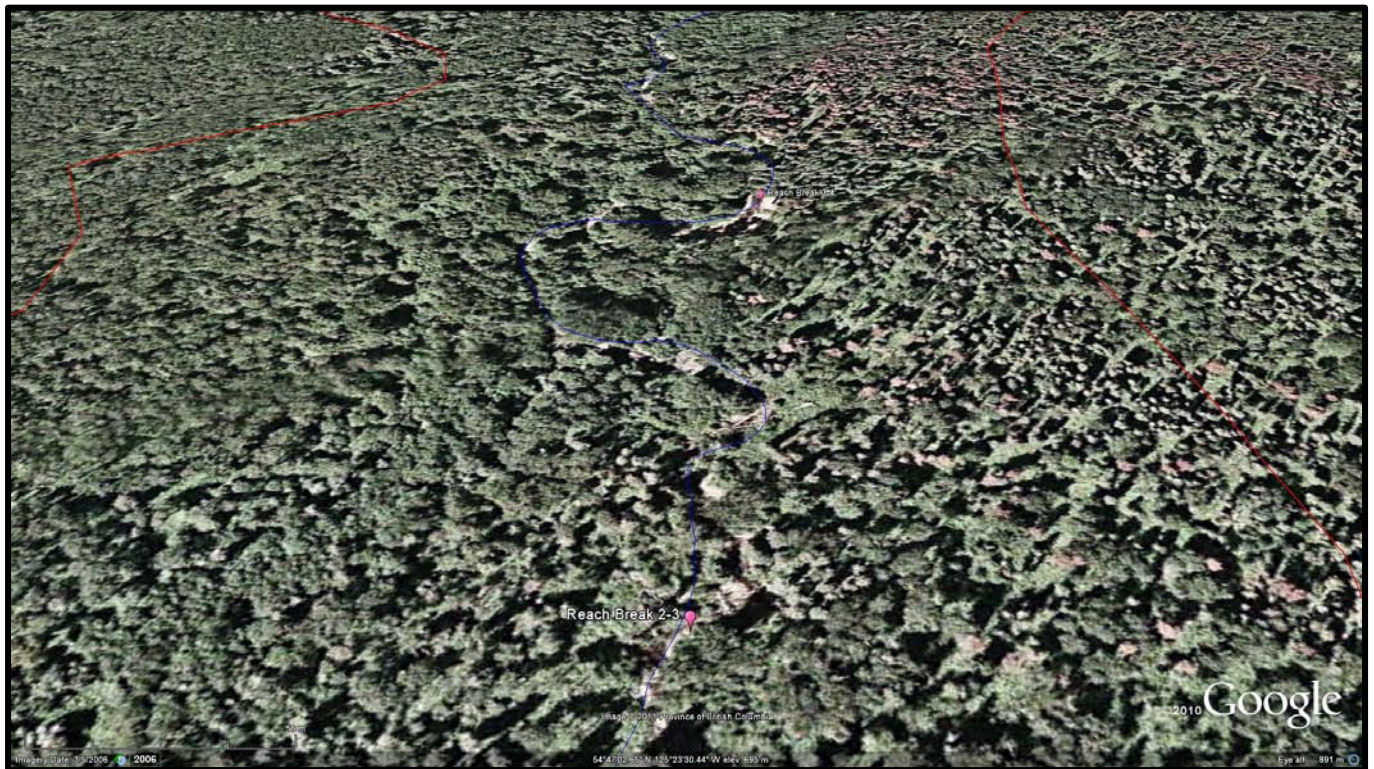


Figure 6. Google Earth image looking upstream along Reach #3 of Paula Creek.



Figure 7. Google Earth image looking upstream along Reach #4 of Paula Creek.



Figure 8. Google Earth image looking upstream along Reach #5 of Paula Creek.

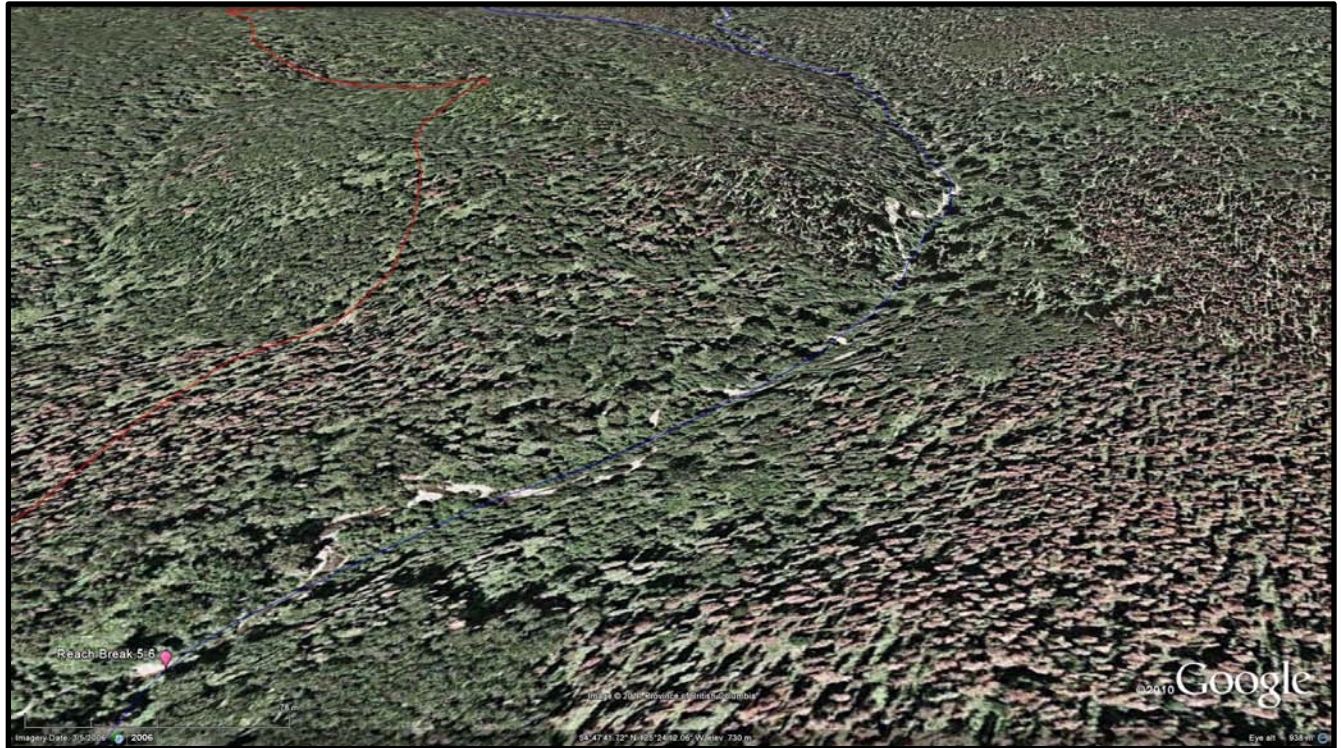


Figure 9. Google Earth image looking upstream along Reach #6 of Paula Creek.



Figure 10. Google Earth image looking upstream along Reach #7 of Paula Creek.



Figure 11. Google Earth image looking upstream along Reach #8 of Paula Creek.



Figure 12. Google Earth image looking upstream along Reach #9 of Paula Creek.

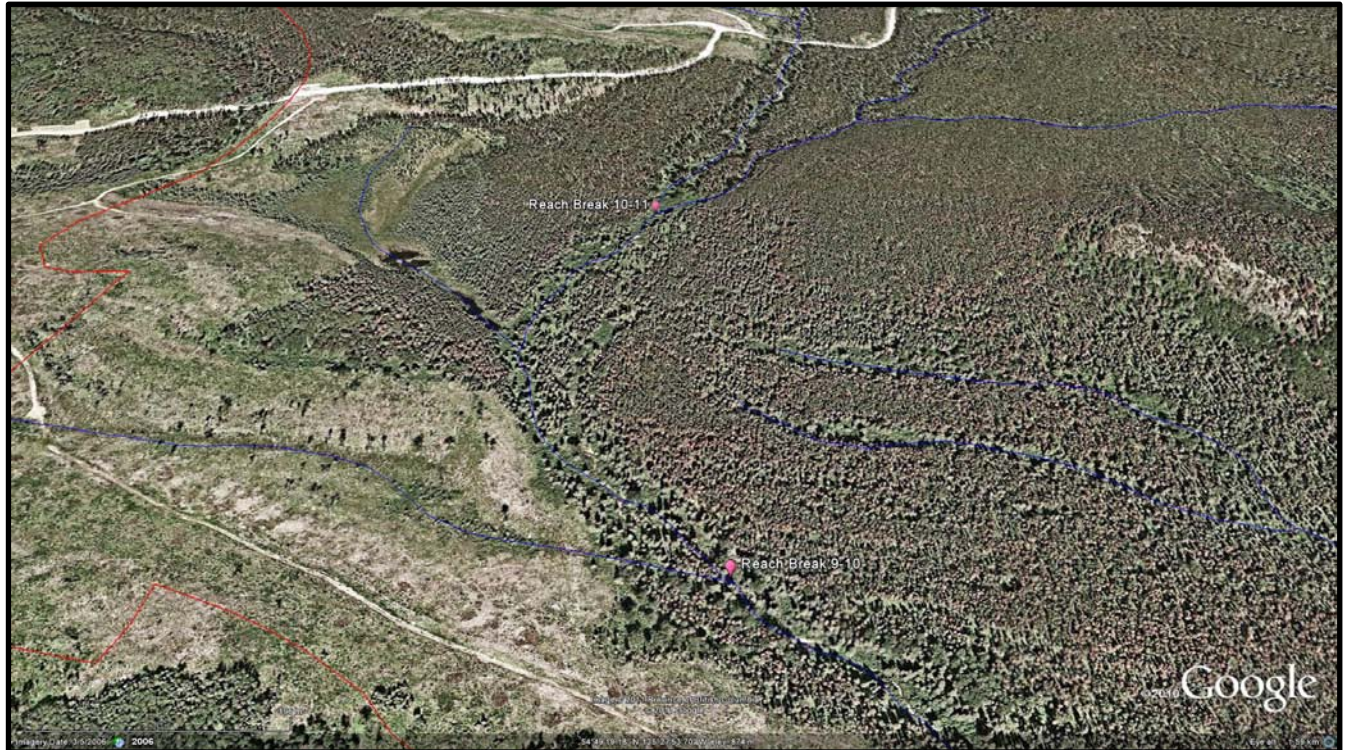


Figure 13. Google Earth image looking upstream along Reach #10 of Paula Creek.



Figure 14. Google Earth image looking upstream along Reach #11 of Paula Creek.



Figure 15. Google Earth image looking upstream along Reach #12 of Paula Creek.

**WATERSHED REVIEW**  
**SANDPOINT CREEK WATERSHED**  
**November 22, 2011**  
 Ministry Contract No: CS12NRH-011

**BIOPHYSICAL AND LAND-USE CHARACTERISTICS OF THE WATERSHED**

Table 1. Summary Information – Watershed Characteristics – (see Figures 1 and 2)

Size (km <sup>2</sup> )	Dominant BEC Zones	Dominant NDT	Elevation Range (m)	Surficial Geology near the Mouth (i.e. sensitive area)	Stream Density (km/km <sup>2</sup> )	Biggest % of watershed in same elevation band <sup>1</sup>	Distribution of slope gradients within the watershed (% of watershed)			
							<10% slope	10 to 30% slope	30 to 60% slope	>60% slope
64.6	SBS	NDT3	696-1982	Very fine textured lacustrine	1.75	33.7	27.8	54.5	16.4	1.3

<sup>1</sup> The entire watershed is divided into 300 m elevation bands of harvestable forest land-base. The less elevation bands there are and the more area is represented by any given single elevation band, then the greater will likely be the effect of forest harvesting on increased peak flows due to the theoretical concept of “synchronization” (i.e. the melt from the cutblocks is synchronized as much of it comes from the same elevation), and the greater sensitivity it will have.

Table 2. Rating of “Sensitivity” of Watershed to Increased Peak Flow at the lower reaches

Rosgen Stream Channel Score	Rosgen Stream Channel Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to vertical conductivity	Sensitivity score relative to climate	Sensitivity score relative to flow synchronization potential	Sensitivity score relative to NDT type	Sensitivity Score	Sensitivity Rating
D4-Stable	4	0.8	1.05	1	1.1	1	1.03	3.81	High

Table 3. Rating of “Sensitivity” of Watershed to Increased Production of Fine Sediment at lower reaches

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to climate	Sensitivity Score	Sensitivity Rating
Dolly Varden	5	0.75	1.1	1.1	4.5	Very High

Table 4. Rating of “Sensitivity” of Watershed to a Loss In riparian Function.

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to loss of LWD	Sensitivity score relative to Aspect	Sensitivity score relative to climate	Overall watershed sensitivity to loss of riparian	Loss of Riparian Sensitivity Rating
Dolly Varden	5	1.25	1.05	1.1	7.22	Extreme

Table 5. Peak Flow Hazard Rating, as indexed by HEDA – current scenario (i.e. no proposed harvesting considered)

Watershed area (km <sup>2</sup> )	Total area Pine Leading (km <sup>2</sup> )	Total area Pine Mixed (km <sup>2</sup> )	Total area harvest (km <sup>2</sup> ) <sup>1</sup>	Total HEDA from Pine Beetle alone (%)	Total HEDA from logging alone (%)	Total HEDA from logging and Pine Beetle mortality (%)
64.6	6.83	12.39	0.82	11.04	1.27	12.31

<sup>1</sup>Note: This includes openings from VRI database, and non-overlapping openings from RESULTS and FTEN databases.

