Watershed Risk Assessment

for

Ellis Creek

Prepared for:

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1.0 INTRODUCTION

A hydrologic risk assessment has been completed on the Ellis Creek community watershed for the BC Timber Sales (BCTS) program, Okanagan – Columbia Business Area. Ellis Creek drains an area of approximately 15,000 ha on the east side of the Okanagan Valley, flowing through the southern half of the City of Penticton where it joins the Okanagan River within city limits [Overview map – Appendix A]. Forest development activity in Ellis Creek on the part of BCTS has been limited over the past 10 years but mountain pine beetle (MPB) related effects are being realized throughout the watershed and BCTS intends to salvage a portion of affected or potentially affected stands. Plans will be prepared with direction in part from this assessment.

The purpose of the assessment is to address objectives set by government for community watersheds as defined in the BCTS Forest Stewardship Plan (FSP)\(^1\). Specifically, BCTS is expected to prevent the cumulative hydrologic effects of primary forest activities within the community watershed from resulting in:

a. a material adverse impact on the quality of water or the timing of the flow of the water from the waterworks, or

b. the water from the waterworks having a material adverse impact on human health that cannot be addressed by water treatment required under:
   i) an enactment

   ii) the licence pertaining to the waterworks.

To assist in this regard the risk assessment will include the following components, as defined in the contract:

- Review of available background materials to identify any known water quality or water quantity related issues.

- Assessment of:

  i) current watershed condition assuming no mountain pine beetle related effects or salvage development,

  ii) expected watershed condition with MPB and no salvage activity, and

  iii) expected watershed condition under a full economic and operable salvage scenario implemented over the next 3 – 5 years.

- Estimate of hydrologic recovery for two different scenarios:

\(^1\) BC Timber Sales, Okanagan-Columbia Business Area, Forest Stewardship Plan, July 2006.
i) Scenario 1 – no further harvesting but the loss of all mature pine, and

ii) Scenario 2 – implementation of the full salvage scenario and loss of any remaining un-economic Lodgepole pine.

- Recommendations for development planning and implementation of other remedial measures to minimize the effect of salvage and MPB on resources at stake.

2.0 BACKGROUND

The Ellis Creek watershed was last assessed from a hydrologic perspective by Dobson Engineering Ltd. in 1998\(^2\) with a follow-up review of proposed development in February 2001\(^3\). Both documents were supported by prior Forest Renewal BC funded projects such as Sediment Source Survey (SSS), Integrated Watershed Restoration Plan (IWRP), and Fish Habitat Assessment (FHAP) reports. None of the latter reports were available for review but findings are assumed to have been incorporated into the more recent hydrology reports produced by Dobson.

Prior report findings and recommendations are summarized as follows:

- The Ellis Creek system has high natural sediment loads on the lower mainstem resulting from large natural landslides and dry ravelling slopes along the canyon reaches in the residual area. Recommendations to explore slope stabilization on slides connected to Ellis Creek were made in the 1998 report.

- Stability and riparian function on the mainstem has been recovering since the channel was scoured in 1941 by flows released from a failed dam in the upper watershed. Some of the landslides on coupled slopes in the residual were attributed to under-cutting of toe slopes during the 1941 dam break.

- An un-armoured and undersized spillway channel from the City of Penticton’s reservoir #4 in the Ellis residual area was considered the most significant land-use related source of sediment to Ellis Creek while in use. The channel is only active when the reservoir is spilling during the freshet period. Recommendations were made for the city to stabilize the spillway channel.


• A high road density was also considered important from a water quality perspective. Deactivation of roads, above the H60 line in particular, was recommended to reduce road density and address sediment generation and delivery issues, generally. Recommendations for application of sediment controls on and around new and existing roads were also provided.

• Four high risk road sediment source sites were identified around major tributary crossings; two in the E2 or South Ellis basin, and two in the E4 or North Fork Ellis basin. Recommendations to address these concerns were made in the 1998 report but the location of these is unknown as no map or other site location details were provided.

• Channel stability and riparian function was considered good on all tributaries and recovering on the mainstem as described above.

• Past forest development related effects on streamflow were considered negligible given fairly limited development over time and good hydrologic recovery in old cutblocks.

