Forest Investment Account

Project #: 4376003

SHINGLE CREEK WATERSHED

Towards

Sustainable Forest Management

Prepared for

Gorman Bros. Lumber Ltd.

August 2004
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1. **INTRODUCTION**

Gorman Bros. Lumber Ltd. (Gormans) initiated the development of a Sustainable Forest Management (SFM) report for the Shingle Creek watershed that incorporates an assessment of watershed condition and past restoration sites, and identifies the opportunities for possible future restoration plans. The management unit includes the Shingle Creek, Riddle Creek, June Creek, and Skulaow Creek sub-basins (refer to Figure 1).

This SFM report integrates hydrologic, terrain stability, and fisheries overview assessments to establish the watershed condition. Through the integration of terrain and fisheries information with hydrology information, the focus moves from a hydrology-based report to one that incorporates three key non-timber components of the ecosystem: water, terrain, and fish.

The objectives of this report are as follows:

- Integrate the results of hydrology, geotechnical, and fisheries overview assessments into one report, based on the results of previous assessments (e.g. IWAPs, TSFAs, Fish Inventories, etc.) plus recent field investigations conducted in October 2003;
- Establish the watershed condition based on hazard levels for various disturbance indicators;
- Outline the fisheries and water supply values in the watershed;
- Conduct a risk assessment for future watershed condition;
- Review the status of past watershed restoration activities; and identify watershed restoration opportunities based on the watershed condition (i.e. hazard and risk levels).

Additionally, as part of the report, a map has been created that includes:

- Current watershed condition based on the integration of fisheries values, terrain sensitivity, and hydrologic sensitivity.
- Overview terrain zones, sub-basins, and reach breaks.
Figure 1
Location Map for the Shingle Creek Community Watershed
2. METHODS

This sustainable forest management report is a summary of overview assessments completed by hydrology, geotechnical, and fisheries specialists. The watershed hazard ratings assigned may vary from those reported in previous watershed reports because the current procedure is based primarily on professional judgement and field investigations with office analyses as supporting information.

Channel disturbance hazard ratings are not assigned in this report. The reason is that channel disturbance is a function of the management of peak flows, surface erosion, terrain stability, and riparian areas. Instead, a summary of the channel conditions is provided as part of the watershed condition. It should be noted that the surface erosion, riparian, and terrain stability hazard ratings assigned in sections 4.3 to 4.5 represent the likelihood of future forest development causing watershed disturbance based on current, conventional forest development practices. Alternative practices could lead to a higher or lower likelihood of disturbance and associated hazard ratings. For the peak flow hazard rating (section 4.2), conventional practices were not considered because there are no standards for equivalent clearcut areas (ECA). Instead, the probable response of each drainage to increasing levels of disturbance (ECAs) was considered in determining the hazard ratings.

The project involved the integration of hydrologic, terrain, and fisheries data provided by a team of professionals. A collaborative approach was taken from the onset, which included a pre-work meeting between Gormans, Columbia Environmental Consulting Ltd. (Columbia), Dobson Engineering Ltd. (Dobson) and Sitkum Consulting Ltd. (SCL) to establish report requirements and format. This report includes:

- an office review of work completed in the watershed,
- field investigations of selected sites in the watershed,
- an evaluation of the watershed hazards,
- an overview of the fisheries and domestic water supply values,
- a risk assessment, and
- review of past watershed restoration activities and existing restoration opportunities.

The field component included only ground investigations, and focused on areas of concern that had been identified in other reports and during office analyses.

This document is an integration of the analyses and interpretations of the geotechnical, fisheries, and hydrology specialists. The geotechnical specialist provided information for sections 3.2 and 4.5, and the fisheries specialist provided information for sections 3.3 and 6. The hydrology specialist provided information for sections 3.1, 4.1 through 4.4, and 5. Based on the watershed information provided by all three specialists, the geotechnical specialist prepared sections 7 to 9.
3. BACKGROUND INFORMATION

3.1 Hydrology

The Shingle Creek Community watershed drains from the Thompson Plateau on the west side of Okanagan Lake near Penticton, BC. The portion of the Shingle Creek watershed above the point of interest (POI) encompasses an area of approximately 8047ha. The area reviewed in this SFM report includes four sub-basins (Upper Shingle, June, Skulaow and Riddle) in the upper portion of the watershed. A search of Land and Water British Columbia’s (LWBC), Water Licence Data Query indicated a number of licences are present on Shingle Creek. The location of diversion points have been plotted on the Watershed Condition Map in Appendix D. Mean annual precipitation in the Penticton area is approximately 310mm. The mean annual flow in Shingle Creek is approximately 0.361m$^3$/s based on information provided by Environment Canada (Hydrometric Station: #08NM038).

The Shingle Creek Community watershed supports multiple land uses including rural infrastructure, agriculture, range, recreation, and forestry. Commercial timber harvesting has occurred in the watershed over the past 30 years, the dominant silvicultural system has been clearcutting in the even-aged lodgepole pine and Engelmann spruce/sub-alpine fir stands at higher elevations.

3.2 Geology

The study area encompasses the majority of the Shingle Creek Community watershed (point of interest at confluence of Shingle and Riddle Creeks) located west of Penticton, BC. The study area is physiographically set within the Thompson Plateau sub-unit of the Interior Plateau. Elevations range from near 820 m in the lower valley bottom at the to approximately 2200 m at the summit of Mt. Brent.

Bedrock geology is predominately composed of Nelson Plutonic Rocks which have been described by Tempelman-Kluit, 1985 as “massive, generally moderately foliated, medium grey weathering, medium- to coarse-grained, equigranular, hornblende-biotite granodiorite, quartz diorite and granite.” A limited area within the upper Riddle Creek watershed has been mapped as containing bedrock from the Kitley Lake Formation which, again Tempelman-Kluit describes as “massive yellowish to buff, trachyte to trachyandesite; plagioclase and biotite glomerophenocrysts to 3 cm (10% of the rock) in a finely crystalline groundmass.”

In general, the terrain is dominated by glacial till overlying bedrock. In upper slopes and ridge top positions, surficial materials are typically thinner and localized areas of bedrock exposures and colluvial deposits exist. Till veneers and till mantles of variable thickness overlying irregular bedrock
controlled terrain is typical in these upper slopes and ridge top positions. Thick till blankets on uniform to slightly irregular bedrock controlled slopes are most commonly encountered on the mid and lower slope positions within the study area. Valley bottoms often contain significant glaciofluvial deposits (terrace, erosional scarps, and plains) containing large amounts of sand and gravel as well as silt. Thick till blankets are also common in the valley bottoms adjacent to glaciofluvial deposits. Major tributaries to Shingle Creek, such as June Creek and Skuloaw Creek, and Riddle Creek become incised as they approach the lower valley positions. Gully erosion is an active geomorphological process in some locations where thick surficial materials remain on the steep sidewalls of these incised creeks.

### 3.3 Fisheries

Eight species of fish are present in the Shingle watershed. The lower reaches, downstream of the study area, are known to contain kokanee, adfluvial (lake-run) rainbow trout, resident rainbow trout, Eastern brook trout, and mountain whitefish. Non-sport fish in the system include largescale sucker, longnose dace, slimy sculpins, and peamouth chub (FISS 2004). New sockeye releases into Skaha Lake could result in sockeye spawning use in the lower reaches of Shingle Creek within the next 12 years.

Within the study area, Riddle, Deschamps, Shingle, Skuloaw, and June Creeks support a resident population of rainbow trout. No other sport fish or non-sport fish have been found. Road access is excellent throughout the year and a Shingle Creek stream fishery is known to be utilized by residents of the Penticton Indian Band for rainbow trout and kokanee. Within the study area no lake stocking occurs although Deschamps Lake, a headwater lake within the Riddle sub-basin, is known to support rainbow trout. The lake is surrounded by private land and is not managed by the Ministry of Water, Land, and Air Protection (FISS 2004). Deschamps Lake should still be considered of high value for biodiversity and conservation of wild stocks of rainbow trout. Historical fish sampling information in the study area shows 18.4 km of fish bearing streams, 42.0 km of non-fish streams, 69.8 km with unknown information, and 18.0 km of non-visible channel (NVC) drainages shown on TRIM.

Fish within the mainstems may move downstream to the lower reaches of Shingle Creek or the Okanagan River and Skaha Lake. Although there is road access at several points to the sub-basin mainstem reaches, typically fish are slow growing and are less than 200 mm long (WSR 1996, Shanner 1997). There is a known kids sport fishery on Shingle Creek and a historical First Nations fishery for Kokanee and rainbow trout in the lower reaches of Shingle Creek.

The study area is within a dry biogeoclimatic zones (ESSF, MS, IDF) with extensive grassland/bunchgrass areas. Field observations revealed that many TRIM streams did not exist and several tributaries to the mainstem...
flow down steep slopes that prevent fish access and do not provide suitable fish habitat. However, the low gradient tributaries to the mainstem reaches in the study area have no known information and may have fish presence.

4. **HAZARD ASSESSMENT**

The current watershed condition summary table is presented in Appendix A. The 2003 summary table includes all forest development completed up to and including December 31, 2003. Field photos are presented in Appendix B and the watershed condition and terrain stability maps are in Appendix C.

Please refer to the Methods section for an overview of the hazard evaluation procedure. Further clarification is in Table 13 of section 7.

4.1 **Channel Disturbance**

4.1.1 **Shingle Creek Sub-basin**

The channel network in the Shingle Creek sub-basin consists of three major third-order streams (Shingle, Skulaow, and June Creeks), which all join together within ~2km of channel upstream from the point of interest (POI). June and Skulaow Creeks are both generally stable and highly robust, but Shingle Creek is slightly to moderately disturbed in sections due to past forest development, activities on private lands, and recent livestock activity on both Crown and private lands.

4.1.1.1 **June Creek Drainage**

June Creek is generally stable and moderately robust in the lower reaches. The bed and banks are dominated by boulder and cobble substrate. Stones lines are intact, moss was observed on some rocks, and minor gravel deposits are distributed along the channel indicating that sediment transport rates are likely low to moderate. Minor, localized bank erosion was evident, but may be within natural levels that occur during spring freshet. A channel avulsion was observed along an old private road adjacent to June Creek at site 10. The gravel material has eroded leaving the road surface dominated by cobble and boulder substrate. The secondary channel appears inactive as indicated by scattered debris and vegetation established on the surface. The headwaters of June Creek were not reviewed in the field, but are assumed to be stable and robust due to the lack of development in the drainage and the stability observed in the lower reaches of June Creek (site 10, photo 1) and in the adjacent headwaters of the Skulaow drainage.
The June Creek headwaters are almost certainly boulder dominated and highly robust based on the ~15% channel gradient.

4.1.1.2 Skulaow Creek Drainage

Skulaow Creek is stable, undisturbed, and highly robust (site 6). The bed and banks are dominated by boulder material. Logs and boulders form steps and cascades in the channel with extensive pools, and moss was observed throughout the channel. The drainage is deeply incised within a canyon with mature riparian vegetation. The channel gradient ranges between 15 and 20%.