Table 5 (continued)

Total area in Agriculture (km <sup>2</sup> )	Total area in Agriculture (% of watershed)	Total area in Proposed Harvest (km <sup>2</sup> )	Total HEDA (%)	HEDA Hazard rating Score	HEDA Hazard Rating
0.00	0.00	0.00	12.31	0.98	Very Low

Table 6. Fine Sediment Hazard Rating, as indexed by the Stream Crossing Density

Watershed area (km <sup>2</sup> )	# of x-ings	#of fish bearing X-ings <sup>1</sup>	#of non-fish bearing X-ings	density of x-ings (#/km <sup>2</sup> )	Density of fish bearing X-ings (#/km <sup>2</sup> )	Density of non-fish bearing X-ings (#/km <sup>2</sup> )	Hazard Rating Score	Hazard Rating
64.6	3	3	0	0.0	0.0	0.00	0	Very Low

<sup>1</sup>Note: The information on stream crossings was provided by MoE and was generated with a GIS model, not fieldwork.

Table 7. Loss of Riparian Function Hazard Rating (See Figures 3 to 14)

Reach Number	Rosgen Stream Type	Reach Length (m)	% riparian logged (as interpreted from air photos)	Apparent stability and other comments (as viewed from air photos)
1	D4-Stable	517	0.0	Stable
2	C4- Stable	655	0.0	Very Stable
3	C4- Stable	999.9	0.0	Very Stable
4	D4-Stable	720.6	0.0	Very Stable
5	C4- Stable	805.9	0.0	Very Stable
6	B4-Stable	501.3	0.0	Very Stable
7	B4-Stable	327.3	0.0	Very Stable
Hazard Scores:			Hazard Rating Score	Hazard Rating
			0.25	Very Low

Table 8. Risk Rankings for the Different Hazards in the watershed current scenario (i.e. no proposed harvesting considered)

Watershed Hazard Types	Sensitivity Score	Sensitivity Rating	Hazard Score	Hazard Rating	Risk Score	Risk Rating
Increased Peak Flow	3.81	High	0.98	Very Low	3.7	Low
Increase in Production of Fine Sediment	4.54	Very High	0.00	Very Low	0.0	Very Low
Loss of Riparian function	7.22	Extreme	0.25	Very Low	1.8	Very Low

## INTERPRETATIONS AND RECOMMENDATIONS FOR MANAGEMENT STRATEGIES FOR PROTECTION OF WATER RESOURCES IN THIS WATERSHED

### Brief Watershed Description (Table 1 and Figures 1 and 2)

The Sandpoint watershed is located at the southern end of the Mitchell Range and has a general topography that ranges from rolling to lightly mountainous. There is a small amount of steep land at the back end of the watershed on the flanks of one of the Nesabut peaks (max elevation = 1982 m). The watershed flows in a generally south-western direction and empties directly into Takla Lake.

The dominant biogeoclimatic zones in this watershed are the SBSwk3 at lower elevations and the ESSFmv3 at mid to higher elevations. Alpine Tundra (AT) can be found at the highest elevations of the watershed. About 82% of the watershed has slopes of 30% or less with only 1.3% of the watershed having slopes greater than 60% (Table 1). This watershed has a much softer topography than Ankwil, Lovell or Frypan.

This watershed has a large alluvial fan at its mouth with a braided Type D channel in Reach 1 (Figure 2 and 5). This is an extremely sensitive stream type, and given the importance of the fish habitat there, this contributes very significantly to the sensitivity of this watershed. Reaches 2 to 5 are C4/D4 channel types which are also sensitive to the potential for increased peak flows (Table 7). As you go up into the watershed, the channel becomes steeper and more incised and thus gradually less sensitive (i.e. reaches 6 and 7 are B4 types) (Figure 4).

### Key Elements that Make this Watershed Sensitive

#### *Sensitivity to Increased Peak Flows*

This watershed is considered to be sensitive to increased peak flows for the following reasons (Table 2):

1. Sensitive stream reach types in the lower parts of the watershed (D4 and C4)
2. Although most of the topography is rolling, there are some steep areas.
3. There are few lakes in the lower part of the watershed to buffer peak flows and the drainage density is relatively high.
4. Most of the soils are deep morainal tills, but some of the watershed has thin soils and exposed bedrock.
5. This is a relatively wet climate with deep snowpacks.

6. There is a large portion of the watershed that is within the same elevation band (34%).

#### *Sensitivity to Increased Delivery of Fine Sediments*

This watershed is considered to be sensitive to erosion processes and delivery of fine sediments for the following reasons (Table 3):

1. The watershed has fish species that are very sensitive to disturbances and increases in fine sediments
2. The watershed has enough slopes and channel connectivity to effectively transport eroded sediments to the stream network.
3. The climate is wet with heavy spring snowmelt which can contribute to the effectiveness of surface erosion and downslope transport of fine sediments.

#### *Sensitivity to a Reduction in Riparian Function*

This watershed is considered to be sensitive to a reduction in Riparian Function for the following reasons (Table 4):

1. The watershed has fish species that are very sensitive to disturbances and loss of riparian function
2. The stream channel types in this watershed are highly dependent on the recruitment of large woody debris to maintain stability and proper ecological functioning.
3. The south-western aspect of this watershed makes it sensitive to a loss of riparian vegetation and possible effects on water temperatures.

### **Risk Assessment for this Watershed**

#### *Risk associated with Potential Increases in Peak Flows*

The peak flow risks are considered Low because of the very low peak flow hazard in the watershed (HEDA = 12.31%, Table 5).

#### *Risk associated with Potential Increases in the Delivery of Fine Sediments to the Stream Network*

The fine sediment risks are considered as Very Low because there are very few stream crossings in this watershed and thus the hazard is Very Low (Table 6).

#### *Risk associated with a Reduction in Riparian Function*

The risks associated with a reduction in riparian function are Very Low because the riparian forest along the mainstem of Sandpoint have not been disturbed by land-use activities, i.e. the hazard is very low (Table 7).

### **Suggested Management Objectives and Strategic Directions for this Sensitive Watershed**

- 1) Maintain the peak flow risk in this watershed below a Moderate level (i.e. Low or Very Low). This means that the HEDA value for this watershed should be maintained below 21.32%, which would allow the harvesting of about 582 ha of healthy stands. Use the Peak Flow Risk Calculator to determine the maximum suggested harvest of different combinations of healthy stands and mountain pine beetle affected stands in order to maintain a peak flow risk level below moderate.
- 2) Minimize riparian disturbances within the riparian management zone (RMZ) located within the areas identified as having a “fluvial fan”, “Lacustrine” or “glacio-fluvial” surficial geology (Figure 2).
- 3) Maintain best management erosion and sediment control practices at any future stream crossing located over the mainstem river. In addition to being very important fish habitat at this location, the soils are easily erodible and could very easily be transported into Sandpoint Creek. I suggest that the Water Quality Effectiveness Evaluation (WQEE) tool be used and that the WQEE rating be maintained below a moderate level (i.e. Low or Very Low). The most recent WQEE protocol can be found at the following web link: <http://www.for.gov.bc.ca/ftp/hfp/external!/publish/frep/indicators/Indicators-WaterQuality-Protocol-2009.pdf>
- 4) For all S4 streams wider than 0.5 m, maintain long term large woody debris (LWD) recruitment to the stream channel by retaining at least 90% of the riparian area in a state undisturbed by primary forest activities. Note that the riparian area refers to the management area measured from the closest streambank to a distance 15m upslope from the streambank.

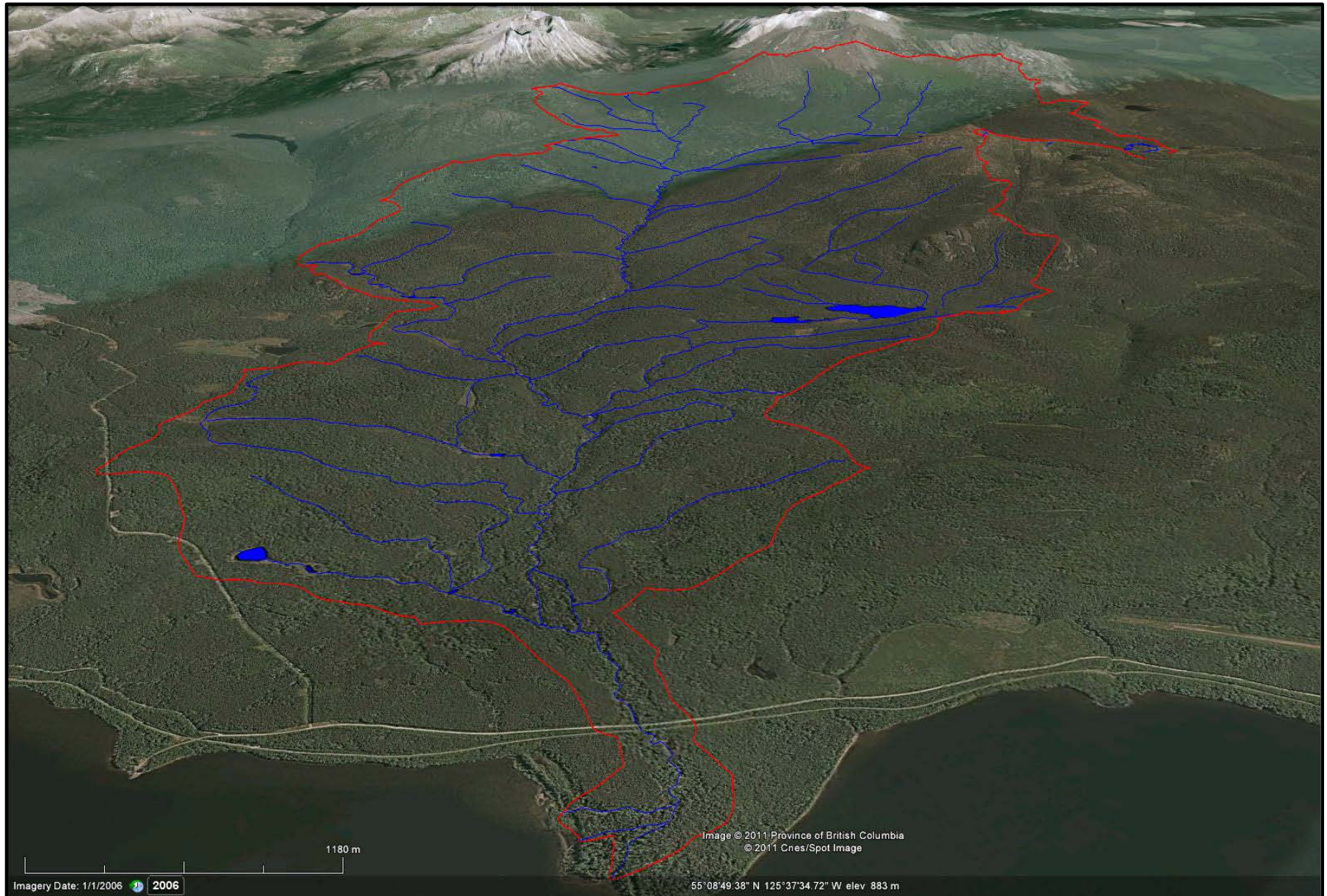


Figure 1. Google earth overview image of Sandpoint Creek watershed, looking upstream into the watershed.