3.0 METHODS

Ortho photos were used to map landslides and alluvial fan and floodplain features [Appendix A]. Fans and floodplains are important depositional landforms where significant channel and riparian related changes can occur with increases in peak flow and sedimentation, or reductions in riparian function. The location and extent of these features is considered approximate based on reconnaissance level field checking. Confirmation is required at the site level for block layout or road design purposes. Definitions and management considerations in fan and floodplain areas are provided in Appendix B.

A review of the entire road and trail network was completed with a focus on main tributary crossings and roads above steep coupled slopes in the residual area. Steep coupled slopes are those directly connected to channels, often shown as terrain Class IV or V [Appendix A]. Streams and riparian areas were reviewed strategically to assess stability and function, respectively.

Informal meetings were conducted with City of Penticton public works staff to discuss water storage, diversion, treatment infrastructure, and both water quality and water quantity issues.

A detailed ECA analysis was done to understand the potential effect of mountain pine beetle (MPB) infestation on susceptible stands and planned salvage activity
from an ECA perspective [Appendix A]. Methods were developed by Huggard\textsuperscript{4} and refined for application in Ellis Creek. The model accounts for dead standing pine, non-pine overstory, and understory related effects on ECA over time. Stands with a low susceptibility to MPB attack and mortality are those with >40% pine and >50 years old in the ESSF biogeoclimatic zone; moderate susceptibility stands are those in other biogeoclimatic zones with >40% pine and >50 but less than 100 years old, and highly susceptible stands are those with >40% pine and more than 100 years old. Four scenarios have been modelled under two different MPB attack situations – moderate and heavy, with recovery over a 60 year period. Under the full attack situation all stands $\geq$50 years old with $\geq$40% overstory pine are attacked by MPB and all pines are killed. MPB mortality is assumed to have begun in Ellis Creek one year ago and is expected to run its course over a five year period ending in 2014. Under the moderate MPB situation stands $\geq$50 years old with $\geq$40% overstory pine are potentially susceptible to MPB, but only 50% of such stands in the ESSF biogeoclimatic zone are killed. In other biogeoclimatic zones 65% of susceptible stands <100 years old and 80% of stands $\geq$100 years old are killed. Both runs are included for discussion purposes.

Scenarios include:

1. Un-salvaged - all susceptible pine is left to die with no salvage effort.
2. WTP 80+% PI - all susceptible stands with 80% or more pine are clearcut salvaged with 10% retained in wildlife tree patches. The remaining susceptible pine is left to die with no additional salvage effort.
3. Full salvage – pine leading stands that are both economic and operable are clearcut logged. The remaining susceptible pine is left to die with no additional salvage effort.
4. Complete salvage – economic and operable pine leading stands are clearcut logged along with all remaining susceptible pine in the watershed.

Scenarios 1 and 3 were specifically requested by BCTS; scenario 2 is included as a possible best management practice (BMP) for a watershed with significant downstream resources at stake, and scenario 4 is the worst case from a short term ECA perspective.

The risk assessment component of the project follows partial risk analysis methods as defined in BC Ministry of Forests - Land Management Handbook 56. Definitions for terms used in the risk assessment are as follows:

Risk assessment – involves the steps of preliminary assessment and risk estimation. It includes the systematic use of information to identify streamflow, sediment source, and riparian function related hazards and estimate the chance for, and severity of, injury or loss to individuals or populations, property, the environment, or other things of value (resources at stake).

Hazard – a source of potential harm, or a situation with a potential for causing harm, in terms of human injury, damage to property, the environment, and other things of value; or some combination of these. In watershed management increases in the frequency and magnitude of high flow events, sediment input to streams from roads and landslides, and reductions in riparian function are considered hazards.

Hazard rating – the measurement or expression of the likelihood of hazard occurrence, or probability of occurrence.

Consequence – the resource at stake (human well-being, property, the environment, or other things of value) and the change, loss, or damage to the resource(s) that may result from a landslide, road erosion event, high streamflow event, etc...

Risk – the chance of injury or loss as defined as a measure of the probability of hazard occurrence and the consequence of an adverse effect on the resource at stake.

4.0 ASSESSMENT

The Ellis Creek watershed is described in the following sections in terms of natural characteristics and processes, current condition from a peak flow, sedimentation, and riparian function perspective, and conditions expected under the no-salvage and full salvage scenarios requested by BCTS. An evaluation of risk with respect to resources at stake is provided for current condition and both the no and full salvage scenarios.