4.1.1.3 Shingle Creek Mainstem

Shingle Creek forms the mainstem channel in the sub-basin with June and Skulaow Creeks being tributaries to Shingle. The mainstem is slightly to moderately disturbed throughout due to past forest development, private land activities, and recent livestock activity on both Crown and private lands. The observed channel disturbance includes scoured banks, minor to moderate channel aggradation, homogeneous bed texture, and parallel alignment of large wood. Forest development impacts include extensive historical riparian harvesting in the middle and upper reaches and probable historical peak flow impacts. A large portion of the drainage area upstream from the Skulaow Creek confluence has been harvested to the stream edge. The local drainage ECA has been moderate (approximately 30% ECAs) for the last 15 years (Table 1). Extensive riparian harvesting has occurred on private lands throughout the lower reaches with possible stream cleaning at site 4 (photo 3).

Livestock impacts were observed throughout mainstem reaches and range from minor to severe, particularly through the lower reaches (site 11, photo 4). At present, livestock activity is the greatest source of watershed disturbance as access to the mainstem channel is abundant and most channel crossings experience chronic trampling.

Overall, Shingle Creek is slightly to moderately robust throughout with localized sections of channel sensitivity. The channel morphology is primarily cascade-pool cobble in the upper and middle reaches and riffle-pool
gravel/cobble in the lower reaches. Large wood abundance is limited due to a lack of recruitment and stream cleaning.

4.1.2 Riddle Creek Sub-basin

Riddle Creek is slightly to moderately aggraded at selected locations in the middle and lower reaches. The disturbance is primarily related to historical riparian harvesting (sites 2 and 8) and stream cleaning (site 8) on private lands, and subsequent livestock impacts. Large wood abundance is limited with buried pieces and the channel lacks complexity. Moss was observed on rocks indicating that sediment transport rates are moderate at most. The channel morphology is generally riffle-pool cobble/gravel and slightly to moderately robust. The sections of channel reviewed in the middle and lower reaches are on private lands. It is expected that channel sections on Crown land without riparian harvesting and stream cleaning are likely stable and robust with natural levels of complexity.

Although the headwaters were not reviewed due to limited access, the channels are likely stable and robust based on the limited development, the overall gentle terrain, and the average channel gradient ranging between 5 and 20%.

4.2 Peak Flows

Historical peak flow related channel disturbance may have been observed in the Shingle Creek watershed during the June 2004 field investigations. The current ECA is low for the Shingle and Riddle sub-basins and low for the Upper Shingle Creek Community watershed as a whole (Table 1); however, ECAs from the mid 1980’s to the present are considered to be moderate to high in the local Shingle Creek drainage upstream from the Skulaow Creek confluence.
TABLE 1
ECAs for the Shingle Creek Community watershed.

<table>
<thead>
<tr>
<th>Drainage</th>
<th>Dec 31, 1988 Equivalent Clearcut Area (%)</th>
<th>Current (Dec 31, 2003) Equivalent Clearcut Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shingle</td>
<td>15.7</td>
<td>18.4</td>
</tr>
<tr>
<td>- Upper Shingle</td>
<td>28.4</td>
<td>30.4</td>
</tr>
<tr>
<td>Riddle</td>
<td>14.4</td>
<td>9.6</td>
</tr>
<tr>
<td>Watershed</td>
<td>12.4</td>
<td>10.8</td>
</tr>
</tbody>
</table>

1. This area comprises the northern portion of the Shingle sub-basin with its POI located above the confluence of Skulaow Creek and does not include Skulaow and June Creeks sub-basins.

- The growth of trees is modeled using Variable Density Yield Predictor (VDYP) and site index values.
- Site index values were updated using the BC Ministry of Forest's Site Index estimates by Site Series (SIBEC) - Second Approximation published in 2003.
- All stands ≥12m in height are considered to be fully recovered, hydrologically, and have been excluded from the ECA calculations.

4.2.1  Shingle Creek Sub-basin

June and Skulaow Creeks are moderately to highly robust and generally stable along their entire lengths. In isolation, these two drainages are able to withstand large peak flow increases; however, Shingle Creek mainstem is only slightly to moderately robust with sections of localized channel sensitivity to peak flows. June and Skulaow Creeks are tributary to Shingle Creek. As elevated peak flows from headwater drainages transfer downstream and increase the potential for downstream impacts, the limiting factor in terms of peak flow sensitivity for the Shingle Creek sub-basin as a whole is the Shingle Creek mainstem. Based on the slightly robust morphology of the Shingle Creek mainstem combined with localized sections of channel sensitivity, the peak flow hazard for future development is considered moderate for the entire Shingle Creek sub-basin.

4.2.2  Riddle Creek Sub-basin

Riddle Creek has been disturbed by riparian harvesting, stream cleaning, and livestock impacts. However, the channel is slightly to moderately robust to peak flows with cobble/gravel substrate. Because of these factors, the peak flow hazard is considered low to moderate for future development in the Riddle Creek sub-basin.
4.3 Surface Erosion

For the most part, the soils throughout the Shingle and Riddle sub-basins are easily suspended and transported, as the material types are generally dominated by fine sands and silts. Most road sections throughout the watershed are stable and well maintained, and the deactivation of roads has helped to curtail surface erosion. Several erosion sites were observed during the June 2004 field review (sites 1 and 7); however, connection to channels is generally low except at locations with livestock impacts.

Numerous channel crossings exist in the study area. With the fine textured nature of the local soils (silts and sands) coupled with the occurrence of range use (primarily cattle grazing) in the watershed, surface erosion is chronic and surface erosion related sediment deposition was observed at several crossings during the field review (sites 7 and 11).

Overall, for the Shingle and Riddle sub-basins, the surface erosion hazard for future development is moderate. Exceptions to this are areas in close proximity to the channel system, particularly terrain units 1, 5, 7, 10, 14, 18, 19, 22, 26, and 30. In these areas, the potential for surface erosion related channel disturbance is considered moderate to high due to the presence of glaciofluvial materials in areas of imperfect drainage close to channels.

4.4 Riparian

Riparian harvesting has occurred adjacent to a large portion of the Shingle Creek mainstem and has caused extensive channel impacts. Past forest development related riparian harvesting has caused channel impacts through the middle reaches. These riparian areas and associated channel disturbance are now recovering. Riparian areas have also been harvested on private lands through the lower reaches. Recovery of these riparian areas is limited. With riparian harvesting, livestock access to channels has increased, thereby, leading to subsequent extensive livestock impacts that are considered severe in several locations (sites 7 and 11). Riparian impacts along Skulaow and June Creeks are minimal.

Riparian impacts have also occurred along the Riddle Creek mainstem on private lands with sections of channel having instream wood removed (site 8). Stream cleaning increases sediment transport rates and flow velocities leading to reduced channel stability and complexity. Overall, the impacts to Riddle Creek are localized.

Not withstanding the past and present impacts of riparian harvesting in the watershed, the likelihood of riparian harvesting related watershed disturbance caused by future forest development is low given the current standards for riparian management practices. The riparian hazard ratings are considered low for the Shingle and Riddle sub-basins.
4.5 Terrain Stability

This section presents terrain stability and soil erodibility information for 30 terrain units within the study area. This information is more detailed than is necessary for this overview level SFM report, but is provided as additional information. The soil erodibility ratings represent the erodibility of the soils in the terrain unit and not the potential for surface erosion to cause channel disturbance (refer to Table 13). For the purposes of this overview level report, the basin level surface erosion hazards discussed in section 4.3 are used in the risk assessment (section 7) and represent the potential for surface erosion related channel impacts.

Information presented in this report is of an overview nature and exceptions are to be expected. The recommendations are intended to reduce the risk of terrain instability related to road construction and timber harvesting, but do not eliminate those risks entirely. This report is prepared in accordance with generally accepted engineering practices in this area. No other warranty, express or implied is made.

Assessments of soils and slope stability are based primarily on air photo interpretation of surface features. Subsurface and bedrock conditions have been inferred from limited, isolated exposures. Variability is inherent in geological features, and actual ground conditions may differ from those inferred.

4.5.1 Methods and Definitions

A map of terrain hazard polygons was created using a combination of air photo and topographical map interpretation. The terrain hazard polygons were first delineated on 1:30,000 scale color air photos (2001) and then hand transferred onto a 1:20,000 scale TRIM base map with 20m contour intervals. In addition, 1:15,000 scale color air photos (1996) were used in some areas to see greater detail. The base map had a light background layer of the orthophotos as well as proposed roads and cutblocks from the FDP visible to aid in hand transferring and interpretation. The Forest Development Plan (FDP) Map (Gorman Bros. Lumber Ltd. 2003, 1:30,000) and FDP Major Amendment (June 2004), as well as relevant Watershed Assessment reports and Soil Erosion Hazard Assessments were also referred to throughout the mapping process. The hand drafted polygons on the 1:20,000 base maps were then digitized by Dobson to create the final terrain hazard map.

Terrain hazard polygons were delineated based on a broad range of qualitative criteria. These criteria included:

- Likelihood of instability following conventional forest harvesting and road building practices;
- Surface erosion potential following conventional forest harvesting and road building practices;
- Significant “gentle over steep” scenarios; and
- Potential impact of erosion and/or instabilities on water courses.

Due to the generalized nature of this mapping, most polygons include significant exceptions and ranges of ratings with regards to these criteria. Polygons were delineated across the landscape and across watershed boundaries without necessarily forming a break. The watershed boundaries do, however, represent a split in the polygon for management reasons. In order to avoid overly small polygons along the watershed boundaries as a result of this management split, a minimum polygon size of roughly 15 ha was used. This results in polygon boundaries following the watershed boundaries in various locations where the natural terrain unit boundary may be better represented by a small deviation for the watershed boundary. Given the detail and purpose of the mapping this is considered appropriate.

The overall terrain hazard rating for each polygon is based on the likelihood of instability following conventional forest harvesting and road building practices rating within the polygon. Where a range of likelihoods exist within one polygon, the dominant likelihood is given as the overall hazard rating for the polygon. This rating may not reflect the highest likelihood of instability within the polygon. To insure significant variances within the polygon are identified, exceptions (higher or lower hazard) have been included in the descriptive paragraph for that specific polygon.

Generalized criteria for the terrain and soil erosion hazard ratings as well as hazard interpretation or management implications are presented in Tables 1 to 6. The generalized criteria listed within these tables are not an exhaustive breakdown of the criteria as many factors contribute to these ratings, but the lists do provide a generalized summary of the typical examples. These criteria take in to account the dry climate regime of the study area.
**TABLE 2**
Terrain stability hazard rating definitions.

<table>
<thead>
<tr>
<th>Terrain Hazard Rating</th>
<th>Generalized Criteria</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negligible</td>
<td>Flat gradient terrain (e.g. valley bottom flood plains or glaciofluvial plains)</td>
<td>No significant stability problems exist or would be expected to develop post timber harvesting or road construction.</td>
</tr>
<tr>
<td>Very Low</td>
<td>Uniform gentle gradient terrain.</td>
<td>There is a very low likelihood of landslides following timber harvesting or road construction.</td>
</tr>
<tr>
<td></td>
<td>Irregular, rock controlled, gentle to moderate gradient terrain.</td>
<td>Minor slumping is expected along road cuts, especially for 1 or 2 years following construction.</td>
</tr>
<tr>
<td>Low</td>
<td>Generally uniform, moderate gradient terrain.</td>
<td>Minor stability problems can develop.</td>
</tr>
<tr>
<td></td>
<td>Generally moderate gradient terrain with occasional gullies.</td>
<td>Timber harvesting should not significantly reduce terrain stability.</td>
</tr>
<tr>
<td></td>
<td>Generally moderately steep, irregular, rock controlled terrain.</td>
<td>There is a low likelihood of landslide initiation following timber harvesting.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minor slumping is expected along road cuts, especially for 1 or 2 years following construction. There is a low likelihood of landslide initiation following road construction.</td>
</tr>
<tr>
<td>Moderate</td>
<td>Typically moderately steep or steeper, uniform slopes.</td>
<td>Expected to contain areas with a moderate likelihood of landslide initiation following timber harvesting or road construction.</td>
</tr>
<tr>
<td></td>
<td>Typically moderate and steeper terrain with frequent gullies.</td>
<td>Old, fully revegetated failure scars may be present.</td>
</tr>
<tr>
<td></td>
<td>Steep, rocky, irregular slopes.</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Any terrain showing indications of active natural instabilities.</td>
<td>Expected to contain areas with a high likelihood of landslide initiation following timber harvesting or road construction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Natural instabilities likely present.</td>
</tr>
</tbody>
</table>

* Modified from the *Mapping and Assessing Terrain Stability Guidebook, 2nd ed., 1999*
### TABLE 3
Soil erodibility definitions.