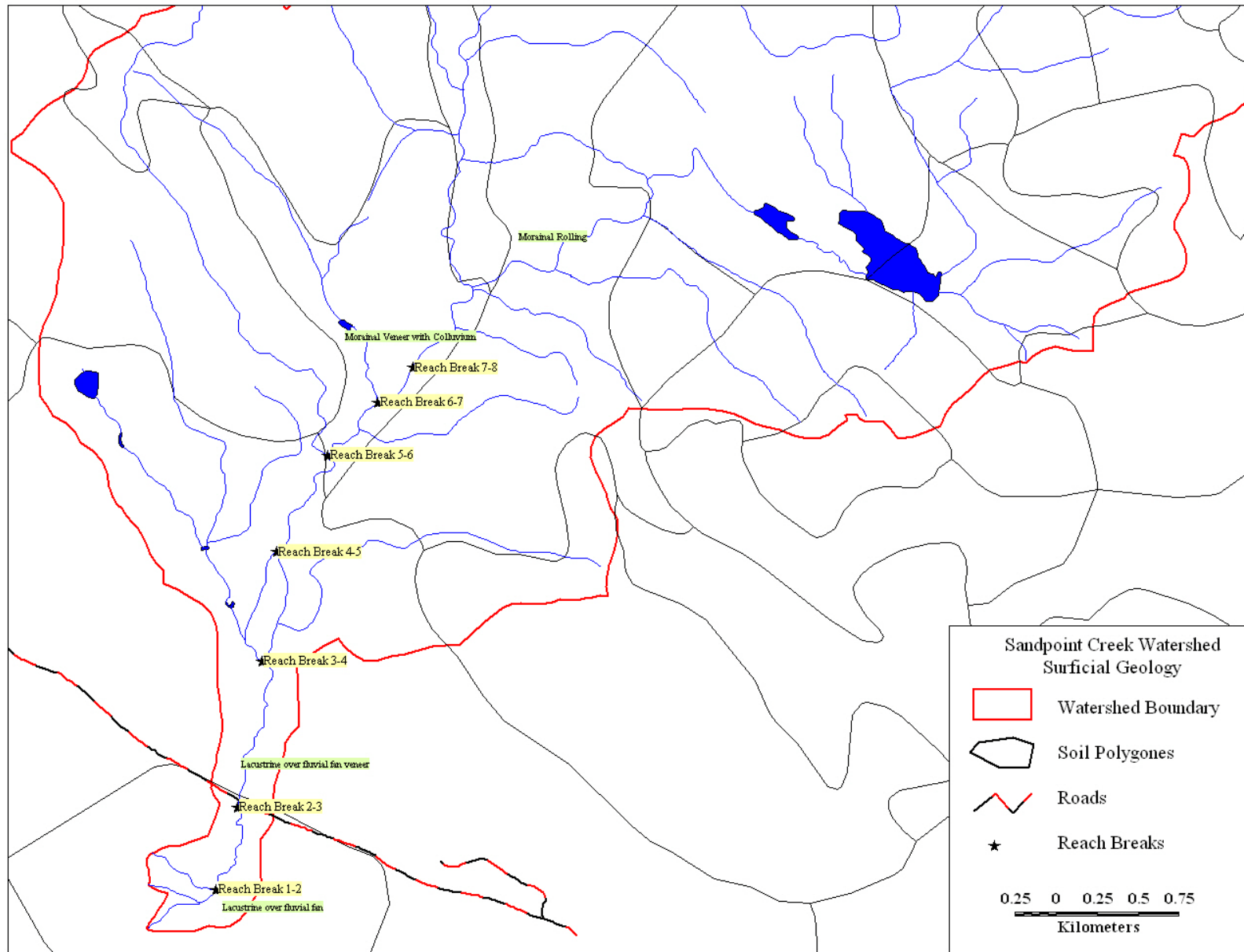


Figure 2. Distribution of surficial geology types near the mouth of Sandpoint Creek.

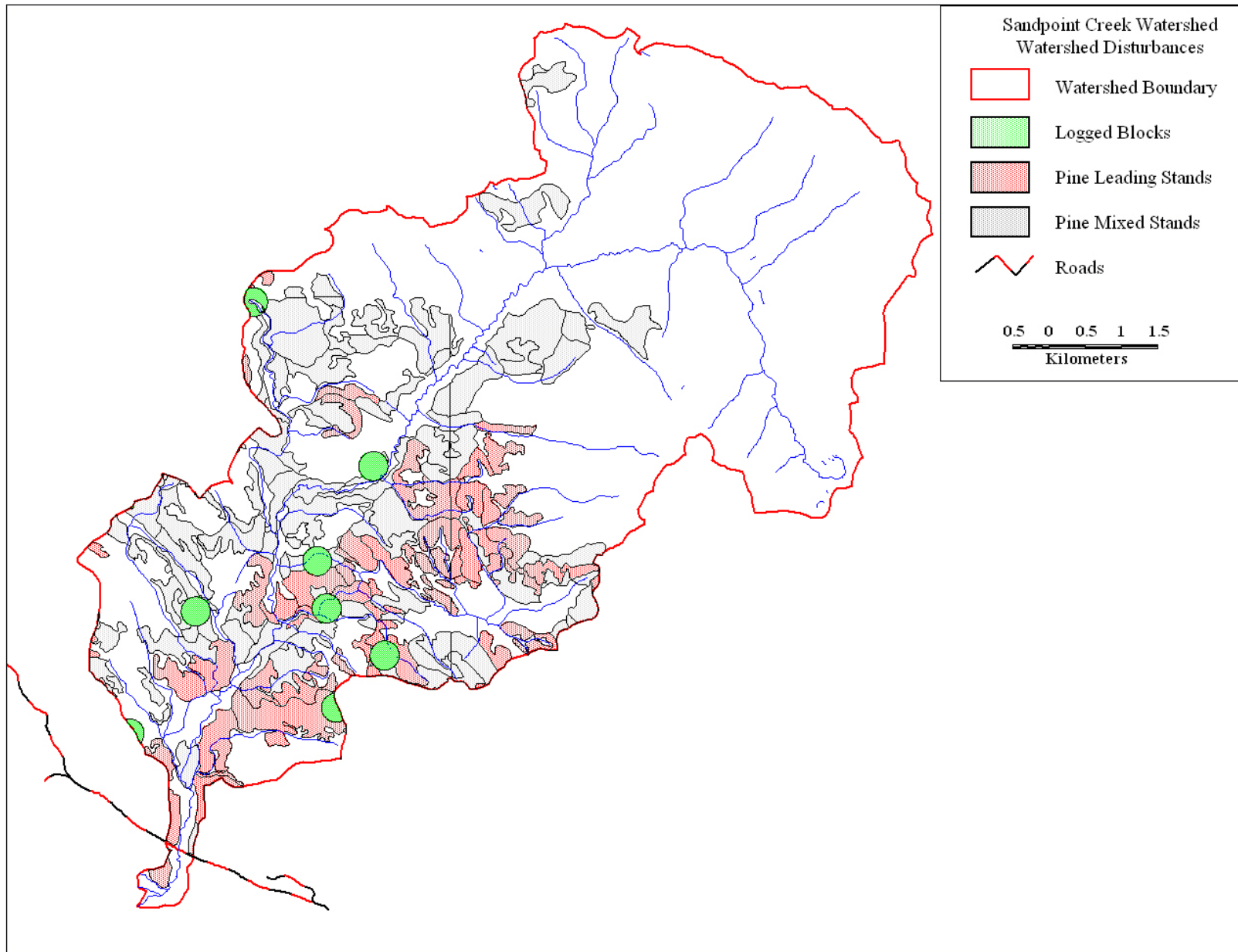


Figure 3. Land-use related and large natural disturbances in the Sandpoint Creek Watershed



Figure 4. Identification of reach breaks along the mainstem of the lower Sandpoint Creek watershed

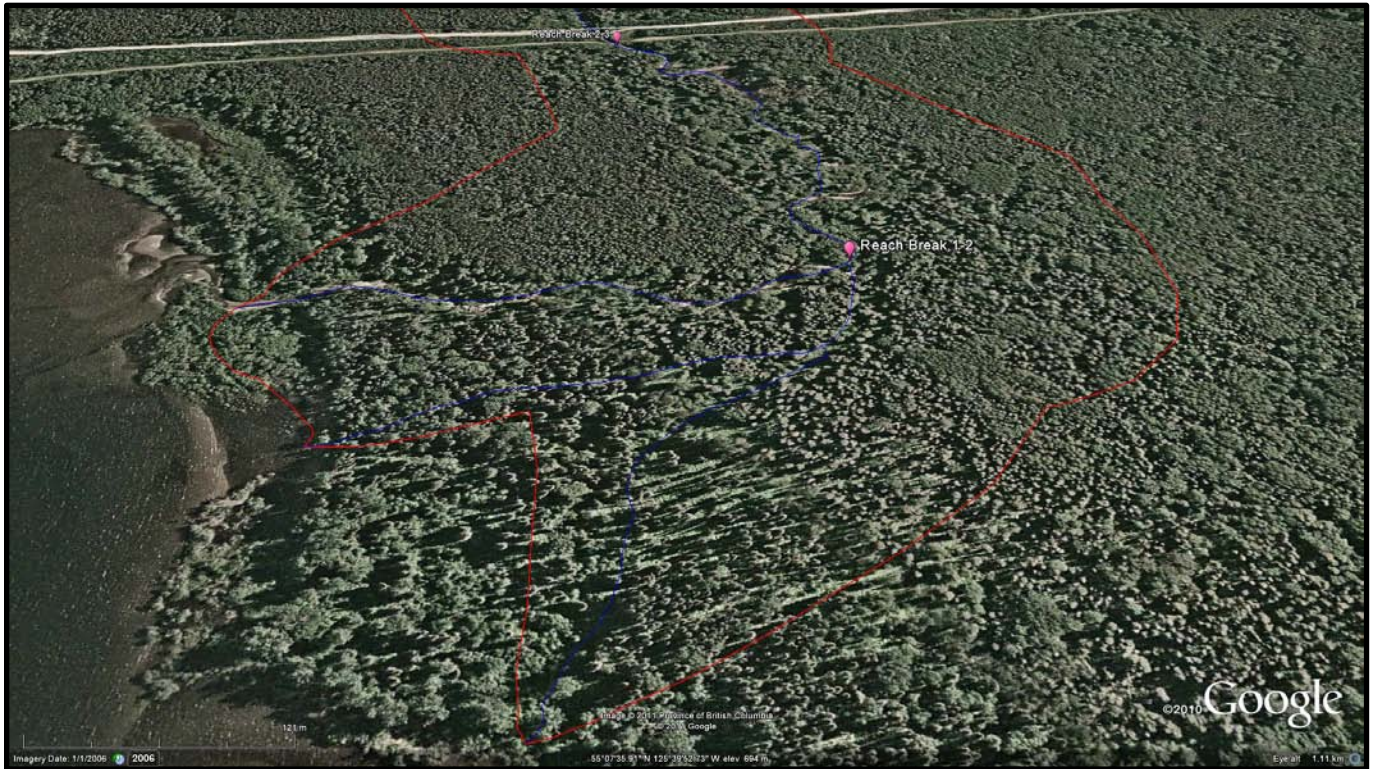


Figure 5. Google Earth image looking upstream along Reaches #1 and 2 of Sandpoint Creek.

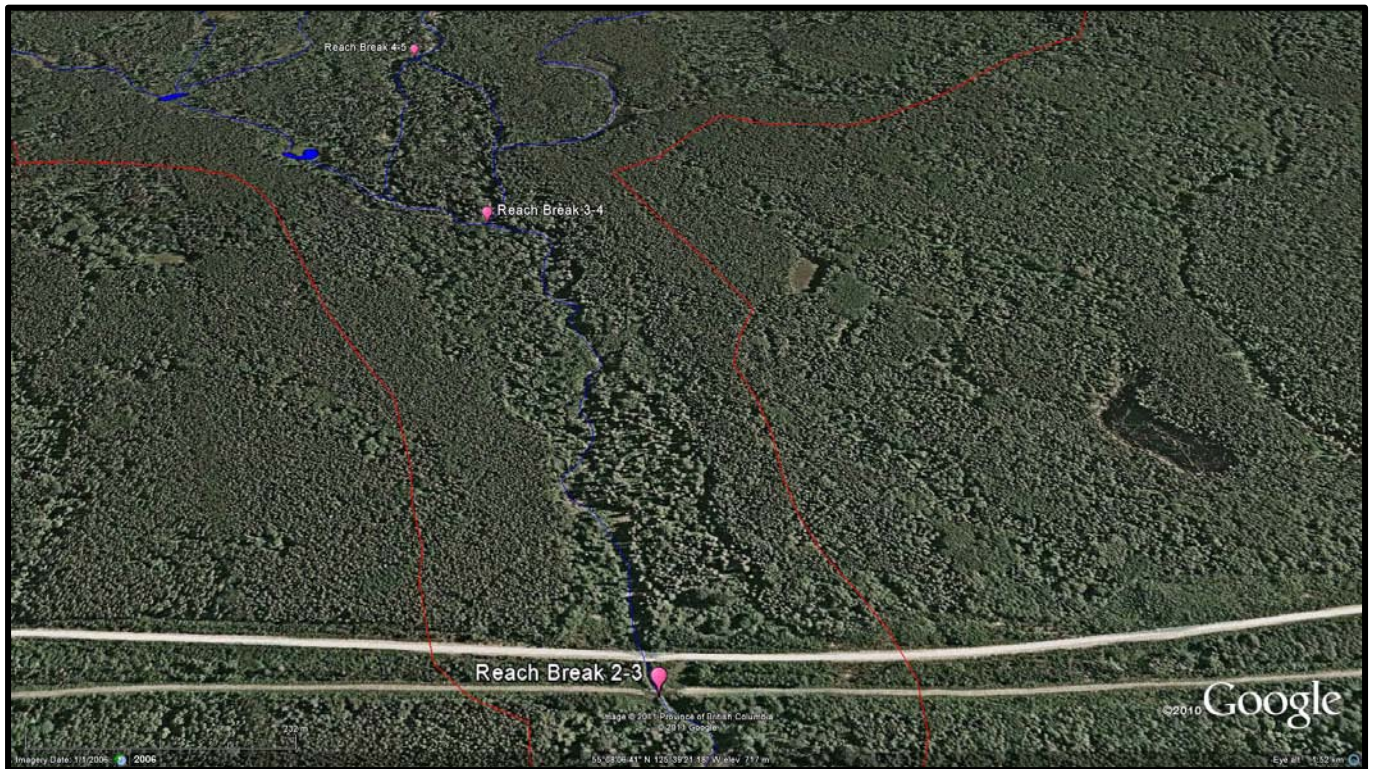


Figure 6. Google Earth image looking upstream along Reaches #3 and 4 of Sandpoint Creek.