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4.1 Watershed Characteristics

Ellis Creek is a plateau-type watershed with low rolling terrain at mid to upper elevation, a steep well incised mainstem channel through the residual area, and a large fan in the valley bottom on which the City of Penticton is located [Appendix A]. Extensive landslide and dry ravelling slope inputs to the mainstem occur throughout the residual area, as noted previously, likely exacerbated by channel bank erosion during the 1941 dam break.

Four basins have been delineated in the watershed for discussion purposes following those defined in prior reports – E2, E3, North Fork Ellis or E4, and E5. Floodplains are present on the mainstem upstream of the fan and along all of the main tributaries to the point where they become first order channels on average. One other fan worth noting is present on the lower reaches of the E3 tributary where the channel loses confinement on the broad valley flat.

High flows most likely occur on Ellis Creek during the spring snowmelt period with the highest flows generated by rain-on-snow events typically in the late spring. The snowline location at the time of peak flow on the mainstem is expected to be near 1520 m in elevation on average, or H40 in hypsometric terms. The snowline elevation is likely higher on solar aspects in the E3 and E4 basins and possibly lower on more northerly slopes in the E2 basin. This snowline location is higher than that used in prior reports but supported by snowline mapping efforts completed elsewhere in the Okanagan-Shuswap region\(^6\) and experience.

Several lakes are present at mid to upper elevation in the residual, and E2 and E5 basins. The City of Penticton has developed storage on two of the lakes, the largest referred to as reservoir #4 in the upper residual area. The un-armoured spillway described in prior reports exits reservoir #4 north of the Carmi Road.

Key resources at stake in the Ellis Creek watershed and processes that affect them are as follows:

- Irrigation water quality and quantity at the City of Penticton intake - the system is not used for domestic water purposes for poor water quality reasons and the city has no intentions of using Ellis Creek as a domestic water source in the future according to city staff\(^7\). The irrigation resource can be affected by increases in sedimentation from both instream and upslope sources, and changes in water yield and the timing of runoff from areas above the snowline in particular.

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\(^7\) Personal communication, Len Robson, Public Works Manager, City of Penticton.
• Public and private land and infrastructure on the Ellis Creek fan in the City of Penticton. Affected by increases in peak flow and sedimentation, or reductions in riparian function on the lower reaches of Ellis Creek that result in mobilization and transport of sediment and debris onto the fan where accumulations at crossings can result in avulsions and flood related damage within city limits.

• Fish habitat in the residual area and Okanagan River downstream of the confluence with Ellis Creek. Kokanee are known to access the lower reaches of Ellis Creek up to a sewer line crossing barrier between Quebec and Fairford Avenues. Habitat on the fan is limited by access and both steep gradients and poor riparian function associated with confinement efforts within city limits. Rainbow trout are known to be present on and upstream of the fan but little is known about habitat value and limitations. It is assumed that both Kokanee and rainbow habitat can be affected by increases in sedimentation from instream and upslope sources and/or reductions in riparian function in the residual and on the fan.

4.2 Current Condition

Hazards

Current peak flow hazard ratings are low for the watershed and all basins. Approximately 26% (3882 ha) of the watershed has been harvested to date or burned recently; 20% (1260 ha) of the area above the snow line. Hydrologic recovery has been good above the snowline where the current ECA is 14%. Road related effects on runoff are considered negligible given the low rolling nature of the mid to upper watershed area, well drained soils, and low drainage density. Drainage diversion and concentration was noted along a portion of the Carmi Road in the residual area but its effect on flows would be negligible. The issue in that location is potential landslide occurrence resulting from drainage concentration on steep slopes connected to Ellis Creek and the E4 mainstem channel.