<table>
<thead>
<tr>
<th>Rating</th>
<th>Generalized Criteria</th>
<th>Management Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very low</strong></td>
<td>• Very coarse textured materials (ex. talus; typically &gt;80% coarse fragments) and competent bedrock.</td>
<td>No or only very minor surface erosion expected.</td>
</tr>
<tr>
<td></td>
<td>• Well to rapidly drained soils.</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>• Thin, medium to coarse textured soils (generally &gt;50% coarse fragments) on irregular slopes.</td>
<td>Expect minor erosion of fines in ditch lines and disturbed soils.</td>
</tr>
<tr>
<td></td>
<td>• Flat to gentle gradient slopes.</td>
<td>Localized problems may develop.宜地措施应被采取来minimize erosion where the sediment delivery potential is high.</td>
</tr>
<tr>
<td></td>
<td>• Moderate to rapidly drained soils.</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>• Thin to thick, medium textured soils (generally 20 to 80% coarse fragments) on gentle to moderately steep gradient slopes.</td>
<td>Expect moderate erosion when water is channeled down road surfaces or ditches.</td>
</tr>
<tr>
<td></td>
<td>• Gentle gradient, well drained, gravelly sandy soils.</td>
<td>Significant problems may develop on a site specific basis. 宜地措施应被采取来minimize erosion where the sediment delivery potential is high.</td>
</tr>
<tr>
<td></td>
<td>• Moderate to well drained soils.</td>
<td>Appropriate harvesting methods should be used to avoid considerable soil disturbance and concentration/redirection of runoff.</td>
</tr>
<tr>
<td>High</td>
<td>• Loose sandy soils (generally &lt;50% coarse fragments)</td>
<td>Significant erosion problems can be created when water is channeled onto or over exposed soil on these sites.</td>
</tr>
<tr>
<td></td>
<td>• Imperfectly drained areas otherwise typical of Moderate hazard ratings.</td>
<td>Appropriate harvesting methods should be used to minimize soil disturbance and concentration/redirection of runoff.</td>
</tr>
<tr>
<td></td>
<td>• Thick material deposits with moderately steep or steeper gradient slopes.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Gullied terrain.</td>
<td></td>
</tr>
<tr>
<td>Very high</td>
<td>• Fine textured or sandy (generally &lt;20% coarse fragments), moderately steep or steeper gradient, imperfectly or poorly drained deposits of thick materials (gullies may be present).</td>
<td>Severe surface and gully erosion problems can be created when water is channeled onto or over these sites.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Appropriate harvesting methods should be used to avoid any significant soil disturbance and concentration/redirection of runoff.</td>
</tr>
</tbody>
</table>

* Modified from the *Mapping and Assessing Terrain Stability Guidebook, 2nd ed., 1999* and *Soil erosion hazard criteria for watershed assessments in the Southern Interior; Final report (BCMof, NFR 2000)*
Tables 4 to 6 present definitions for some of the descriptive terms used throughout the terrain stability section relating to soil and slope properties.

**TABLE 4**
Surficial material thickness.

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Surficial Material Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blanket</td>
<td>&gt; 1.0 m thick</td>
</tr>
<tr>
<td>Veneer</td>
<td>&lt; 1.0 thick</td>
</tr>
</tbody>
</table>

**TABLE 5**
Slope gradient.

<table>
<thead>
<tr>
<th>Slope Gradient</th>
<th>Percent (%) Range</th>
<th>Degree Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>&lt;5</td>
<td></td>
</tr>
<tr>
<td>Gentle</td>
<td>5-26</td>
<td>4-15</td>
</tr>
<tr>
<td>Moderate</td>
<td>26-50</td>
<td>16-26</td>
</tr>
<tr>
<td>Moderately Steep</td>
<td>50-70</td>
<td>27-35</td>
</tr>
<tr>
<td>Steep</td>
<td>70-90</td>
<td>35-42</td>
</tr>
<tr>
<td>Very Steep</td>
<td>90</td>
<td>&gt; 42</td>
</tr>
</tbody>
</table>

**TABLE 6**
Surface configuration\(^1\) (modified):

<table>
<thead>
<tr>
<th>Surface Configuration</th>
<th>Relief (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform</td>
<td>&lt;1.0</td>
</tr>
<tr>
<td>Slightly Irregular</td>
<td>1.0 – 2.0</td>
</tr>
<tr>
<td>Irregular</td>
<td>2.0 – 4.0</td>
</tr>
<tr>
<td>Very Irregular</td>
<td>&gt;4.0</td>
</tr>
</tbody>
</table>


In addition to the above descriptive terms, slope shape is based on the overall shape of the slope between distinct slope breaks and includes concave, convex, straight, and benched shapes (Ministry of Environment 1998).

There are a number of limitations which may affect the accuracy or reliability of the hazard mapping. These limitations include: the scale and quality of the air photos; the complexity of the terrain and surficial materials; the type and density of the vegetation; the
skill and experience of the mapper; the extent of field checking; and the quality of the TRIM maps.

The air photos were generally of good quality. Some photos had a dull haze in the center; however, this did not affect the mapping for this project. The photo scale at 1:30,000 was appropriate for the level of detail being mapped.

The terrain and surficial materials present in the study are typical for the region. Vegetation coverage is also typical for the region and did not present any extra limitations beyond the norm.

The mapper has considerable experience in air photo interpretation throughout the Okanagan region. No field checking by the mapper was completed for this project. One day of field review was completed by the project supervisor. It should be noted; however, that the mapper has spent over 40 days field checking for a variety of other projects throughout the Okanagan area (including stability mapping in adjacent watersheds) in previous years and, as a result, is familiar with the terrain.

The polygons delineated on the air photos were subsequently hand transferred onto the 1:20,000 TRIM base maps. The quality of the TRIM (accuracy of elevation contours, water features, etc.) has a direct affect on the special accuracy of the transferred line work. Given the level of detail being mapped for this project, this method of polygon transferring is considered satisfactory.

The following references were used in the completion of the terrain stability component of this project:

- TRIM maps, 1:20,000.
- Map 1736A, Geology, Penticton, mapped by Tempelman-Kluit, 1:250,000.
- Soils of the Penticton Map Area 82E, Summerland BC. Department of Energy, Mines and Resources 1976, 1:50,000.
- Terrain Stability Map at TSIL C 1:20 000 completed by AGRA, 1998-99.
- 1:50,000 topographic map.
- Lower Trout Creek; Developing a Sustainable Forest Management Report.
- Ecosystem Restoration Plans, FIA Activity Standards document.
4.5.2 **Shingle North – terrain unit 1**

The dominant surficial material in this valley bottom polygon is glaciofluvial in the form of thick terraces and undulating deposits. Slopes gradient are typically gentle to moderate, with moderately steep gradient slopes along the erosional scarp commonly present above the valley bottom flood plain. Two relatively recent slump scars (likely less than 100 years) and other small slides and erosional scours exist along these erosional scarps.

A significant portion of this polygon is within private land, much of which is cleared. Existing roads are also located within this polygon. No future forest development is proposed.

The likelihood of instability generally ranges from negligible to moderate, with very low and low being dominant. Isolated areas of high exist where natural instabilities are evident. The areas of moderate exist along the moderately steep gradient erosional scarp of thick glaciofluvial materials. The soil erosion potential for the polygon ranges from generally moderate to high due to the likely loose sandy soils in the lower slope position. It is likely that sediment resulting from a landslide or soil erosion initiating within this polygon would directly impact Shingle Creek or a significant tributary.

A “gentle over steep” scenario exists on the terraces above the steeper erosional scarps. Extra precautions should be taken in this area during harvesting or road building to avoid the concentration and redirection of runoff onto the steeper slopes below.

The overall terrain hazard rating for Shingle Lower is moderate.

4.5.3 **Shingle Lower North Slope – terrain unit 2**

This polygon consists of moderate to moderately steep gradient terrain ranging from a lower to upper slope position. The dominant surficial material is till, ranging in thickness from a blanket to a veneer and lesser amounts of colluvial materials exist on the steeper sections of the mid to upper slope positions. No existing failures were identified in this polygon.

There is no existing or proposed forest development within this polygon.

The likelihood of instability is dominantly low with isolated sections of moderate where the slope gradients are steepest. The soil erosion potential is generally moderate. It is possible that sediment derived from a landslide or soil erosion initiating within this polygon to directly impact a small tributary to Shingle Creek.
The overall terrain hazard rating for Shingle Lower North Slope is low.

4.5.4 Shingle Mid—terrain unit 3

This polygon consists of moderate to moderately steep gradient terrain from a valley bottom to ridge top slope position. The dominant surficial material is till, ranging in thickness from a blanket to a veneer and lesser amounts of colluvial materials exist on the steeper sections. Tree coverage is sparse on south aspect convex areas within the polygon. No existing failures were identified in this polygon.

Some existing roads and cutblocks are located within this polygon and one additional cutblock is proposed near the south west end of the polygon.

The likelihood of instability is low with isolated areas of moderate where slope gradients are steepest. The soil erosion potential is generally moderate. It is possible that sediment resulting from a landslide or soil erosion initiating within this polygon could directly impact either June Creek or Skulaow Creek which are major tributaries to Shingle Creek.

The overall terrain hazard rating for Shingle Mid is low.

4.5.5 June South Ridge—terrain unit 4

The terrain in this ridge top polygon is generally irregular and rock controlled. Slope gradients are dominantly gentle with some short moderate gradient slopes. Surficial materials generally consist of till veneers and lesser blankets with occasional rock outcrops. No existing failures were identified in this polygon.

There is no existing or proposed forest development within this polygon.

The likelihood of instability is dominantly very low. The soil erosion potential ranges from low on the most irregular terrain where soils are thin to moderate on the more uniform sloping terrain with thicker till deposits. It is unlikely for sediment from soil erosion to directly impact June Creek or any of its tributaries.

The overall terrain hazard rating for June South Ridge is very low.
4.5.6 June South Fork – terrain unit 5

This polygon ranges from valley bottom to an upper slope position, though is mostly situated in the mid-slope position. Slope gradients are generally moderate with some moderately steep gradient slopes in the south west of the polygon. The slope configuration is typically uniform. A till blanket overlies bedrock for the majority of this polygon, and some glaciofluvial materials are located along the valley bottom. No existing failures are evident in this polygon. Some gullying is evident on the moderately steep gradient slopes in the south west of the polygon.

No existing or proposed forest development is located in this polygon.