Figure 7. Google Earth image looking upstream along Reaches #5 and 6 of Sandpoint Creek.



Figure 8. Google Earth image looking upstream along Reach #7 of Sandpoint Creek.

**WATERSHED REVIEW**  
**SIDNEY CREEK WATERSHED**  
**November 22, 2011**  
 Ministry Contract No: CS12NRH-011

**BIOPHYSICAL AND LAND-USE CHARACTERISTICS OF THE WATERSHED**

Table 1. Summary Information – Watershed Characteristics – (see Figures 1 and 2)

Size (km <sup>2</sup> )	Dominant BEC Zones	Dominant NDT	Elevation Range (m)	Surficial Geology near the Mouth (i.e. sensitive area)	Stream Density (km/km <sup>2</sup> )	Biggest % of watershed in same elevation band <sup>1</sup>	Distribution of slope gradients within the watershed (% of watershed)			
							<10% slope	10 to 30% slope	30 to 60% slope	>60% slope
43.8	SBS	NDT3	700-1975	Fine textured fluvial	2.27	34.1	23.3	45.6	27.8	3.3

<sup>1</sup> The entire watershed is divided into 300 m elevation bands of harvestable forest land-base. The less elevation bands there are and the more area is represented by any given single elevation band, then the greater will likely be the effect of forest harvesting on increased peak flows due to the theoretical concept of “synchronization” (i.e. the melt from the cutblocks is synchronized as much of it comes from the same elevation), and the greater sensitivity it will have.

Table 2. Rating of “Sensitivity” of Watershed to Increased Peak Flow at the lower reaches

Rosgen Stream Channel Score	Rosgen Stream Channel Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to vertical conductivity	Sensitivity score relative to climate	Sensitivity score relative to flow synchronization potential	Sensitivity score relative to NDT type	Sensitivity Score	Sensitivity Rating
C4- Lightly unstable/disturbed	4	1	1.1	1	1.1	1	1	4.84	Very High

Table 3. Rating of “Sensitivity” of Watershed to Increased Production of Fine Sediment at lower reaches

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to climate	Sensitivity Score	Sensitivity Rating
Dolly Varden	5	0.8	1.2	1.1	5.3	Very High

Table 4. Rating of “Sensitivity” of Watershed to a Loss In riparian Function.

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to loss of LWD	Sensitivity score relative to Aspect	Sensitivity score relative to climate	Overall watershed sensitivity to loss of riparian	Loss of Riparian Sensitivity Rating
Dolly Varden	5	1.25	1.1	1.1	7.56	Extreme

Table 5. Peak Flow Hazard Rating, as indexed by HEDA – current scenario (i.e. no proposed harvesting considered)

Watershed area (km <sup>2</sup> )	Total area Pine Leading (km <sup>2</sup> )	Total area Pine Mixed (km <sup>2</sup> )	Total area harvest (km <sup>2</sup> ) <sup>1</sup>	Total HEDA from Pine Beetle alone (%)	Total HEDA from logging alone (%)	Total HEDA from logging and Pine Beetle mortality (%)
43.8	0.88	1.14	7.62	1.79	15.00	16.79

<sup>1</sup>Note: This includes openings from VRI database, and non-overlapping openings from RESULTS and FTEN databases.

Table 5 (continued)

Total area in Agriculture (km <sup>2</sup> )	Total area in Agriculture (% of watershed)	Total area in Proposed Harvest (km <sup>2</sup> )	Total HEDA (%)	HEDA Hazard rating Score	HEDA Hazard Rating
0.00	0.00	0.00	16.79	1.41	Very Low

Table 6. Fine Sediment Hazard Rating, as indexed by the Stream Crossing Density

Watershed area (km <sup>2</sup> )	# of x-ings	#of fish bearing X-ings <sup>1</sup>	#of non-fish bearing X-ings	density of x-ings (#/km <sup>2</sup> )	Density of fish bearing X-ings (#/km <sup>2</sup> )	Density of non-fish bearing X-ings (#/km <sup>2</sup> )	Hazard Rating Score	Hazard Rating
43.8	35	35	0	0.8	0.8	0.00	3.3264	Mod

<sup>1</sup>Note: The information on stream crossings was provided by MoE and was generated with a GIS model, not fieldwork.

Table 7. Loss of Riparian Function Hazard Rating (See Figures 3 to 14)

Reach Number	Rosgen Stream Type	Reach Length (m)	% riparian logged (as interpreted from air photos)	Apparent stability and other comments (as viewed from air photos)
1	D4-Stable	48	0.0	Stable
2	C4- Stable	132	0.0	Stable
3	C4- Stable	341	0.0	Stable
4	C4- Stable	288	0.0	Stable
5	C4- Stable	244	0.0	Very Stable
6	C4- Stable	471	0.0	Stable
7	C4- Stable	598	0.0	Stable
8	B4-Stable	838	0.0	Stable
9	B4-Stable	1029	0.0	Stable
10	B4-Stable	907	0.0	Stable
Hazard Scores:			Hazard Rating Score	Hazard Rating
			0.25	Very Low

Table 8. Risk Rankings for the Different Hazards in the watershed current scenario (i.e. no proposed harvesting considered)

Watershed Hazard Types	Sensitivity Score	Sensitivity Rating	Hazard Score	Hazard Rating	Risk Score	Risk Rating
Increased Peak Flow	4.84	Very High	1.41	Very Low	6.8	Low
Increase in Production of Fine Sediment	5.28	Very High	3.33	Mod	17.6	High
Loss of Riparian function	7.56	Extreme	0.25	Very Low	1.9	Very Low

## INTERPRETATIONS AND RECOMMENDATIONS FOR MANAGEMENT STRATEGIES FOR PROTECTION OF WATER RESOURCES IN THIS WATERSHED

### Brief Watershed Description (Table 1 and Figures 1 and 2)

The Sidney Creek watershed also flows down from Mt Sidney Williams, but unlike Van Decar it flows into the West end of Trembleur Lake, rather than the Middle River. Elevations range between 700 and 1975 m for this watershed. The topography is lightly mountainous to steeply mountainous with abundant exposed bedrock at the back end of the watershed. The watershed flows in a southerly direction, with most of the lower part of the watershed being located in a Park (Figures 1 and 3).

The dominant biogeoclimatic zones in this watershed are the SBSmc2 and SBSwk3 at lower elevations and the ESSFmv3 at mid to higher elevations. Alpine Tundra (AT) can be found at the highest elevations of the watershed. About 69% of the watershed has slopes of 30% or less with 3.3% of the watershed having slopes greater than 60% (Table 1).

The lower reaches of Sydney Creek flow through lacustrine soils and a large alluvial fan near its mouth (Figures 2, 4 and 5). All of the lower reaches are a Rosgen Type 4 stream type, and given the importance of the fish habitat there, this contributes very significantly to the sensitivity of this watershed (Table 7). As you go up into the watershed, the channel becomes steeper and more incised and thus gradually less sensitive (i.e. reaches 8, 9 and 10 are B4 types) (Table 7 and Figure 4).

### Key Elements that Make this Watershed Sensitive

#### *Sensitivity to Increased Peak Flows*

This watershed is considered to be very sensitive to increased peak flows for the following reasons (Table 2):

1. Sensitive stream reach types in the lower parts of the watershed (C4)
2. Although much of the topography is rolling, there are extensive areas of steep topography in this watershed.
3. There are no lakes in the lower part of the watershed to buffer peak flows and the drainage density is relatively high.
4. Most of the soils are deep morainal tills, but much of the upper watershed has thin soils and exposed bedrock.

5. This is a relatively wet climate with deep snowpacks.
6. There is a large portion of the watershed that is within the same elevation band (34%).

#### *Sensitivity to Increased Delivery of Fine Sediments*

This watershed is considered to be very sensitive to erosion processes and delivery of fine sediments for the following reasons (Table 3):

1. The watershed has fish species that are very sensitive to disturbances and increases in fine sediments
2. The watershed has enough slopes and channel connectivity to effectively transport eroded sediments to the stream network.
3. The climate is wet with heavy spring snowmelt which can contribute to the effectiveness of surface erosion and downslope transport of fine sediments.
4. There is an abundance of highly erodible soils in the lower part of this watershed (Fluvial fan and lacustrine materials).

#### *Sensitivity to a Reduction in Riparian Function*

This watershed is considered to be sensitive to a reduction in Riparian Function for the following reasons (Table 4):

1. The watershed has fish species that are very sensitive to disturbances and loss of riparian function
2. The stream channel types in this watershed are highly dependent on the recruitment of large woody debris to maintain stability and proper ecological functioning.
3. The south aspect of this watershed makes it sensitive to a loss of riparian vegetation and possible effects on water temperatures.

### **Risk Assessment for this Watershed**

#### *Risk associated with Potential Increases in Peak Flows*

The peak flow risks are considered Low because of the very low peak flow hazard in the watershed (HEDA = 16.79%, Table 5).

#### *Risk associated with Potential Increases in the Delivery of Fine Sediments to the Stream Network*

The fine sediment risks are considered as Very Low because there are very few stream crossings in this watershed and thus the hazard is Very Low (Table 6).

#### *Risk associated with a Reduction in Riparian Function*

The risks associated with a reduction in riparian function are Very Low because the riparian forest along the mainstem of Sidney Creek have not been disturbed by land-use activities, i.e. the hazard is very low (Table 7).

### **Suggested Management Objectives and Strategic Directions for this Sensitive Watershed**

- 1) Maintain the peak flow risk in this watershed below a Moderate level (i.e. Low or Very Low). This means that the HEDA value for this watershed should be maintained below 17.2%, which would allow the harvesting of only about 18 ha of healthy stands. Use the Peak Flow Risk Calculator to determine the maximum suggested harvest of different combinations of healthy stands and mountain pine beetle affected stands in order to maintain a peak flow risk level below moderate. Note that the opportunity for additional harvesting is limited because the current operational areas are constrained by the steepness of the watershed upstream and the extensive park boundaries downstream (Figure1).
- 2) Minimize riparian disturbances within the riparian management zone (RMZ) located within the areas identified as having a “fluvial fan”, “Lacustrine” or “glacio-fluvial” surficial geology (Figure 2).
- 3) Maintain best management erosion and sediment control practices at any future stream crossing located over the mainstem river. In addition to being very important fish habitat at this location, the soils are easily erodible and could very easily be transported into Sidney Creek. I suggest that the Water Quality Effectiveness Evaluation (WQEE) tool be used and that the WQEE rating be maintained below a moderate level (i.e. Low or Very Low). The most recent WQEE protocol can be found at the following web link: <http://www.for.gov.bc.ca/ftp/hfp/external!/publish/frep/indicators/Indicators-WaterQuality-Protocol-2009.pdf>
- 4) For all S4 streams wider than 0.5 m, maintain long term large woody debris (LWD) recruitment to the stream channel by retaining at least 90% of the riparian area in a state undisturbed by primary forest activities. Note that the riparian area refers to the management area measured from the closest streambank to a distance 15m upslope from the streambank.



Figure 1. Google earth overview image of Sidney Creek watershed, looking upstream into the watershed.

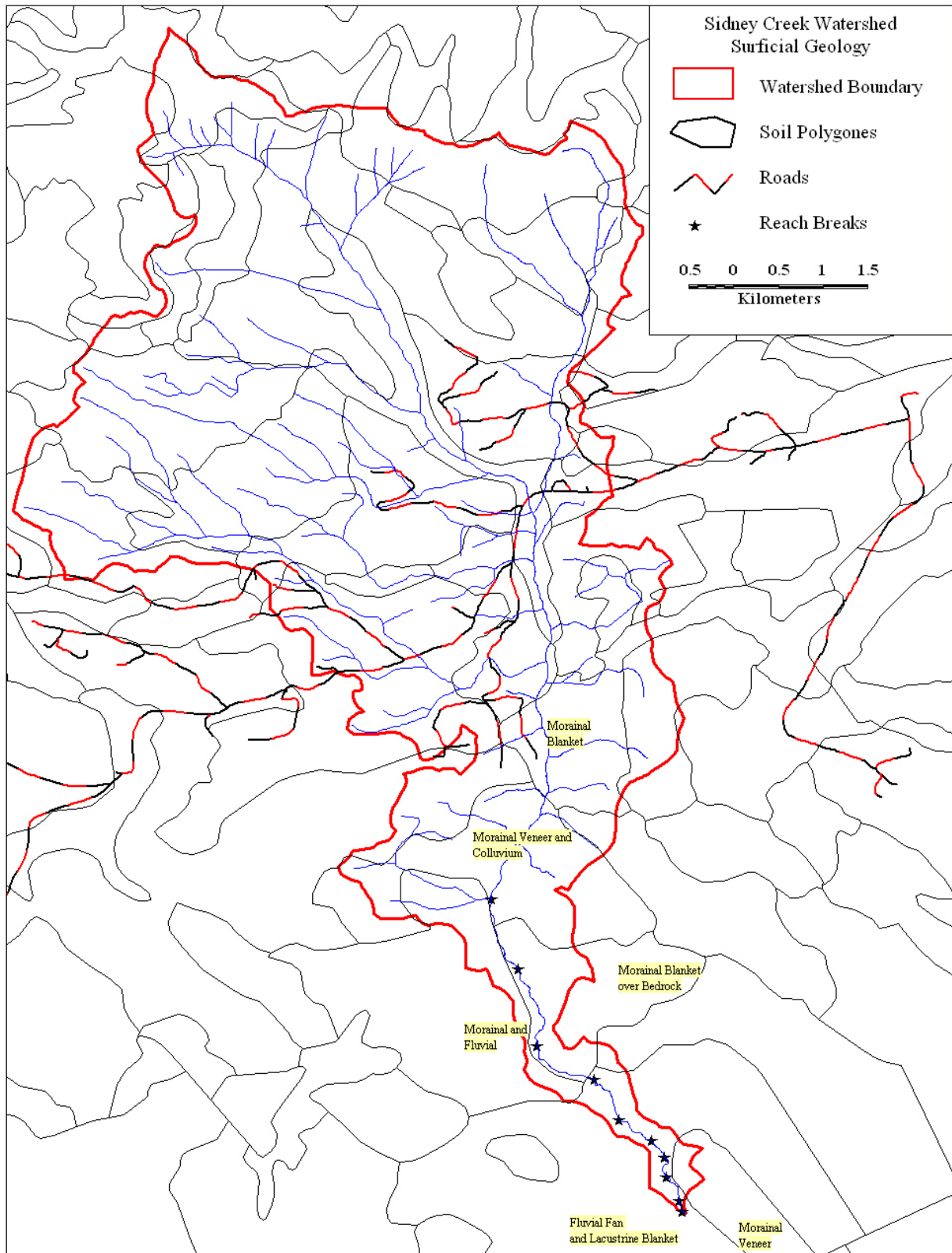


Figure 2. Distribution of surficial geology types near the mouth of Sidney Creek.