The likelihood of instability ranges from very low to low, with isolated areas of moderate in the south west. The soil erosion potential is generally moderate with areas of high where glaciofluvial materials are located in the valley bottom and where imperfectly drained soils exist. It is likely that sediment resulting from either erosion or a landslide would directly impact June Creek or its south fork tributary.

The overall terrain hazard rating for June South Fork is low.

4.5.7 June South Upper – terrain unit 6

The polygon consists of gentle to moderate gradient, with slightly irregular to irregular slopes in the mid to upper slope position. The surficial material is typically till ranging in thickness from a blanket to a veneer. No existing failures were identified within the polygon.

There is both existing and proposed forest development located in this polygon.

The likelihood of instability ranges from very low to low. The soil erosion potential is generally moderate. It is likely that sediment resulting from either erosion or a landslide would directly impact a minor tributary to June Creek.

The overall terrain hazard rating for June South Upper is very low.

4.5.8 June Main - terrain unit #7

The terrain is generally gentle gradient with uniform slopes overlain by a blanket of till and areas of thick glaciofluvial deposits with short moderate to moderately steep gradient slopes along the scarps near the valley bottom. Some small debris slides are likely present along the glaciofluvial scarps along June Creek.
Both existing and proposed roads and cutblocks are located within this polygon.

The likelihood of instability is generally very low with a range of low to high along the glaciofluvial scarps. The soil erosion potential is moderate with significant areas of high where moisture is concentrated and glaciofluvial materials are located. It is likely that sediment from erosion or landslides would directly impact June Creek.

There is a “gentle over steep” scenario that results from the short moderately steep gradient scarps directly adjacent to June Creek with gentle gradient slopes above. Extra precautions should be taken during any forest development in this area not to concentrate or redirect runoff onto the short steeper slopes directly adjacent to June Creek.

The overall terrain hazard rating for this polygon is very low.

4.5.9 June / Mt. Brent - terrain unit #8

The surface configuration is generally uniform in this high elevation, concave shaped polygon. Slope gradients are typically gentle, and surficial materials are till blankets with pockets of non forested organic blankets. There are no existing failures within this polygon.

No existing or proposed forest development is proposed for this polygon.

The likelihood of instability ranges from negligible to very low. The soil erosion potential ranges from low to moderate. It is likely that sediment from landslides or soil erosion would directly impact the upper reach of June Creek.

The overall terrain hazard rating for June / Mt. Brent is very low.

4.5.10 Mt. Brent - terrain unit #9

This polygon is in the upper slope to ridge top position and is sparsely or non-treed alpine above approximately 2040 m elevation. Slope gradients are dominantly moderate with lesser areas of gentle and moderately steep gradient slopes. The dominant surficial material within this polygon is a till blanket to veneer with areas of colluvium and occasional bedrock outcroppings in the alpine. There are no existing failures within this polygon; however, soil creep and solifluction are likely active processes in the alpine environment. No existing or proposed forest development is proposed for this polygon.
The likelihood of instability is very low to low. The soil erosion potential is generally low to moderate. It is unlikely that sediment originating from soil erosion or a landslide would directly impact June Creek, Skulaow Creek, or any minor tributaries.

The overall terrain hazard rating for Mt. Brent is low.

4.5.11 Skulaow Upper - terrain unit #10

The surface configuration is generally uniform in this mid-slope position polygon which is generally concave. Slope gradients are typically gentle to moderate. A till blanket is the dominant surficial material although areas of glaciofluvial are located along the creeks. A small relatively recent (likely <20yrs) landslide as well as other older revegetated slump scars are evident on the glaciofluvial scarps along Skuloaw Creek in the south west of the polygon. No other signs of instability are evident.

There are some existing roads and cutblocks within this polygon and some additional forest development is proposed.

The likelihood of instability ranges from very low to low with isolated areas of high along the thick material scarps adjacent to Skuloaw Creek in the south west of the polygon. The soil erosion potential is generally high in the concave areas where drainage is concentrated and where glaciofluvial materials exist, and moderate on adjacent slopes within the polygon. It is likely that sediment from landslides or soil erosion would directly impact an upper tributary to Skuloaw Creek.

The overall terrain hazard rating for Skulaow Upper is low.

4.5.12 Mt. Brent North Ridge Top - terrain unit #11

A till veneer to blanket overlies the majority of this ridge top polygon. Slope gradients are typically gentle with lesser areas of moderate. There are no existing failures located within this polygon.

There is no existing or proposed forest development in this polygon.

The likelihood of instability is generally negligible to very low. The soil erosion potential is generally moderate. It is unlikely for sediment from landslides or erosion to directly impact any tributary creeks.

The overall terrain hazard rating for Mt. Brent North Ridge Top is very low.
4.5.13 **Mt. Brent North North East Slope - terrain unit #12**

A till blanket with some till veneers overlie the majority of this typically uniform, mid-slope position polygon. Slope gradients are generally moderate with minor areas of moderately steep gradient slopes. There are no existing failures located within this polygon.

There is no existing or proposed forest development in this polygon.

The likelihood of instability is generally low. The soil erosion potential is moderate. It is possible for sediment from landslides or erosion to directly impact a minor tributary to Skuloaw Creek in the north west half of the polygon.

The overall terrain hazard rating for Mt. Brent North East Slope is low.

4.5.14 **Shingle Upper - terrain unit #13**

The terrain in this mid slope to ridge top polygon is generally irregular and rock controlled. Slope gradients range from gentle to moderate. Surficial materials consist of till veneers and blankets with occasional rock outcrops. There are no existing failures.

There is some existing as well as future proposed forest development within this polygon.

The likelihood of instability is generally very low to low. The soil erosion potential is generally moderate. Areas of low soil erosion potential exist where terrain is bedrock controlled and thin soils dominate. Isolated areas of high soil erosion can be found near creeks where soils are thicker and drainage is concentrated. It is likely for sediment from erosion or landslides to directly impact Shingle Creek or a minor tributary in most areas of the polygon.

The overall terrain hazard rating for Shingle Upper is very low.

4.5.15 **Shingle Main - terrain unit #14**

The slope gradients of this large polygon are dominantly gentle. The surficial material is mostly a till blanket, though significant areas of glaciofluvial materials also exist often overlying the till. There are no existing failures.

There are extensive previously harvested areas with associated roads, and some additional forest development is proposed.

The likelihood of instability is negligible to very low. The soil erosion potential is moderate with areas of high located where
drainage is imperfect and where loose glaciofluvial sands exist. It is likely that sediment derived from soil erosion or landslides would directly impact Shingle Creek or a minor tributary in most areas of the polygon.

The overall terrain hazard rating for Shingle Main is very low.

4.5.16 **Shingle Canyon - terrain unit #15**

This valley bottom polygon is dominated by a significantly incised section of Shingle Creek. Slope gradients are generally moderate to moderately steep, with minor areas of steep gradient terrain. Surficial materials include thick glaciofluvial deposits as well some till, colluvium (talus), and occasional rock outcrops. There are no existing failures; however, rockfall is an active process along the east side of the polygon.

There are no existing or proposed cutblocks, but a road does cross the polygon.

The likelihood of instability ranges from very low to moderate (moderate where the steepest slopes are located above the creek). The soil erosion potential is also variable due to the variable surficial materials: very low soil erosion potentials exist on talus slopes and rock outcrops; high soil erosion potentials exist on moderate and steeper glaciofluvial scarps as well as areas of imperfect drainage; moderate soil erosion potentials exist for much of the remainder of the polygon area. It is likely that sediment derived from soil erosion or landslides would directly impact Shingle Creek.

The overall terrain hazard rating for Shingle Canyon is moderate.

4.5.17 **Shingle North East - terrain unit #16**

This polygon ranges from mid to upper slope position and has a uniform to slightly irregular slope configuration. The surficial material is till, ranging in thickness from a blanket to a veneer. Slope gradients are mostly moderate, with some gentle and minor moderately steep gradient sections. Tree coverage is sparse with many open areas due to the south aspect, thin soils, and low elevation. There are no existing failures.

There is no existing or proposed forest development within this polygon.

The likelihood of instability is generally low with some areas of very low. The soil erosion potential is generally moderate. It would be possible for sediment from erosion to directly impact Shingle Creek or a minor tributary along the western polygon boundary.
The overall terrain hazard rating for Shingle North East is low.

4.5.18 Riddle Lower East Slope - terrain unit #17

This uniform to irregular, moderate gradient, mid to upper slope position polygon is overlain with a blanket to veneer of till. Occasional bedrock outcrops exist. Thin forest cover is prevalent throughout the polygon, especially on convex areas with thinner soils. There are no existing failures within the polygon.

There is no existing or proposed forest development within the polygon.

The likelihood of instability is generally low. The soil erosion potential is generally moderate with areas of low. It would be possible for sediment from erosion or landslides to directly impact Riddle Creek or a tributary.

The overall terrain hazard rating for Riddle Lower East Slope is low.

4.5.19 Riddle Lower - terrain unit #18

The terrain in this polygon consists of dominantly thick glaciofluvial deposits near the valley bottom with a generally uniform surface configuration. No existing failures are located within this polygon.

The majority of the land is privately owned and has been cleared for agriculture. Roads also traverse the polygon. No future forest development is proposed.

The likelihood of instability is generally negligible to very low. The soil erosion potential is generally moderate to high due to the likely loose sandy soils. It is possible for sediment from erosion or landslides to directly impact Riddle Creek.

The overall terrain hazard rating for Riddle Lower is very low.

4.5.20 Riddle Main - terrain unit #19

The terrain consists of gentle to steep gradient slopes on either side of Riddle Creek. Surficial materials are dominantly thick glaciofluvial deposits forming terraces and scarps. No significant failures are evident within this polygon; however, some active erosion and small slides are likely along the steeper sections of the glaciofluvial scarps.

An existing road is located at the south end of the polygon, and no additional forest development is proposed.
The likelihood of instability is low to negligible on the gentle gradient terrace tops, and low to moderate along the erosional scarp with isolated areas of high. The soil erosion potential ranges from moderate to high due to the thick glaciofluvial deposits with steep erosional scarps at the valley bottom. It is likely that sediment originating from erosion or landslides would directly impact Riddle Creek.

There is a “gentle over steep” scenario that results from the moderately steep gradient scarps directly adjacent to Riddle Creek with gentle gradient slopes above. Extra precautions should be taken during any forest development on the gentle gradient terrain not to concentrate or redirect runoff onto the steeper slopes below.

The overall terrain hazard rating for Riddle Main is moderate.

4.5.21 Riddle Lower East - terrain unit #20

The terrain consists of gentle gradient slopes overlain with till ranging in thickness from a blanket to a veneer. The surface configuration is uniform to slightly irregular. There are no existing instabilities in this polygon.

One old existing road traverses the polygon, and no future forest development is proposed.

The likelihood of instability ranges from negligible to very low. The soil erosion potential is typically moderate with areas of low where the surface configuration is most irregular and thinner soils dominate. It is possible that sediment originating from erosion or landslides would directly impact minor tributaries to Riddle Creek.

A “gentle over steep” scenario exists with this mostly gentle gradient polygon lying upslope of Riddle Main (polygon 19). Extra precautions should be taken in this area during harvesting or road building to avoid the concentration and redirection of runoff onto the steeper slopes below this polygon.

The overall terrain hazard rating for Riddle Lower East is very low.