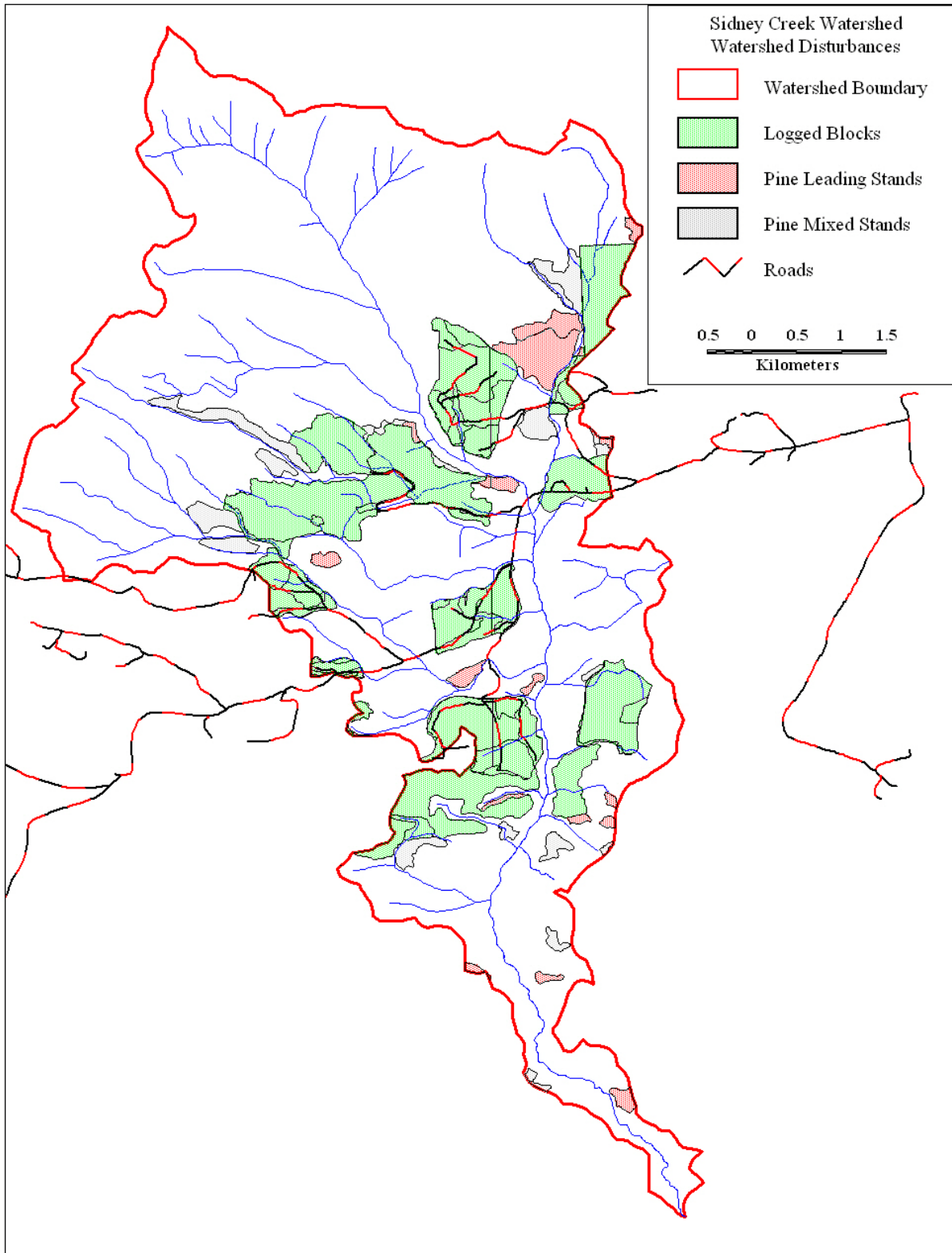


Figure 3. Land-use related and large natural disturbances in the Sidney Creek Watershed

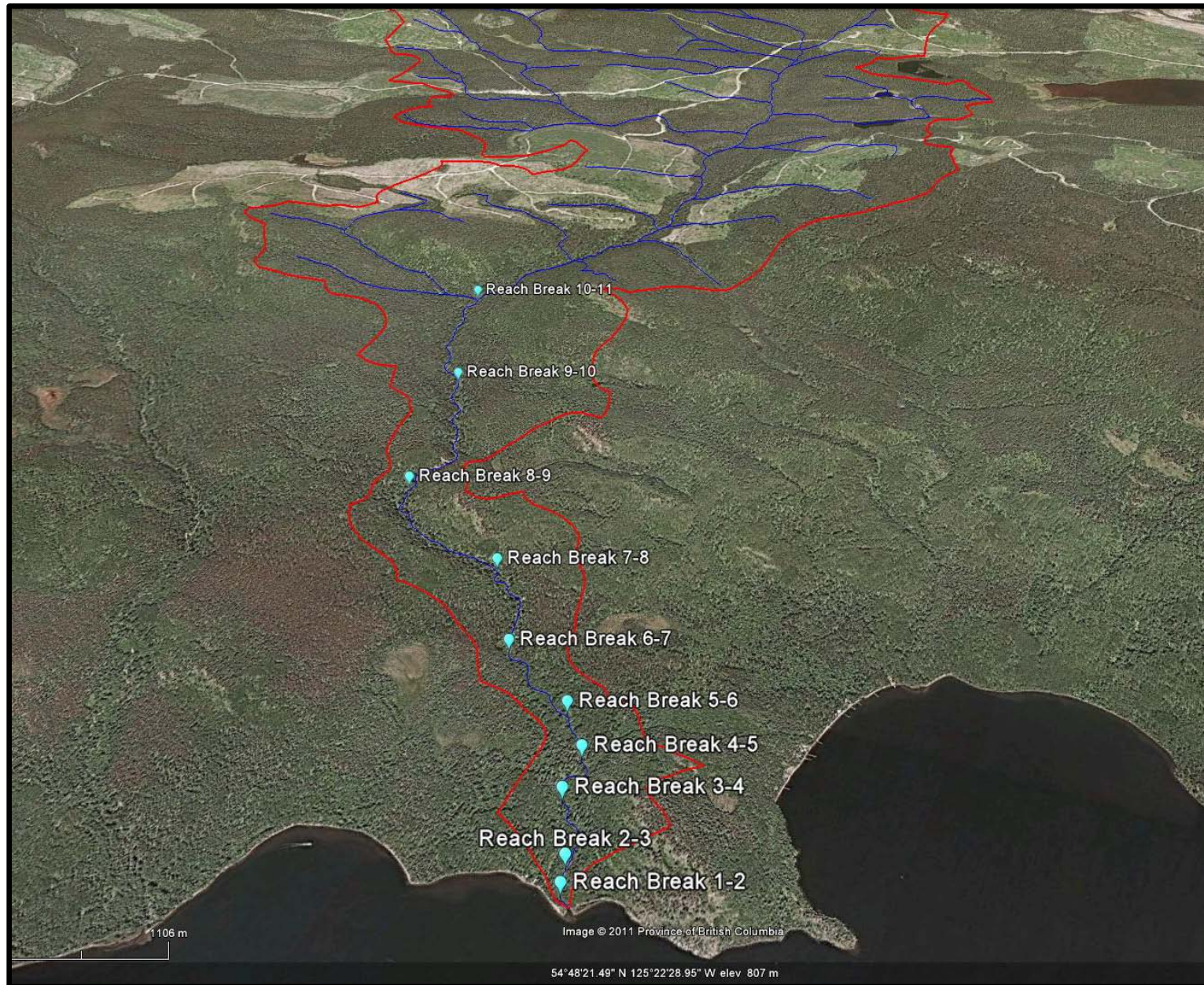


Figure 4. Identification of reach breaks along the mainstem of the lower Sidney Creek watershed



Figure 5. Google Earth image looking upstream along Reaches #1 and 2 of Sidney Creek.

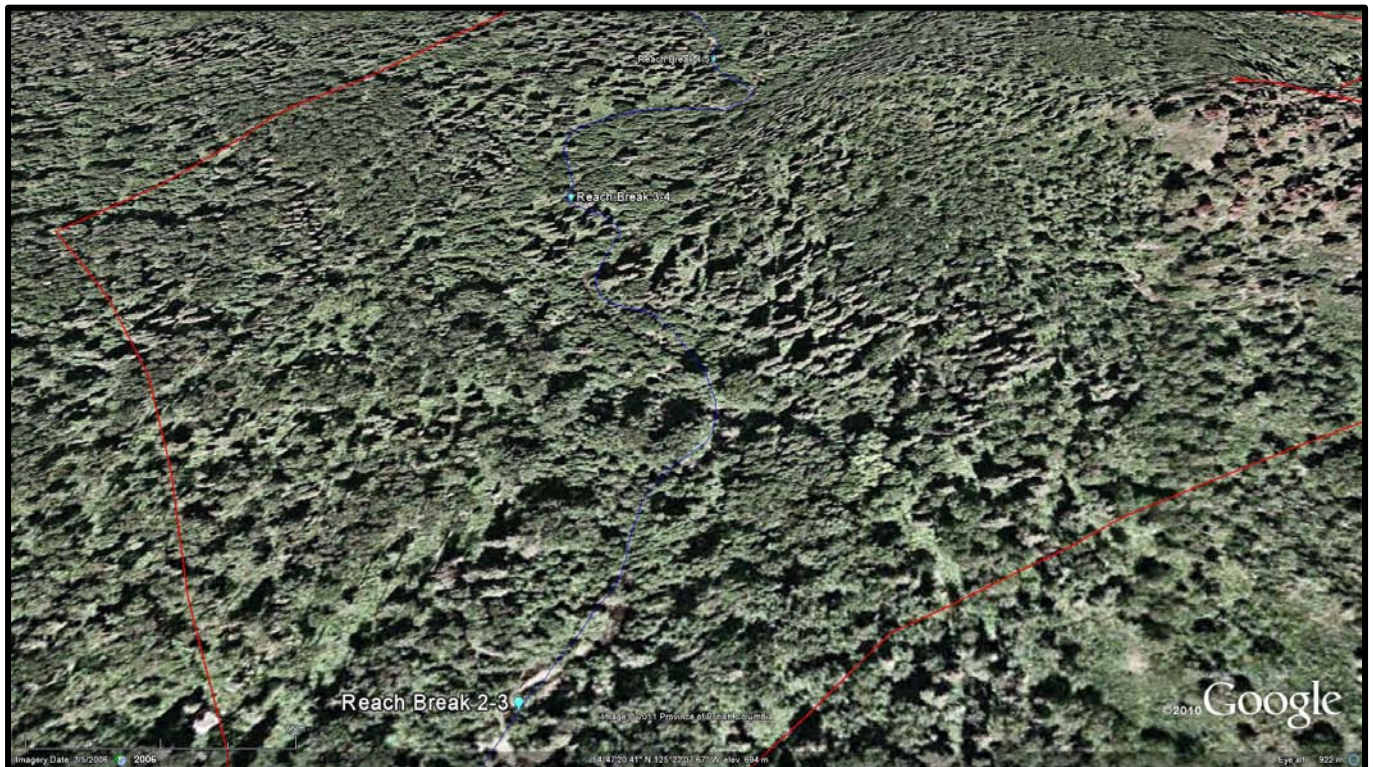


Figure 6. Google Earth image looking upstream along Reaches #3 and 4 of Sidney Creek.