4.5.22 Riddle Lower West - terrain unit #21

The terrain consists of gentle gradient, bedrock controlled slopes overlain with a blanket to veneer of till. These mid to upper slope position slopes are generally uniform to slightly irregular in surface configuration. There are no existing failures within this polygon.

One old existing road traverses part of the polygon, and no future forest development is proposed.
The likelihood of instability is generally negligible to very low. The soil erosion potential is typically moderate with areas of low where the terrain is most irregular. It is possible for sediment from erosion or landslides within this polygon to directly impact minor tributaries to Riddle Creek.

A “gentle over steep” scenario exists with this polygon. Extra precautions should be taken in this area during harvesting or road building to avoid the concentration and redirection of runoff onto the steeper slopes below this polygon.

The overall terrain hazard rating for Riddle Lower West is very low.

4.5.23 Riddle Mid - terrain unit #22

The terrain consists of extensive thick glaciofluvial deposits with till blankets present as well. Slope gradients are gentle, and these lower to mid slope position slopes are generally uniform to slightly irregular in surface configuration. There are no existing failures within this polygon.

There are extensive existing roads and cutblocks within this polygon, and some additional forest development is proposed.

The likelihood of instability is generally negligible to very low. The soil erosion potential is typically moderate to high due to the extent of glaciofluvial materials in the lower slope position. It is possible for sediment from erosion to directly impact Riddle Creek or a minor tributary.

A “gentle over steep” scenario exists with this polygon. Extra precautions should be taken in the area near the eastern polygon boundary during harvesting or road building to avoid the concentration and redirection of runoff onto the steeper slopes of Riddle Main (polygon 19) below this polygon.

The overall terrain hazard rating for Riddle Mid is very low.

4.5.24 Riddle North East - terrain unit #23

The surface configuration is generally very irregular in this upper slope to ridge top polygon which is sparsely treed. A till blanket to veneer is the typical surficial material and occasional rock outcrops exist. Slope gradients are generally gentle to moderate. There are no existing failures located within this polygon.

There is no existing or proposed forest development plans within this polygon.
The likelihood of instability ranges from negligible to low, with very low being dominant. The soil erosion potential is dominantly low with lesser areas of moderate. It is possible for sediment from erosion or a landslide to directly impact a minor tributary stream to Riddle Creek.

The overall terrain hazard rating for Riddle North East is very low.

4.5.25 Riddle Mid South Slope - terrain unit #24

The terrain is dominated by moderate gradient slopes in the mid slope position with a typically uniform surface configuration. The surficial material is most commonly a till blanket, though areas of thinner till veneers exist. This mostly south aspect polygon is sparsely treed in the western half. There are no existing failures within this polygon.

There is one existing road, and future forest development is proposed in the eastern portion of the polygon.

The likelihood of instability ranges from very low to low. The soil erosion potential is moderate. It is likely for sediment derived from erosion or a landslide to directly impact a tributary stream where the proposed harvesting is located, and possible for sediment derived from erosion or a landslide to directly impact Riddle Creek from the central portion of the polygon.

The overall terrain hazard rating for Riddle Mid South Slope is low.

4.5.26 Riddle North West - terrain unit #25

The terrain is dominated by gentle gradient slopes in the mid to upper slope position with a typically slightly irregular surface configuration. The surficial material is most commonly a till blanket, though areas of thinner till veneers exist on convex slope areas. There are no existing failures within this polygon.

There is both existing and proposed forest development within this polygon.

The likelihood of instability ranges from negligible to very low. The soil erosion potential is generally moderate. It is possible for sediment derived from erosion or a landslide to directly impact a tributary stream to Riddle Creek in many parts of the polygon.

The overall terrain hazard rating for Riddle North West is very low.
4.5.27 **Riddle Upper - terrain unit #26**

The terrain in this valley bottom polygon consists of till blankets and thick deposits of glaciofluvial material. Slope gradients are generally gentle to moderate, with some moderately steep slope gradients along some scarp sections (particularly in the east end of the polygon). There are no existing failures evident.

There is both existing and proposed forest development within this polygon.

The likelihood of instability ranges from negligible to low, with localized areas of moderate on the steeper sections of scarps. The soil erosion potential is moderate to high due to the thick glaciofluvial materials in the valley bottom with moderate gradient scarps. It is likely that sediment derived from soil erosion or a landslide would directly impact Riddle Creek.

There is a “gentle over steep” scenario that results from the short moderately steep gradient scarps directly adjacent to Riddle Creek with gentle gradient slopes above. Extra precautions should be taken during any forest development in this area not to concentrate or redirect runoff onto the short steeper slopes below.

The overall terrain hazard rating for Riddle Upper is low.

4.5.28 **Riddle Tributary South - terrain unit #27**

The terrain is dominated by moderate to moderately steep gradient slopes in the mid slope position with a typically uniform to slightly irregular surface configuration. The surficial materials consist of blankets and veneers of colluvium as well as till and the slope is sparsely treed. There are no existing failures within this polygon.

There is no existing or proposed forest development plans within this polygon.

The likelihood of instability ranges from low to moderate. The soil erosion potential is generally low to moderate. It is possible for sediment derived from erosion or a landslide to directly impact Riddle Creek.

The overall terrain hazard rating for Riddle Tributary South is moderate.

4.5.29 **Riddle Upper South - terrain unit #28**

The terrain consists of dominantly moderate gradient (with lesser gentle gradient), bedrock controlled slopes overlain with a blanket
to veneer of till. These lower to upper slope position slopes are generally uniform to slightly irregular in surface configuration. There are no existing failures within this polygon.

There are no existing roads or cutblocks, although considerable proposed forest development is located within this polygon.

The likelihood of instability is ranges from very low to low. The soil erosion potential is generally moderate. It is possible for sediment from erosion or landslides within this polygon to directly impact the upper reach of Riddle Creek or minor tributaries to Riddle Creek.

The overall terrain hazard rating for Riddle Upper South is low.

4.5.30 Riddle Upper North - terrain unit #29

The terrain consists of generally moderate gradient slopes in the mid slope position with thick till being the dominant surficial material. The surface configuration is generally slightly irregular. There are no existing failures.

No existing, but some proposed forest development is located within this polygon.

The likelihood of instability is low with areas of very low where the lower gradient slopes exist. The soil erosion potential is generally moderate. It is possible for sediment derived from erosion or a landslide to directly impact Riddle Creek or a tributary.

The overall terrain hazard rating for Riddle Upper North is low.

4.5.31 Riddle Upper South West - terrain unit #30

A till blanket to veneer overlies the majority of this mostly moderate gradient mid slope to ridge top polygon. Some gentle gradient slopes are located at the ridge top position. The surface configuration is generally slightly irregular. There are no existing failures.

There is no existing or proposed forest development within this polygon.

The likelihood of instability is low, with an area of very low near the ridge top. The soil erosion potential is moderate with lesser areas of high where soil moisture is concentrated. It is likely for sediment derived from erosion or a landslide in this polygon to directly impact a minor tributary to Riddle Creek near the center of the polygon.

The overall terrain hazard rating for Riddle Upper South West is low.
### 4.6 Hazard Ratings

A summary of the overall hazard ratings is presented in Tables 7a and 7b:

**TABLE 7a**

2003 hazard ratings for the Shingle Creek Community watershed.

<table>
<thead>
<tr>
<th>Drainage</th>
<th>HAZARD CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Surface Erosion</td>
</tr>
<tr>
<td>Shingle</td>
<td>Moderate</td>
</tr>
<tr>
<td>Riddle</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

**TABLE 7b**

2003 hazard ratings for the Shingle Creek Community watershed.

<table>
<thead>
<tr>
<th>Drainage</th>
<th>Terrain Unit Number</th>
<th>Terrain Unit</th>
<th>HAZARD CATEGORY</th>
<th>Soil Erodibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shingle</td>
<td>1</td>
<td>Shingle Lower</td>
<td>moderate</td>
<td>moderate to high</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Shingle Lower North Slope</td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Shingle Mid</td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>June South Ridge</td>
<td>very low</td>
<td>low to moderate</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>June South Fork</td>
<td>low</td>
<td>moderate to high</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>June South Upper</td>
<td>very low</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>June Main</td>
<td>very low</td>
<td>moderate to high</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>June / Mt. Brent</td>
<td>very low</td>
<td>low to moderate</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Mt. Brent</td>
<td>low</td>
<td>low to moderate</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Skulaow Upper</td>
<td>low</td>
<td>moderate to high</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Mt. Brent North Ridge Top</td>
<td>very low</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Mt. Brent North East Slope</td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Shingle Upper</td>
<td>very low</td>
<td>low to high</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Shingle Main</td>
<td>very low</td>
<td>moderate to high</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Shingle Canyon</td>
<td>moderate</td>
<td>low to high</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>Shingle North East</td>
<td>low</td>
<td>moderate</td>
</tr>
</tbody>
</table>
### TABLE 7b - continued
2003 hazard ratings for the Shingle Creek Community watershed.

<table>
<thead>
<tr>
<th>Drainage</th>
<th>Terrain Unit Number</th>
<th>Terrain Unit</th>
<th>HAZARD CATEGORY</th>
<th>Soil Erodibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riddle</td>
<td>17</td>
<td>Riddle Lower East</td>
<td>low</td>
<td>low to moderate</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>Riddle Main</td>
<td>low</td>
<td>low to moderate</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>Riddle Lower West</td>
<td>low</td>
<td>low to moderate</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Riddle North East</td>
<td>low</td>
<td>low to moderate</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>Riddle Mid South</td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>Riddle Upper South</td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>Riddle Upper South</td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>Riddle Upper North</td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>Riddle Tributary</td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>Riddle Upper South</td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>Riddle Mid South</td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>Riddle Lower East</td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>Riddle Upper South</td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>Riddle Upper North</td>
<td>low</td>
<td>moderate to high</td>
</tr>
</tbody>
</table>
5. DOMESTIC WATER SUPPLY

Shingle Creek is designated a community watershed by the Province supplying both domestic and irrigation water to the Penticton Indian Band. The District’s licensed water allocation is approximately 9,676 ac-ft/yr with a licensed storage of approximately 1,561 ac-ft/yr.

Domestic and irrigation water supply are a primary non-timber resource value (along with fisheries values) with potential for impacts from hydrologic disturbance. The primary concerns regarding future forest development from a water supply perspective are the potential for increased delivery of sediment to water intakes on Shingle / Riddle Creeks and the potential to alter the timing and level of peak flows and low flows at water intakes. In terms of sediment delivery, the focus for watershed management is to minimize the impacts of forest development on channel stability, surface erosion, and terrain stability. Minimizing the impacts of forest development on peak flows and low flows requires appropriate management of harvest levels (ECA), as timber harvesting influences spring snowmelt and the uptake of water by vegetation, which both directly influence flows.

With these management issues identified, water supply values are incorporated in the risk assessment in section 6, along with fisheries values, as a potential consequence of watershed disturbance.

6. FISHERIES VALUES

Fisheries values are the other primary non-timber resource value (in addition to water supply) with potential for impacts from hydrologic disturbance. As such, fisheries values, along with water supply values, are incorporated in the risk assessment in section 7 as a potential consequence of watershed disturbance.