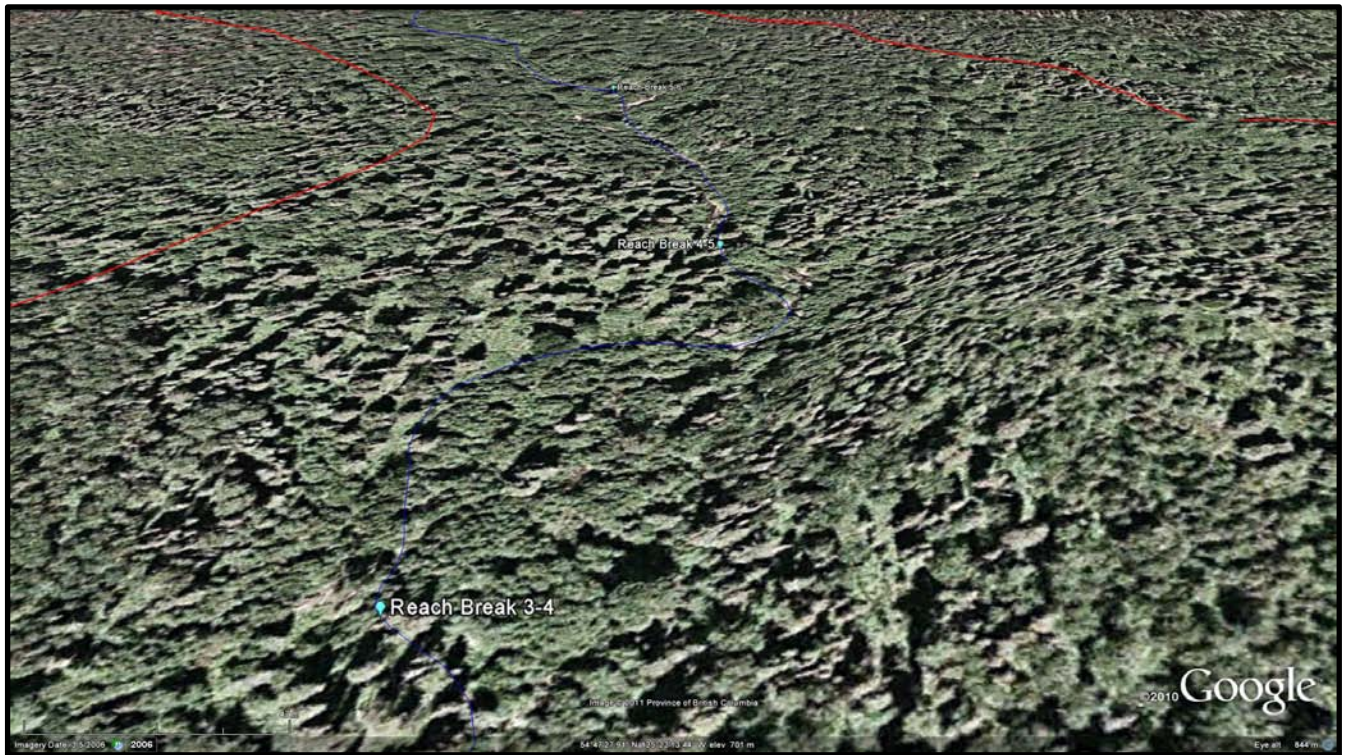


Figure 7. Google Earth image looking upstream along Reaches #4 and 5 of Sidney Creek.



Figure 8. Google Earth image looking upstream along Reach #6 of Sidney Creek.

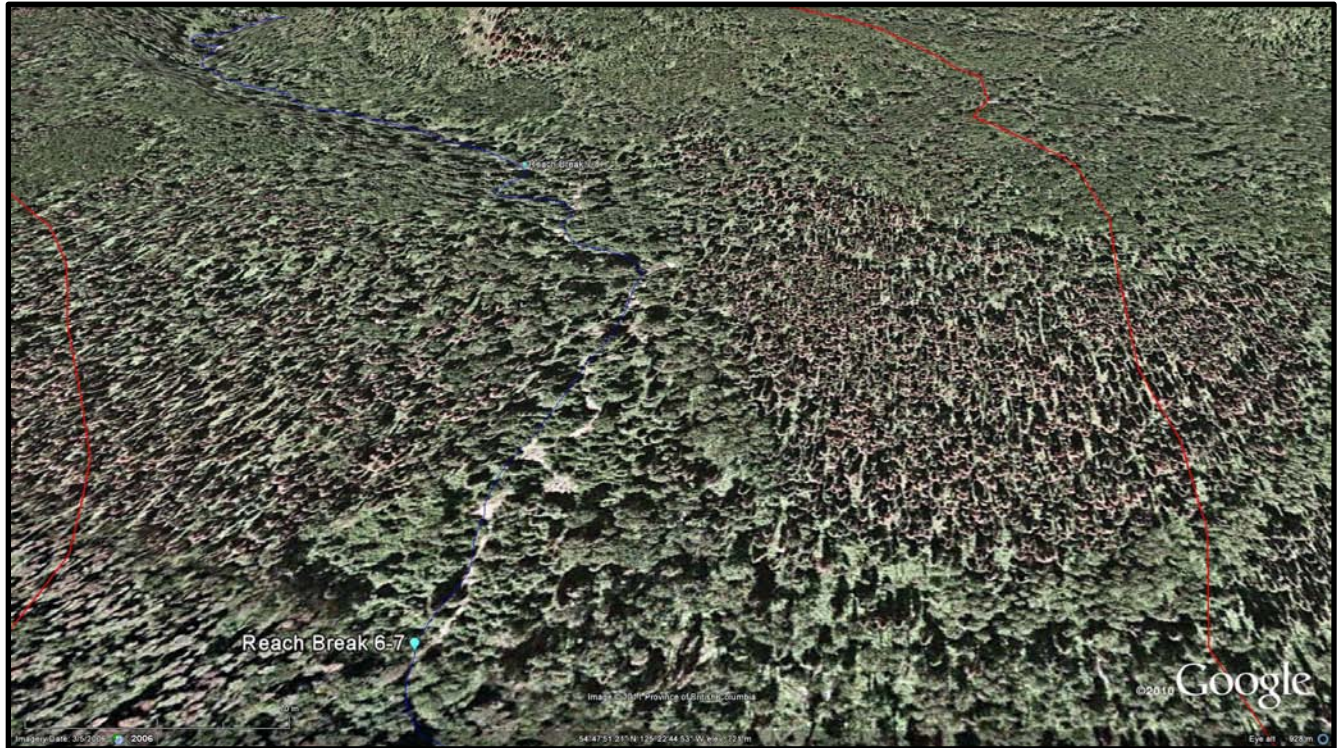


Figure 9. Google Earth image looking upstream along Reach #7 of Sidney Creek.

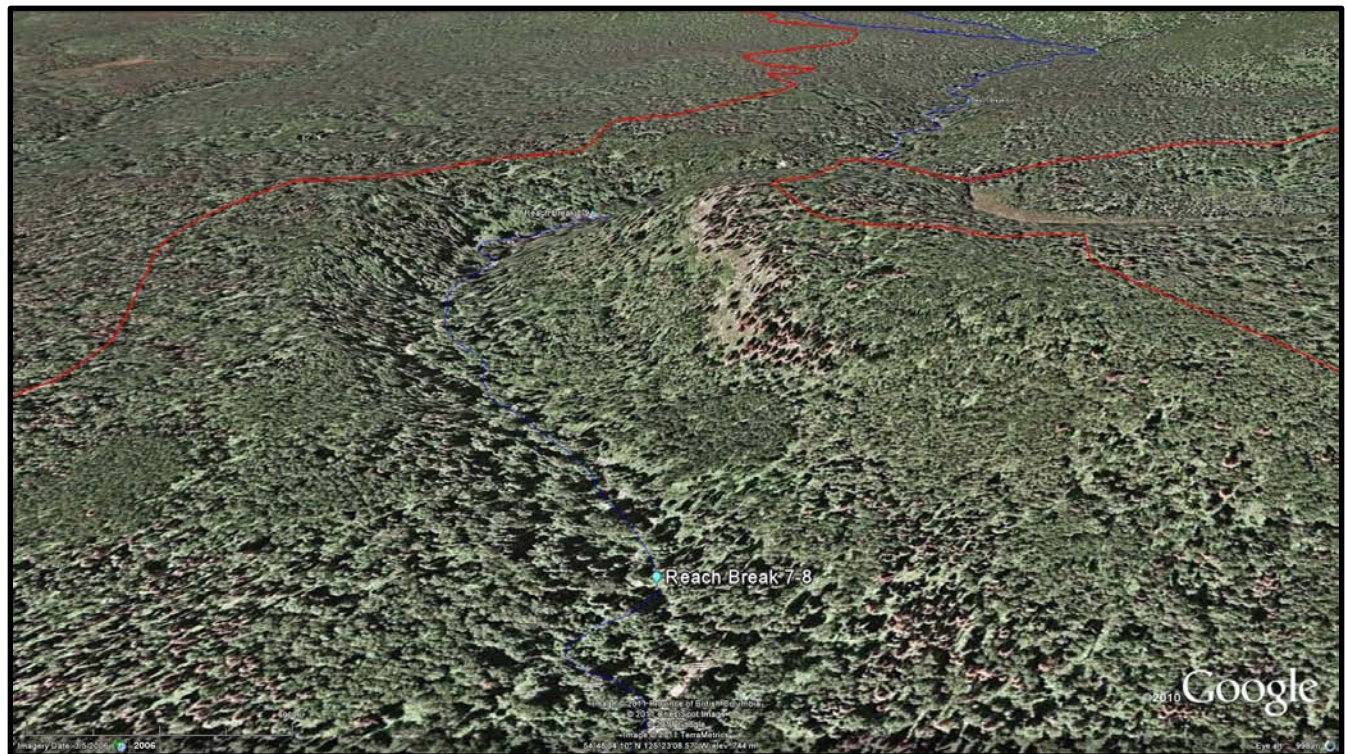


Figure 10. Google Earth image looking upstream along Reach #8 of Sidney Creek.



Figure 11. Google Earth image looking upstream along Reach #9 of Sidney Creek.



Figure 12. Google Earth image looking upstream along Reach #10 of Sidney Creek.

**WATERSHED REVIEW**  
**VAN DECAR CREEK WATERSHED**  
**November 22, 2011**  
 Ministry Contract No: CS12NRH-011

**BIOPHYSICAL AND LAND-USE CHARACTERISTICS OF THE WATERSHED**

Table 1. Summary Information – Watershed Characteristics – (see Figures 1 and 2)

Size (km <sup>2</sup> )	Dominant BEC Zones	Dominant NDT	Elevation Range (m)	Surficial Geology near the Mouth (i.e. sensitive area)	Stream Density (km/km <sup>2</sup> )	Biggest % of watershed in same elevation band <sup>1</sup>	Distribution of slope gradients within the watershed (% of watershed)			
							<10% slope	10 to 30% slope	30 to 60% slope	>60% slope
26.9	SBS	NDT3	701-1984	Fine textured fluvial	1.90	42.8	12.6	63.9	19.6	3.9

<sup>1</sup> The entire watershed is divided into 300 m elevation bands of harvestable forest land-base. The less elevation bands there are and the more area is represented by any given single elevation band, then the greater will likely be the effect of forest harvesting on increased peak flows due to the theoretical concept of “synchronization” (i.e. the melt from the cutblocks is synchronized as much of it comes from the same elevation), and the greater sensitivity it will have.

Table 2. Rating of “Sensitivity” of Watershed to Increased Peak Flow at the lower reaches

Rosgen Stream Channel Score	Rosgen Stream Channel Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to vertical conductivity	Sensitivity score relative to climate	Sensitivity score relative to flow synchronization potential	Sensitivity score relative to NDT type	Sensitivity Score	Sensitivity Rating
C5- Stable	3.5	1	1.1	1	1.1	1	1.03	4.36	High

Table 3. Rating of “Sensitivity” of Watershed to Increased Production of Fine Sediment at lower reaches

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to topography	Sensitivity score relative to lateral connectivity	Sensitivity score relative to climate	Sensitivity Score	Sensitivity Rating
Dolly Varden	5	0.8	1.2	1.1	5.3	Very High

Table 4. Rating of “Sensitivity” of Watershed to a Loss In riparian Function.

Most sensitive fish species in watershed	Species Sensitivity Score	Sensitivity score relative to loss of LWD	Sensitivity score relative to Aspect	Sensitivity score relative to climate	Overall watershed sensitivity to loss of riparian	Loss of Riparian Sensitivity Rating
Dolly Varden	5	1.25	0.85	1.1	5.84	Extreme

Table 5. Peak Flow Hazard Rating, as indexed by HEDA – current scenario (i.e. no proposed harvesting considered)

Watershed area (km <sup>2</sup> )	Total area Pine Leading (km <sup>2</sup> )	Total area Pine Mixed (km <sup>2</sup> )	Total area harvest (km <sup>2</sup> ) <sup>1</sup>	Total HEDA from Pine Beetle alone (%)	Total HEDA from logging alone (%)	Total HEDA from logging and Pine Beetle mortality (%)
26.9	0.445	0.82	1.793	1.74	4.94	6.68

<sup>1</sup>Note: This includes openings from VRI database, and non-overlapping openings from RESULTS and FTEN databases.