6.1 Methods and Definitions

Within the study area, there are many streams without fisheries information. For these streams, the criteria used to evaluate the fisheries values were as follows: Low gradient tributaries to the mainstem are rated as moderate. Similar streams that have been inventoried did support rainbow trout populations. However, higher gradient tributaries (>20% slope) did not support fish due to natural barriers to fish access and seasonal flows that prevent the establishment of a permanent fish population. These tributaries, and similar higher gradient tributaries with no fish inventory information, are rated as low fisheries values. These streams are typically undisturbed with low channel sensitivity, as observed in the field, and would have moderate connectivity for sediment transport.

Reach boundaries for the upper Shingle Creek watershed were taken from maps contained within a Fish and Fish Habitat Inventory reports (WSR 1996,
Shanner 1997). They were determined from aerial photos using criteria defined in the Resource Inventory Committee (RIC) standards. For the purposes of this assessment, tributary reaches of named creeks were not shown.

6.1.1 **Fisheries Values**

Fish utilization and distribution within the upper Shingle Creek watershed were determined based on existing information from Fish and Fish Habitat reports, stream identification reports, Fisheries Information Summary System and Gorman Brothers Lumber Ltd. files. Fisheries values, or the importance of the reach to the fisheries resource, is defined for each reach as follows:

<table>
<thead>
<tr>
<th>Fisheries Value</th>
<th>Category Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Reach supports salmon or resident fish that contribute to a local fishery, a regionally important fish species, supports conservation of wild stocks for biodiversity, or contains critical fish habitat.</td>
</tr>
<tr>
<td>Moderate</td>
<td>Reach supports resident fish or is accessible to resident fish only. Fish productivity is generally too low and the fish too small to provide a local sport fishery.</td>
</tr>
<tr>
<td>Low</td>
<td>Reach does not contain fish or fish habitat, or may contain potential fish habitat that is not accessible to fish.</td>
</tr>
</tbody>
</table>

A moderate fisheries values ranking does not imply that the fish and fish habitat in these areas does not need to be rigorously protected since the *Fisheries Act* applies to all fish and fish habitat.

In addition to ranking fisheries values in the sections below, comments regarding the productivity of fish habitat are provided. These comments are based on observations of the quality and quantity of fish habitat during the overview flight and ground inspections. Professional judgement was used since no quantitative fish sampling was conducted during this assessment.

6.1.2 **Channel Sensitivity**

Channel sensitivity, for the purposes for this assessment, is defined as the susceptibility of a channel to morphologic change. Large amounts of sediment can enter a stream from natural or development-related landslides. Sediment has the potential to fill in pools, cause bank erosion, and alter drainage patterns; however, the potential occurrence and magnitude of these channel changes
varies greatly depending on the channel morphology. Channel Sensitivity is defined for each reach in Table 9.

### TABLE 9
Reach-based ranking system for channel sensitivity.

<table>
<thead>
<tr>
<th>Channel Sensitivity</th>
<th>Category Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High</strong></td>
<td>Channel is currently unstable and there is evidence of ongoing elevated rates of sediment deposition and/or bank erosion. Includes both impacted and non-impacted channels such as naturally unstable reaches on alluvial fans.</td>
</tr>
<tr>
<td><strong>Moderate</strong></td>
<td>Reach is generally stable but there is evidence of channel instability. Includes naturally unstable reaches and reaches that have been historically impacted.</td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td>Reach is stable and possibly bedrock or boulder-controlled. Shows no signs of elevated rates of bank erosion, channel aggradation (in-filling), or channel degradation (down-cutting).</td>
</tr>
</tbody>
</table>

#### 6.1.3 Connectivity

A large deposit of sediment into a stream reach not only has the potential to impact that reach, but can also impact downstream reaches through transport of sediment. As a “sediment wedge”, or “slug of sediment”, moves into downstream reaches, it can cause increased rates of bank erosion, in-filling of pools, and channel avulsions. These channel impacts can occur over decades. When channel connectivity between an upstream impacted reach and a downstream high value (i.e. fish-bearing) reach is low, it is unlikely that disturbance to the fish habitat would occur. For the purposes of this assessment, connectivity is defined as the ability of a reach to transport sediment to downstream reaches.
TABLE 10
Reach-based ranking system for downstream connectivity.

<table>
<thead>
<tr>
<th>Downstream Connectivity</th>
<th>Category Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Reach has a high sediment and debris transport capability due to high stream power with limited sediment storage capacity. Sediment is transported downstream at a high rate.</td>
</tr>
<tr>
<td>Moderate</td>
<td>Reach has moderate transport capability with a moderate to high sediment storage capacity. Some coarser-textured sediment is transported downstream.</td>
</tr>
<tr>
<td>Low</td>
<td>Reach has a low sediment transport capability and a moderate to high sediment storage capacity. Only small particles (silt and clay) are transported downstream. Typically a lake, swamp, low gradient channel.</td>
</tr>
</tbody>
</table>

6.2 Overview

Fisheries data is typically limited to the mainstem reaches of Riddle, Deschamps, Shingle, Skuloaw and June. The information is qualitative due to the absence of complete enclosure fishing and was surveyed for the purpose of fish presence/absence. No non-sport fish were found during historical sampling and only one sport fish species (rainbow trout) was found within the study watersheds.

Within the study area, there were many streams without fisheries information and these streams had to be rated for fisheries values. The criteria used to evaluate the streams were as follows: Low gradient tributaries to the mainstem were rated as moderate fishery values streams. These streams may be accessible to resident rainbow trout populations. However, higher gradient tributaries (>20% slope) did not support fish due to natural barriers to fish access and seasonal flows that may prevent the establishment of a permanent fish population. These tributaries, and similar higher gradient tributaries with no fish inventory information, were rated as low. These streams were typically undisturbed with low channel sensitivity, as viewed in the field, and would have moderate connectivity for sediment transportation.

6.2.1 Riddle Sub-basin

Reach 1 of Riddle Creek has impacts from a road crossing, an agricultural irrigation dam, a historical riparian road and cattle damage to riparian vegetation. The dam within Reach 1 is 1.0 m high and requires a fish passage structure. The stream habitat is degraded due to the aforementioned impacts but was rated as high fish value due to the resident wild rainbow trout population within the stream and permanent population within Deschamps Lake. This reach has a lack of woody debris with some moderate aggradations. Stream sensitivity and connectivity was rated as moderate.
Reaches 1 and 2 of the mainstem channel were within a small valley that has gentle sloping surrounding lands. Disturbances to the valley flats are not likely to increase the channel sensitivity.

Reach 3 was surveyed upstream and downstream of the power line crossing. The stream has been confirmed as non-fish bearing. Multiple beaver dams were found upstream that trap sediment and also cause multiple channel structure that has caused erosion. Downstream of the power line the stream was historically logged, and is aggraded with alder and poplar dominated riparian vegetation. The stream has a lack of woody debris, deep pools, and overall complexity. Reach 3 was stable and with moderate sensitivity and high connectivity. Reach 4 was not surveyed, air photos show natural vegetation without road access or human activity.

6.2.2 Deschamps Creek

A field review of the watershed revealed a dry steep terrain watershed where most of the TRIM streams were identified as non-visible channels. Deschamps Creek Reach 1 and Deschamps Lake (Reach 2) have been inventoried in 1997 and a resident population of rainbow trout was found. These reaches were identified as a high value stream and lake that supports a wild rainbow trout fishery. Deschamps lake inlet was observed to have a high proportion of spawning habitat available, woody debris and abundant cover for fish. This reach likely provides critical spawning and egg incubation habitat. The wetlands, located approximately 800 m upstream of the lake, are controlled by a series of beaver dams and likely utilized for fish rearing. The wetland reach would have low sensitivity and low connectivity.

6.2.3 Shingle Sub-basin

Reach 2 of Shingle Creek is within the Bobtail Ranch property and has a large section with no riparian vegetation and a perched culvert that requires restoration works for fish passage. Heavy cattle use has caused erosion of stream banks with no vegetation to stabilize the stream banks. This location requires restoration works.

Approximately half of sub-basin mainstem of Shingle Creek has been historically logged adjacent to the stream. Based on air photos and field observations, the riparian vegetation appears to have changed from a pine dominated stand to alder and popular stands. The stream reaches are aggraded with a high proportion of riffle, a high width to depth ratio, and a lack of pools. Although the streams also have a lack of woody debris, the stream channels are well vegetated with little bank erosion, and would be robust at flood
flows. These streams have some spawning gravels and Reaches 3, 4, and 5 mainstem reaches are known to support a natural population of rainbow trout. Reaches 6 and 7 are not accessible to fish due to natural barriers within the stream. The stream was rated as moderate for sensitivity and high for connectivity. A culvert observed at Site 4 (photo 5) has a 0.4 m high perch combined with high stream velocities that create a partial barrier to fish and block bedload movement. A culvert observed at Site 7 (photo 6) has a 0.6 m high perch and high stream velocities that also create a barrier to fish. These two culverts require restoration works.

Tributaries to Shingle creek have not been surveyed although during our field assessment some TRIM stream did not exist and many were too steep for fish access. These steep tributaries were rated as moderate for connectivity and low for sensitivity. One major tributary (Site 5) was rated as moderate habitat for rainbow trout. The stream has low gradient, contained abundant spawning gravel and good complexity for fish habitat. The stream has moderate connectivity and sensitivity.

### 6.2.4 Skulaow Sub-basin

Skulaow Creek was observed at a natural location within Reach 2 (Site 6) with stable step-pool morphology, multiple deep pools, good spawning gravels, abundant large woody debris, and stable stream banks. Reach 2 supports resident rainbow trout and has natural riparian vegetation through to Reach 1. Skulaow Creek has a high connectivity rating and moderate sensitivity rating.

Reach 3 was inventoried in 1996 and natural barriers prevent fish access. The third reach of Skulaow Creek show no signs of human activity from air photo analysis and is expected to have similar habitat as Reach 2.

### 6.2.5 June Creek

This sub-basin has a similar drainage area as Skulaow Creek and has a similar channel width. The stream was found to be dry in 1996 during a stream survey within Reach 1. Our survey within Reach 1 found a stable cascade/pool system with a moderate volume of spawning gravel, good cover, and stable woody debris. A culvert at site 10 (photo 7), first observed in 1996, remains a barrier to fish with a 0.9 m high perch and. This culvert requires restoration works.

Reaches 1, 2 and 3 have some historical logging although the stream appears stable with little erosion and intact riparian
vegetation. June Creek has a high connectivity and moderate sensitivity. The tributary streams have fisheries information for only one stream that confirms no fish present (SRR 2000). Tributary streams were rated low for sensitivity and moderate for connectivity.

6.2.6 Shingle Creek Downstream of Study Area

Stream characteristics downstream of the study area are highly variable. Moving downstream from the study area, Reach 2 has three distinct sub-reaches due to land use. The upper reach is forested and stable. The mid reach has agricultural use and a wide wetland riparian area with stabilizing shrubs. The lowest section of Reach 2 is deeply down cut with elevated mid channel bars, eroding banks, and an unstable highly sinuous channel lacking woody debris. Stream restoration works were completed within this sub reach in 1998 (FNOSEPS) and 2000 (Columbia) to soft armor the stream banks, add woody debris, and complete riparian planting.

Reach 1 parallels Green Mountain Road for its entire length. There are multiple locations where roads, housing, and agriculture impact the riparian vegetation or the stream has been moved. The reach has a cascade pool morphology with boulders and bedrock moving to riffle pool morphology within the last two kilometers before it meets Okanagan River. There are adequate amounts of spawning gravels with relatively few deep pools. Local residents catch 1-5 kg adfluvial rainbow trout and kokanee are also a traditional food source caught within Reach 1. The reach has high connectivity and moderate sensitivity. Reach 1 has high value for fisheries due to its use by kokanee, rainbow trout, mountain whitefish, largescale sucker, longnose dace, prickly sculpins, peamouth, potentially sockeye in the future, and potentially others species from Skaha Lake.