Table 5 (continued)

Total area in Agriculture (km <sup>2</sup> )	Total area in Agriculture (% of watershed)	Total area in Proposed Harvest (km <sup>2</sup> )	Total HEDA (%)	HEDA Hazard rating Score	HEDA Hazard Rating
0.00	0.00	0.00	6.68	0.44	Very Low

Table 6. Fine Sediment Hazard Rating, as indexed by the Stream Crossing Density

Watershed area (km <sup>2</sup> )	# of x-ings	#of fish bearing X-ings <sup>1</sup>	#of non-fish bearing X-ings	density of x-ings (#/km <sup>2</sup> )	Density of fish bearing X-ings (#/km <sup>2</sup> )	Density of non-fish bearing X-ings (#/km <sup>2</sup> )	Hazard Rating Score	Hazard Rating
26.9	3	3	0	0.1	0.1	0.00	1.1088	Very Low

<sup>1</sup>Note: The information on stream crossings was provided by MoE and was generated with a GIS model, not fieldwork.

Table 7. Loss of Riparian Function Hazard Rating (See Figures 3 to 14)

Reach Number	Rosgen Stream Type	Reach Length (m)	% riparian logged (as interpreted from air photos)	Apparent stability and other comments (as viewed from air photos)
1	C5- Stable	92.8	0.0	Stable
2	C4- Stable	164.2	0.0	Very Stable
3	C4- Stable	522.7	0.0	Very Stable
4	C4- Stable	463.7	0.0	Very Stable
5	C4- Stable	350	0.0	Very Stable
6	C4- Stable	439	0.0	Very Stable
7	B4-Stable	1349	0.0	Very Stable
8	B4-Stable	761	0.0	Very Stable
9	B4-Stable	967	0.0	Very Stable
Hazard Scores:			Hazard Rating Score	Hazard Rating
			0.25	Very Low

Table 8. Risk Rankings for the Different Hazards in the watershed current scenario (i.e. no proposed harvesting considered)

Watershed Hazard Types	Sensitivity Score	Sensitivity Rating	Hazard Score	Hazard Rating	Risk Score	Risk Rating
Increased Peak Flow	4.36	High	0.44	Very Low	1.9	Very Low
Increase in Production of Fine Sediment	5.28	Very High	1.11	Very Low	5.9	Low
Loss of Riparian function	5.84	Extreme	0.25	Very Low	1.5	Very Low

## INTERPRETATIONS AND RECOMMENDATIONS FOR MANAGEMENT STRATEGIES FOR PROTECTION OF WATER RESOURCES IN THIS WATERSHED

### Brief Watershed Description (Table 1 and Figures 1 and 2)

The Van Decar watershed flows down from Mt Sidney Williams with a maximum elevation of 1984m. It has a topography that is lightly mountainous to steeply mountainous with abundant exposed bedrock at the back end of the watershed. The watershed flows in a generally northeastern direction and empties directly into the Middle River (Figures 1 and 3).

The dominant biogeoclimatic zones in this watershed are the SBSwk3 and SBSdk at lower elevations and the ESSFmv3 at mid to higher elevations. Alpine Tundra (AT) can be found at the highest elevations of the watershed. About 76.5% of the watershed has slopes of 30% or less with 3.9% of the watershed having slopes greater than 60% (Table 1).

The lower reaches of Van Decar Creek flow through lacustrine soils and a large alluvial fan near its mouth (Figures 2, 4 and 5). All of the lower reaches are a Rosgen C4 stream type, and given the importance of the fish habitat there, this contributes very significantly to the sensitivity of this watershed (Table 7). As you go up into the watershed, the channel becomes steeper and more incised and thus gradually less sensitive (i.e. reaches 7, 8 and 9 are B4 types) (Table 7 and Figure 4).

### Key Elements that Make this Watershed Sensitive

#### *Sensitivity to Increased Peak Flows*

This watershed is considered to be sensitive to increased peak flows for the following reasons (Table 2):

1. Sensitive stream reach types in the lower parts of the watershed (C4)
2. Although much of the topography is rolling, there are extensive areas of steep topography in this watershed.
3. There are no lakes in the lower part of the watershed to buffer peak flows and the drainage density is relatively high.

4. Most of the soils are deep morainal tills, but much of the upper watershed has thin soils and exposed bedrock.
5. This is a relatively wet climate with deep snowpacks.
6. There is a large portion of the watershed that is within the same elevation band (43%).

#### *Sensitivity to Increased Delivery of Fine Sediments*

This watershed is considered to be very sensitive to erosion processes and delivery of fine sediments for the following reasons (Table 3):

1. The watershed has fish species that are very sensitive to disturbances and increases in fine sediments
2. The watershed has enough slopes and channel connectivity to effectively transport eroded sediments to the stream network.
3. The climate is wet with heavy spring snowmelt which can contribute to the effectiveness of surface erosion and downslope transport of fine sediments.
4. There is an abundance of highly erodible soils in the lower part of this watershed.

#### *Sensitivity to a Reduction in Riparian Function*

This watershed is considered to be sensitive to a reduction in riparian function for the following reasons (Table 4):

1. The watershed has fish species that are very sensitive to disturbances and loss of riparian function.
2. The stream channel types in this watershed are highly dependent on the recruitment of large woody debris to maintain stability and proper ecological functioning.

### **Risk Assessment for this Watershed**

#### *Risk associated with Potential Increases in Peak Flows*

The peak flow risks are considered Very Low because of the very low peak flow hazard in the watershed (HEDA = 6.7%, Table 5).

#### *Risk associated with Potential Increases in the Delivery of Fine Sediments to the Stream Network*

The fine sediment risks are considered as Low because there are very few stream crossings in this watershed and thus the hazard is Very Low (Table 6).

#### *Risk associated with a Reduction in Riparian Function*

The risks associated with a reduction in riparian function are Very Low because the riparian forest along the mainstem of Van Decar Creek have not been disturbed by land-use activities, i.e. the hazard is very low (Table 7).

### **Suggested Management Objectives and Strategic Directions for this Sensitive Watershed**

- 1) Maintain the peak flow risk in this watershed below a Moderate level (i.e. Low or Very Low). This means that the HEDA value for this watershed should be maintained below 18.9%, which would allow the harvesting of about 328 ha of healthy stands. Use the Peak Flow Risk Calculator to determine the maximum suggested harvest of different combinations of healthy stands and mountain pine beetle affected stands in order to maintain a peak flow risk level below moderate.
- 2) Minimize riparian disturbances within the riparian management zone (RMZ) located within the areas identified as having a “fluvial fan”, “Lacustrine” or “glacio-fluvial” surficial geology (Figure 2).
- 3) Maintain best management erosion and sediment control practices at any future stream crossing located over the mainstem river. In addition to being very important fish habitat at this location, the soils are easily erodible and could very easily be transported into Van Decar Creek. I suggest that the Water Quality Effectiveness Evaluation (WQEE) tool be used and that the WQEE rating be maintained below a moderate level (i.e. Low or Very Low). The most recent WQEE protocol can be found at the following web link: <http://www.for.gov.bc.ca/ftp/hfp/external!/publish/frep/indicators/Indicators-WaterQuality-Protocol-2009.pdf>
- 4) For all S4 streams wider than 0.5 m, maintain long term large woody debris (LWD) recruitment to the stream channel by retaining at least 90% of the riparian area in a state undisturbed by primary forest activities. Note that the riparian area refers to the management area measured from the closest streambank to a distance 15m upslope from the streambank.

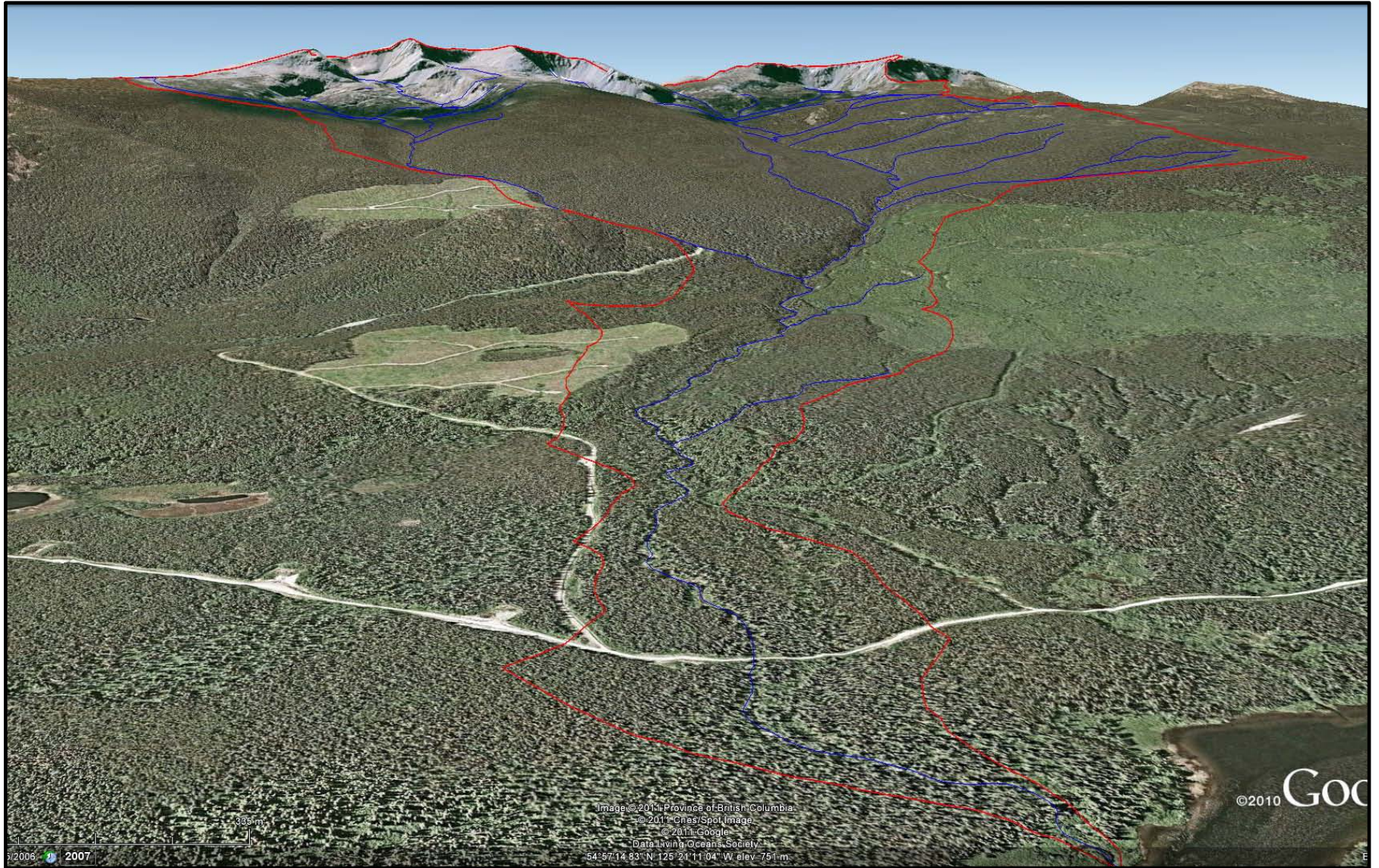


Figure 1. Google earth overview image of Van Decar Creek watershed, looking upstream into the watershed.

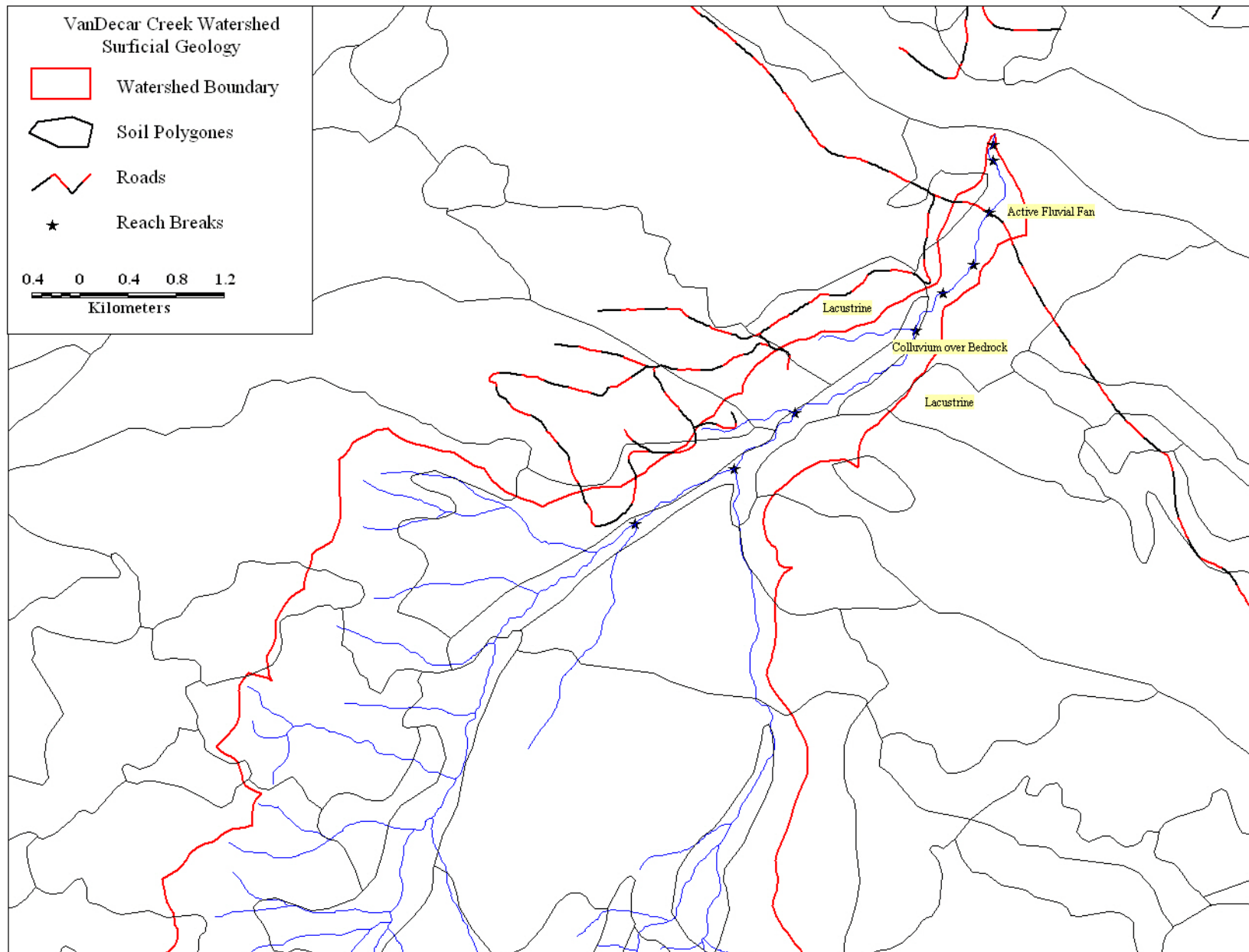


Figure 2. Distribution of surficial geology types near the mouth of Van Decar Creek.