6.3 Fisheries Values and Channel Conditions

A summary of the overall fisheries values and channel conditions is presented in Table 11. Fish values are the primary non-timber resource value with potential for impacts from hydrologic disturbance. As such, fish values are incorporated into the risk assessment in section 7.0 as the potential consequence of watershed disturbance.
# TABLE 11
Fisheries values and channel conditions in the Shingle Creek watershed.

<table>
<thead>
<tr>
<th>Sub-Basin</th>
<th>Stream</th>
<th>Reach</th>
<th>Fisheries Values</th>
<th>Channel Sensitivity</th>
<th>Downstream Connectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Riddle Creek</strong></td>
<td>Riddle Creek</td>
<td>1-2</td>
<td>High</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Riddle Creek</td>
<td>3-4</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Unnamed tributaries &lt; 20% gradient</td>
<td>All</td>
<td>Moderate</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Unnamed tributaries &gt; 20% gradient</td>
<td>All</td>
<td>Low</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Deschamps Creek and Lake</td>
<td>1, 3, 5</td>
<td>High</td>
<td>Moderate</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2, 4</td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>Deschamps tributaries</td>
<td>All</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td><strong>Shingle</strong></td>
<td>Shingle Creek</td>
<td>3-5</td>
<td>High</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Shingle Creek</td>
<td>6-7</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Unnamed tributaries &lt; 20% gradient</td>
<td>All</td>
<td>Moderate</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Unnamed tributaries &gt; 20% gradient</td>
<td>All</td>
<td>Low</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Skulaow</strong></td>
<td>Skulaow Creek</td>
<td>1-2</td>
<td>High</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Skulaow Creek</td>
<td>3</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Unnamed tributaries &gt; 20% gradient</td>
<td>All</td>
<td>Low</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>June</strong></td>
<td>June Creek</td>
<td>1</td>
<td>High</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>June Creek</td>
<td>2-3</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Unnamed tributaries &gt; 20% gradient</td>
<td>All</td>
<td>Low</td>
<td>Low</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
7. RISK ASSESSMENT

The following sections outline the watershed risks for each disturbance index (peak flows, surface erosion, riparian, and terrain stability). The risk evaluation is based on the risk matrix in Table 12, where risk is the product of hazard and consequence. The definitions used for determining the hazard (presented in section 4) and consequence ratings are presented in Table 13.

### TABLE 12
Risk evaluation matrix.

<table>
<thead>
<tr>
<th>Risk</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negligible</td>
<td>Negligible</td>
<td>Very Low</td>
<td>Low</td>
</tr>
<tr>
<td>Very Low</td>
<td>Very Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Moderate</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>High</td>
<td>Moderate</td>
<td>High</td>
<td>Very High</td>
</tr>
</tbody>
</table>
TABLE 13  
Hazard and consequence definitions.

<table>
<thead>
<tr>
<th>Disturbance Indicator</th>
<th>Hazard</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak flows</td>
<td>Consider the potential for forestry-induced peak flow increases to cause channel disturbance (within the sub-basin or downstream)</td>
<td>Consider the overall impact of potential peak flow related channel disturbance on fisheries values (within the sub-basin or downstream) and on water quality at the water supply intake.</td>
</tr>
<tr>
<td>Surface erosion</td>
<td>Consider the potential for present day road construction and deactivation practices to cause surface erosion and subsequent channel disturbance (within the sub-basin or downstream)</td>
<td>Consider the overall impact of potential surface erosion related channel disturbance on fisheries values (within the sub-basin or downstream) and on water quality at the water supply intake.</td>
</tr>
<tr>
<td>Riparian</td>
<td>Consider the potential for present day riparian management practices to cause channel disturbance (within the sub-basin or downstream)</td>
<td>Consider the overall impact of potential riparian management related channel disturbance on fisheries values (within the sub-basin or downstream) and on water quality at the water supply intake.</td>
</tr>
<tr>
<td>Terrain</td>
<td>Consider the potential for present day forest operations (roads, cutblocks, etc) to initiate a slope failure.</td>
<td>Consider the overall impact of potential terrain stability related channel disturbance on fisheries values (within the sub-basin or downstream) and on water quality at the water supply intake. Incorporate the proximity of failures and connectivity to fisheries values and the water intake.</td>
</tr>
</tbody>
</table>

7.1 Peak Flows

Table 14 outlines the peak flow risk evaluation for Shingle Creek watershed. The peak flow hazard ratings are outlined in section 4.2 and the rationale for the assigned consequence ratings is given in the table below. It should be noted that elevated peak flows from a particular sub-basin transfer downstream to a point where they are sufficiently attenuated, either through dilution by other tributaries or by buffering from a large water body.
TABLE 14
Peak flow risks within the Shingle Creek Community watershed.

<table>
<thead>
<tr>
<th>Drainage</th>
<th>Hazard</th>
<th>Consequence</th>
<th>Risk</th>
<th>Rationale for Consequence Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riddle</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
<td>The first two reaches of Riddle and three reaches of Deschamps Creek support populations of wild rainbow trout and therefore is considered a high fisheries value. These high fisheries values could be impacted by elevated peak flows. Peak flow related channel disturbance could also deliver sediment to the water supply.</td>
</tr>
<tr>
<td>Shingle</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
<td>Shingle Creek mainstem supports conservation of wild stocks for biodiversity and is considered a high fisheries value. These high fisheries values could be impacted by elevated peak flows. Peak flow related channel disturbance could also deliver sediment to the water supply.</td>
</tr>
<tr>
<td>Skulaow</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
<td>Skulaow Creek supports conservation of wild stocks for biodiversity and therefore is considered a high fisheries value. These high fisheries values could be impacted by elevated peak flows. Peak flow related channel disturbance could also deliver sediment to the water supply.</td>
</tr>
<tr>
<td>June</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
<td>June Creek supports conservation of wild stocks for biodiversity and therefore is considered a high fisheries value. These high fisheries values could be impacted by elevated peak flows. Peak flow related channel disturbance could also deliver sediment to the water supply.</td>
</tr>
</tbody>
</table>

- Refer to section 4.2 for the review of peak flow hazards.
- The risk evaluation matrix is outlined in Table 12.
7.2 **Surface Erosion**

Table 15 outlines the surface erosion risk evaluation for Shingle Creek Community watershed. The surface erosion hazard ratings are outlined in section 4.3 and the rationale for the assigned consequence ratings is given in the table below. Soil erodibility ratings are provided in section 4.5, but are not used for the risk assessment because the erodibility ratings do not represent the likelihood of surface erosion related channel disturbance (as defined in Table 13). These soil erodibility ratings were produced as part of the terrain stability mapping process, but are more site specific than is needed in this overview project. The ratings should be utilized during site level forest development planning.

It should be noted that lakes and wetlands prevent or reduce the transport of eroded sediment downstream to a location supporting fisheries values. Reaches with high connectivity have only temporary potential impacts to fish, as sediment is readily flushed downstream. Channel reaches with moderate connectivity have the greatest potential impacts to fish, as sediment is deposited causing egg and fish mortality. In contrast, the higher the downstream connectivity, the greater the potential for delivery to the water supply intake with subsequent water quality impacts. This connectivity is considered during the evaluation of surface erosion consequence.
TABLE 15
Surface erosion risks within the Shingle Creek Community watershed.

<table>
<thead>
<tr>
<th>Drainage</th>
<th>Hazard</th>
<th>Consequence</th>
<th>Risk</th>
<th>Rationale for Consequence Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riddle</td>
<td>Moderate</td>
<td>High</td>
<td>Moderate</td>
<td>Riddle and Deschamps lower mainstems have high fisheries values and moderate connectivity indicating that sediment could deposit in high value habitat. Impacts to water quality at downstream water intakes are of a lesser concern.</td>
</tr>
<tr>
<td>Shingle</td>
<td>Moderate</td>
<td>High</td>
<td>Moderate</td>
<td>Shingle mainstem has high fisheries values and moderate connectivity indicating that sediment could deposit in high value habitat. Impacts to water quality at downstream water intakes are of a lesser concern</td>
</tr>
<tr>
<td>Skulaow</td>
<td>Moderate</td>
<td>High</td>
<td>Moderate</td>
<td>Skulaow mainstem has high fisheries values and moderate connectivity indicating that sediment could deposit in high value habitat. Impacts to water quality at downstream water intakes are of a lesser concern</td>
</tr>
<tr>
<td>June</td>
<td>Moderate</td>
<td>High</td>
<td>Moderate</td>
<td>June mainstem has high fisheries values and moderate connectivity indicating that sediment could deposit in high value habitat. Impacts to water quality at downstream water intakes are of a lesser concern</td>
</tr>
</tbody>
</table>

- Refer to section 4.3 for the review of riparian hazards.
- The risk evaluation matrix is outlined in Table 12.

7.3 Riparian

Table 16 outlines the riparian risk evaluation for Shingle Creek Community watershed. The riparian hazard ratings are outlined in section 4.4 and the rationale for the assigned consequence ratings is given in the table below. Since riparian impacts are generally localized, the rationale is weighted
towards within-reach fisheries values rather than downstream fisheries values. Since, in some instances, harvesting can cause riparian impacts that lead to downstream disturbance, any exceptions to the overall risks are outlined.

### TABLE 16
Riparian risks within the Shingle Creek Community watershed.

<table>
<thead>
<tr>
<th>Drainage</th>
<th>Hazard</th>
<th>Consequence</th>
<th>Risk</th>
<th>Rationale for Consequence Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riddle</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
<td>Riddle mainstem supports high fisheries values with adjacent forest development opportunities</td>
</tr>
<tr>
<td></td>
<td>(moderate to high locally)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shingle</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
<td>Shingle mainstem supports high fisheries values with adjacent forest development opportunities</td>
</tr>
<tr>
<td></td>
<td>(moderate to high locally)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skulaow</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
<td>Skulaow mainstem supports high fisheries values with adjacent forest development opportunities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
<td>June mainstem supports high fisheries values with adjacent forest development opportunities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Refer to section 4.4 for the review of riparian hazards.
- The risk evaluation matrix is outlined in Table 12.

### 7.4 Terrain Stability

Table 17 outlines the terrain stability risk evaluation for Shingle / Riddle Creeks watershed. The terrain stability hazard ratings are outlined in section 4.5 and the rationale for the assigned consequence ratings is given in the table below. In addressing the consequences of landslides, the localized impacts of the scour and deposition zones are considered along with the impacts of transported sediment on fisheries values at downstream locations. As with surface erosion impacts, connectivity directly influences the extent of downstream impacts. It is important to note that the risk levels can be increased or decreased through alternate forest development practices.
**TABLE 17**

Terrain stability risks within the Shingle Creek Community watershed.