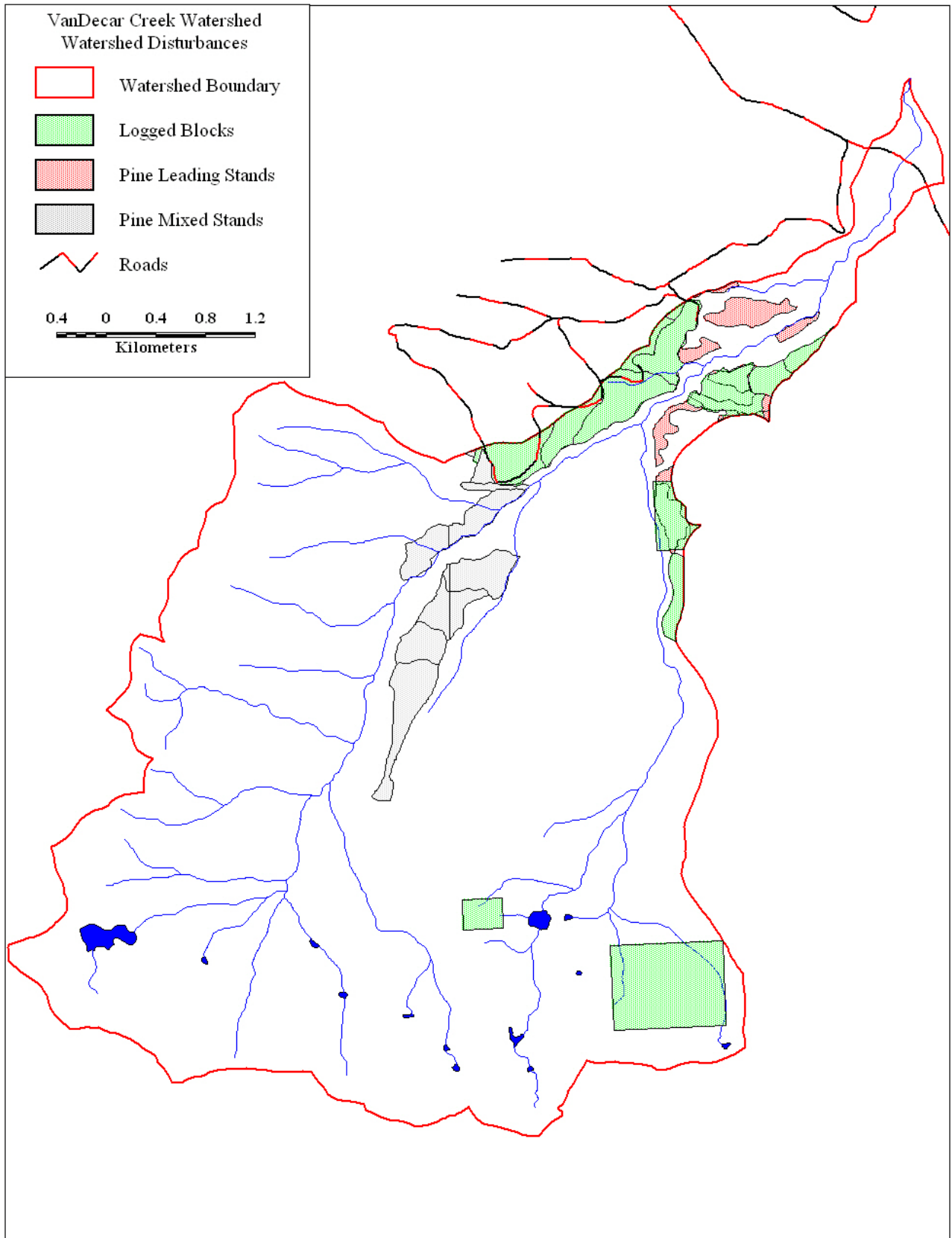


Figure 3. Land-use related and large natural disturbances in the Van Decar Creek Watershed

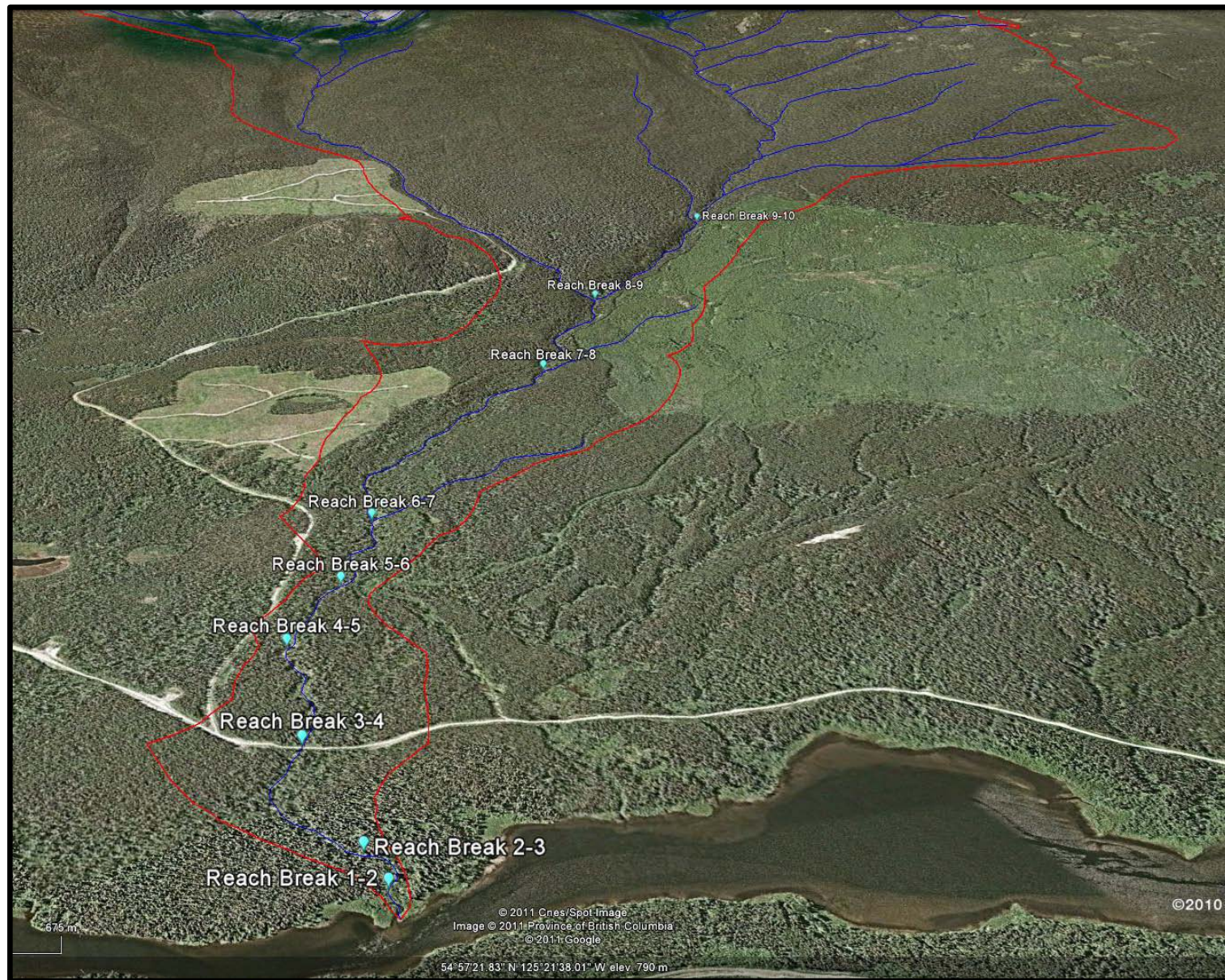


Figure 4. Identification of reach breaks along the mainstem of the lower Van Decar Creek watershed



Figure 5. Google Earth image looking upstream along Reaches #1 and 2 of Van Decar Creek.



Figure 6. Google Earth image looking upstream along Reach #3 of Van Decar Creek.



Figure 7. Google Earth image looking upstream along Reaches #4, and 5 of Van Decar Creek.

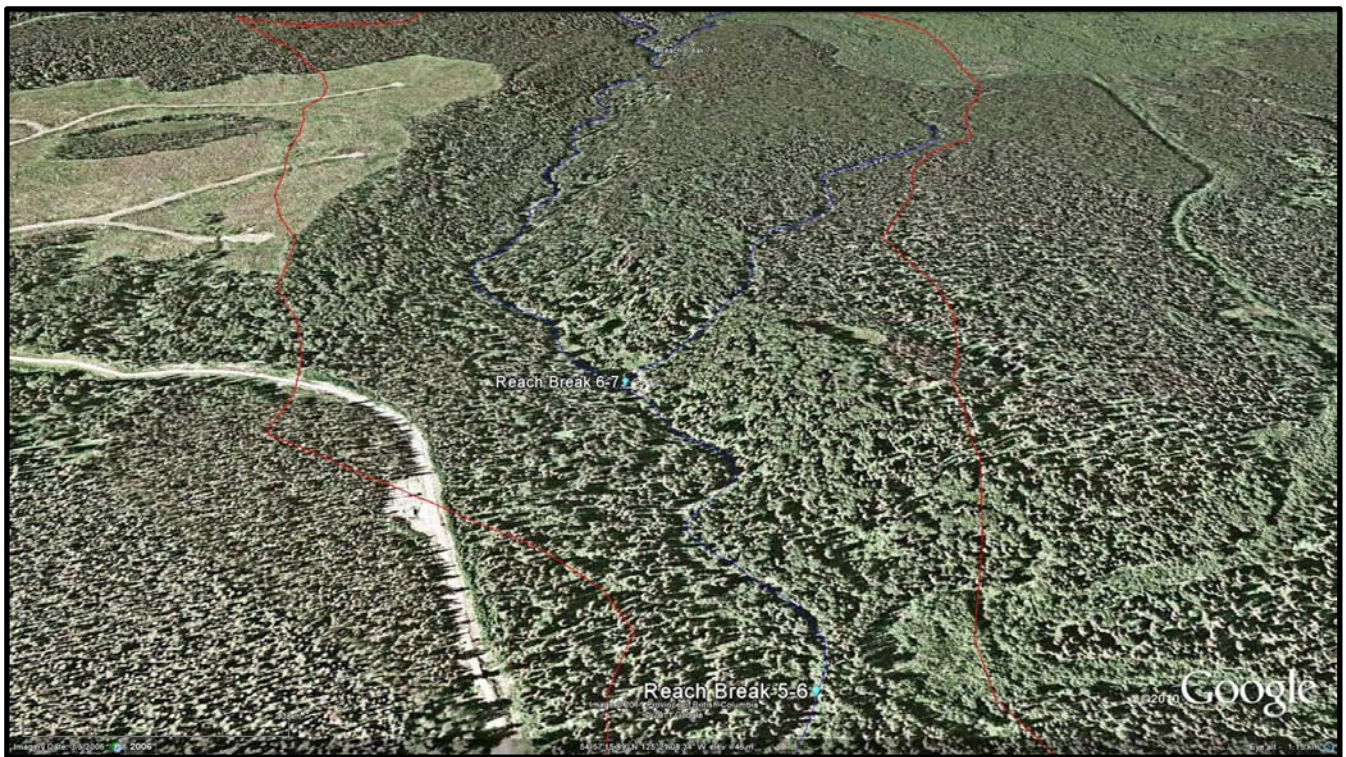


Figure 8. Google Earth image looking upstream along Reaches #6 and 7 of Van Decar Creek.