<table>
<thead>
<tr>
<th>Drainage</th>
<th>Terrain Unit Number</th>
<th>Terrain Unit</th>
<th>Hazard</th>
<th>Consequence</th>
<th>Risk</th>
<th>Rationale for Consequence Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shingle</td>
<td>1</td>
<td>Shingle Lower</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
<td>It is likely that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in Shingle Creek</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Shingle Lower North Slope</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>It is possible that sediment resulting from a landslide initiating within this polygon would directly impact high fisheries values in Shingle Creek</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Shingle Mid</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>It is possible that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in June or Skulaow Creeks</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>June South Ridge</td>
<td>Very low</td>
<td>Low</td>
<td>Very low</td>
<td>It is unlikely that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in June Creek</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>June South Fork</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
<td>It is likely that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in June Creek</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>June South Upper</td>
<td>Very low</td>
<td>Moderate</td>
<td>Very low</td>
<td>It is likely that sediment resulting from a landslide initiating within this polygon could directly impact a tributary to June Creek</td>
</tr>
</tbody>
</table>
**TABLE 17, continued**

Terrain stability risks within the Shingle Creek Community watershed.

<table>
<thead>
<tr>
<th>Drainage</th>
<th>Terrain Unit Number</th>
<th>Terrain Unit</th>
<th>Hazard</th>
<th>Consequence</th>
<th>Risk</th>
<th>Rationale for Consequence Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shingle</td>
<td>7</td>
<td>June Main</td>
<td>Very low</td>
<td>High</td>
<td>Low</td>
<td>It is likely that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in June Creek</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>June / Mt. Brent</td>
<td>Very low</td>
<td>High</td>
<td>Low</td>
<td>It is likely that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in June Creek</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Mt. Brent - polygon</td>
<td>Low</td>
<td>Low</td>
<td>Very low</td>
<td>It is unlikely that sediment resulting from a landslide initiating within this polygon could directly impact June or Skulaow Creeks</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Skulaow Upper</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>It is possible that sediment resulting from a landslide initiating within this polygon could directly impact an upper tributary to Skulaow</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Mt. Brent North Ridge Top</td>
<td>Very low</td>
<td>Low</td>
<td>Very low</td>
<td>It is unlikely that sediment resulting from a landslide initiating within this polygon could directly impact an streams</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Mt. Brent North East Slope</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>It is possible that sediment resulting from a landslide initiating within this polygon could directly impact a tributary to Skulaow Creek</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Shingle Upper</td>
<td>Very low</td>
<td>High</td>
<td>Low</td>
<td>It is likely that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in Shingle Creek</td>
</tr>
</tbody>
</table>
**TABLE 17, continued**  
Terrain stability risks within the Shingle Creek Community watershed.

<table>
<thead>
<tr>
<th>Drainage</th>
<th>Terrain Unit Number</th>
<th>Terrain Unit</th>
<th>Hazard</th>
<th>Consequence</th>
<th>Risk</th>
<th>Rationale for Consequence Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shingle</td>
<td>14</td>
<td>Shingle Main</td>
<td>Very low</td>
<td>High</td>
<td>Low</td>
<td>It is likely that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in Shingle Creek</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Shingle Canyon</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
<td>It is likely that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in Shingle Creek</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>Shingle North East</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>It is possible that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in Shingle Creek</td>
</tr>
<tr>
<td>Riddle</td>
<td>17</td>
<td>Riddle Lower East Slope</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>It is possible that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in Riddle Creek</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>Riddle Lower</td>
<td>Very low</td>
<td>Moderate</td>
<td>Very low</td>
<td>It is possible that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in Riddle Creek</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>Riddle Main</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
<td>It is likely that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in Riddle Creek</td>
</tr>
</tbody>
</table>
**TABLE 17, continued**

Terrain stability risks within the Shingle Creek Community watershed.

<table>
<thead>
<tr>
<th>Drainage</th>
<th>Terrain Unit Number</th>
<th>Terrain Unit</th>
<th>Hazard</th>
<th>Consequence</th>
<th>Risk</th>
<th>Rationale for Consequence Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riddle</td>
<td>20</td>
<td>Riddle Lower East</td>
<td>Very low</td>
<td>Moderate</td>
<td>Very low</td>
<td>It is possible that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in Riddle Creek</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>Riddle Lower West</td>
<td>Very low</td>
<td>Moderate</td>
<td>Very low</td>
<td>It is possible that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in Riddle Creek</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>Riddle Mid</td>
<td>Very low</td>
<td>Moderate</td>
<td>Very low</td>
<td>It is possible that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in Riddle Creek</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>Riddle North East</td>
<td>Very low</td>
<td>Moderate</td>
<td>Very low</td>
<td>It is possible that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in Riddle Creek</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>Riddle Mid South Slope</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>It is possible that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in Riddle Creek</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>Riddle Mid South Slope</td>
<td>Very low</td>
<td>Moderate</td>
<td>Very low</td>
<td>It is possible that sediment resulting from a landslide initiating within this polygon could directly impact a tributary to Riddle Creek</td>
</tr>
</tbody>
</table>
### TABLE 17, continued
Terrain stability risks within the Shingle Creek Community watershed.

<table>
<thead>
<tr>
<th>Drainage</th>
<th>Terrain Unit Number</th>
<th>Terrain Unit</th>
<th>Hazard</th>
<th>Consequence</th>
<th>Risk</th>
<th>Rationale for Consequence Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riddle</td>
<td>26</td>
<td>Riddle Upper</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
<td>It is likely that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in Riddle Creek</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>Riddle Tributary South</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>It is possible that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in Riddle Creek</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>Riddle Upper South</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>It is possible that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in Riddle Creek</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>Riddle Upper North</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>It is likely that sediment resulting from a landslide initiating within this polygon could directly impact high fisheries values in</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>Riddle Upper South West</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>It is likely that sediment resulting from a landslide initiating within this polygon could directly impact a minor tributary to Riddle Creek</td>
</tr>
</tbody>
</table>

Refer to section 4.5 for the review of terrain stability hazards.
The risk evaluation matrix is outlined in Table 12.
8. WATERSHED RESTORATION

8.1 Review of Past Restoration

Past watershed restoration initiatives have been limited to minor road deactivation works to control identified high sediment sources. These works were undertaken in the early years of FRBC funding. No field review of the works was carried out in the completion of this report, however, it is our understanding (pers. comm. Randy Hardy) that these sites were of a low priority.

8.2 Restoration Opportunities

Table 18 outlines details regarding five priority restoration opportunities identified during the June 2004 field investigations. Consideration should be given to mitigating any impacts.

**TABLE 18**
Watershed restoration opportunities within the Shingle Creek Community watershed.

<table>
<thead>
<tr>
<th>Drainage</th>
<th>Site No.</th>
<th>Photo No.</th>
<th>Restoration Type</th>
<th>Condition/Opportunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riddle</td>
<td>8</td>
<td></td>
<td>Fishway</td>
<td>A 1.0 m high dam prevents upstream movement of fish.</td>
</tr>
<tr>
<td>Shingle</td>
<td>4</td>
<td>5</td>
<td>Culvert Replacement</td>
<td>A 0.6 m high perched culvert with high velocity prevents upstream movement of fish. Observed in 1996 (WSR).</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>6</td>
<td>Culvert Replacement</td>
<td>A 0.4 m high perched culvert with high velocity prevents upstream movement of fish and impacts the channel morphology.</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>4</td>
<td>Culvert Replacement / Riparian Restoration</td>
<td>A perched culvert with high velocity prevents fish passage. Complete removal of riparian vegetation by agriculture has occurred.</td>
</tr>
<tr>
<td>June</td>
<td>10</td>
<td>7</td>
<td>Culvert Replacement</td>
<td>A 0.9 m high perched culvert with high velocity prevents upstream movement of fish. Observed in 1996 (WSR).</td>
</tr>
</tbody>
</table>
9. CONCLUSIONS

A summary of conclusions follows:

- In total, five restoration sites were identified, not including minor road deactivation or private lands issues. All five sites providing fish access where barriers currently exist.

- The primary concerns for future watershed condition in the Shingle Creek watershed are related to managing peak flows and surface erosion issues. Terrain stability and riparian management are generally of low concern.

- The surface erosion risks for future watershed condition are moderate.

- The peak flow risks for future watershed condition are moderate.

- The riparian risks for future watershed condition are moderate.

- The terrain stability risks for future watershed condition range from very low to high but low risks predominate.
1. CLOSURE

The information and recommendations presented in this report are based on an overview assessment. This report is prepared in accordance with generally accepted engineering practices in this area. No other warranty, express or implied is made.

Assessments of soils and slope stability are based on interpretation of surface features and limited subsurface exposures. Subsurface and bedrock conditions have been inferred from the limited, isolated exposures. Variability is inherent in geological features, and actual ground conditions may differ from those inferred.

Hydrologic assessment is based on modelling and, as such, the results are only as accurate as the model represents the true watershed characteristics and processes.

If you have any question or require further information, please contact the undersigned at (250) 861-5595.

Respectfully submitted,

Dobson Engineering Ltd.

Original signed by: ___________________________  Original signed by: ________________
Project Manager                                Senior Reviewer

MN/dd
11. LITERATURE CITED


Ecosystem Restoration Plans, FIA Activity Standards document.


HYDAT - Surface Water and sediment Data, Water Survey of Lower Trout Creek; Developing a Sustainable Forest Management Report.

Map 1736A, Geology, Penticton, mapped by Tempelman-Kluit, 1:250,000.


Soils of the Penticton Map Area 82E, Summerland BC. Department of Energy, Mines and Resources 1976, 1:50,000.

Terrain Stability Map at TSIL C 1:20 000 completed by AGRA, 1998-99.

Wildstone Resources Ltd. 1996. Fish and Fish Habitat Operational Inventory, 1996. Penticton, BC.

Wahl, Douglas, 2000. Summary of Fish Stream Inventory Reports. Snowy River Resources Ltd. Summerland, B.C.
APPENDICES
## APPENDIX A

Watershed Condition Summary Table
### Watershed Report Card for Shingle/Riddle Creeks 2003*

<table>
<thead>
<tr>
<th>Basin</th>
<th>Gross Area (ha)</th>
<th>Total Harvested Area Ha</th>
<th>ECA ha %</th>
<th>ECA below Snowline ha %</th>
<th>ECA Above Snowline ha %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shingle Community Watershed Above Reach 3</td>
<td>1,764.2</td>
<td>863.0</td>
<td>535.6</td>
<td>462.9</td>
<td>72.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shingle Community Watershed Residual</td>
<td>2,831.4</td>
<td>420.6</td>
<td>301.7</td>
<td>246.3</td>
<td>55.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riddle Creek</td>
<td>3,451.2</td>
<td>800.7</td>
<td>332.6</td>
<td>236.4</td>
<td>96.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watershed</td>
<td>8,046.7</td>
<td>2,084.3</td>
<td>1,169.9</td>
<td>945.5</td>
<td>224.3</td>
</tr>
</tbody>
</table>

* Includes all blocks cut or projected to be cut in 2003
# Shingle Community Watershed/Riddle Creek 10 year ECA Recovery*

*Values in ha and %*

<table>
<thead>
<tr>
<th>Basin</th>
<th>Gross Area (ha)</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shingle Above Reach 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,764.2</td>
<td>535.6</td>
<td>535.3</td>
<td>524.3</td>
<td>496.1</td>
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* ECA values calculated for December 31 of each year

August 19, 2004
APPENDIX B
Field Photos


PHOTO 5. June 2004. Site 4. Perched culvert (0.4m high) on Shingle Creek creating a partial barrier to fish.

PHOTO 6. June 2004. Site 7. Perched culvert (0.6m) on Shingle Creek creating a partial barrier to fish.
PHOTO 7. June 2004. Site 10. Perched culvert (0.9m high) on June Creek creating a barrier to fish.
APPENDIX C

Maps