The current sedimentation hazard rating is high for the watershed but low in all basins. Natural inputs to the mainstem through the residual made worse by the 1941 dam break continue to impair water quality in a significant way [Photos 1, 2 – Appendix C], and likely reduce the quality of fish spawning, holding, and rearing habitat throughout the lower reaches of Ellis Creek and Okanagan River downstream of the confluence. The reservoir #4 spillway remains the most significant land-use related source of sediment when active [Photos 3, 4, 5]. The city currently minimizes sediment generation from this source by limiting use. Further reduction in sediment generation could be achieved by enlarging and armouring the entire channel from source to confluence with Ellis Creek. The City of Penticton is also a source of fine sediment and other contamination to the
lower system with the privately owned and operated gravel pit at the fan apex being the most significant contributor during rainfall and snowmelt periods. Improved sediment controls in the pit and an attempt to filter storm water or reduce the volume of material available for erosion into the system during rainfall and snowmelt periods could reduce inputs in this regard. Forest road conditions are good and related sediment inputs are small when compared to background levels but there are several priority road sites or sections in the watershed where current or expected sediment generation levels justify some attention. Sites, details, and recommended treatments include:

- **Carmi Road crossing on E4 mainstem channel** [Photos 6, 7, 8, 9] – a metal culvert is in place on this S3 floodplain channel. Active erosion of fill is occurring at the inlet and outlet. The structure is expected to fail with accumulations of mobile sediment and debris during high flow events and is currently an active source of sediment. Replacement with a more suitable span structure would address the issue. Alternatively the crossing could be armoured to prevent road prism failure in the event of blockage. This site is maintained by the Ministry of Transportation (MOT).

- **Carmi Road crossing on reservoir #4 spillway channel** [Photo 10]. Multiple metal culverts are in place downstream of an actively eroding portion of the spillway channel. Accumulations of sediment and debris at culvert inlets could result in road prism failure. A span or oversized culverts in this location would address the issue or the crossing could be armoured to prevent erosion in the event of existing structure blockage. This site is also maintained by MOT.

- **Carmi Road, maintained by MOT, between the point where it enters the Ellis watershed and crossing on the E4 mainstem channel.** Low cross drain frequency on this section is causing drainage diversion and concentration to existing culvert sites located above steep slopes connected to the Ellis and E4 mainstem channels. Installation of cross-drains on natural drainage courses lacking structures at this time would address the issue. A plan prepared by a qualified professional would be required to ensure proper sizing and placement.

- **The following FSR crossings:**
  - Ellis Creek FSR on the E3 mainstem fan [Photo 11], E4 mainstem channel and S4 tributary in the E5 basin [Photo 12]; and
  - Derenzy FSR on the S3 tributary in the E2 basin [Photo 13] and the S3 tributary on the south side of the residual area.

  All sites involve culverts on channels with narrow floodplains and mobile sediment and debris. Replacement with suitable span structures or armouring to prevent erosion in the event of failure will address the issue. In the case of the Derenzy S3 crossing in the residual the existing
structure is backed up with a cross ditch but not armoured. Failure of the structure will erode the cross-ditch and road prism if not protected.

The riparian function hazard is high for the watershed based on disturbance associated with the 1941 dam break [Photos 2, 14], and significant reductions in riparian function and effects on natural fan processes in the City of Penticton. Riparian function is good in the basins with intact riparian vegetation in fan and floodplain areas providing stability for the channels. The channel on the fan in the City of Penticton has been straightened and confined using a combination of rip-rap derived from historic alluvial deposits [Photo 15] and concrete structures. The removal of riparian vegetation and containment efforts have restricted the ability of the Ellis Creek fan to dissipate flow related energy and sedimentation over the fan surface, but not eliminated it. Avulsions or change in channel course resulting from erosion of levees built using alluvial materials, or accumulations of sediment and woody debris at road crossings within city limits are considered possible during low return interval events such as 1 in 50 and 1 in 100 years. Restrictions on natural fan and riparian processes have also increased sediment delivery potential to the Okanagan River and reduced the quality and quantity of fish habitat on the fan. Ongoing recovery is expected in riparian areas upstream of the fan but the restoration of natural fan processes within city limits is considered unlikely.

**Risk**

There is currently a moderate risk of water quality impairment with respect to its intended use for irrigation at the City of Penticton intake. Significant negative effects on water quality are occurring as a result of natural and to a lesser degree land-use related sediment inputs, but the City of Penticton is limiting the effect on end users by restricting use to irrigation only and making users aware of the poor water quality condition. Clearly, good water quality is not required for irrigation purposes but it is likely that improved water quality would be of benefit to all involved.

There is a moderate risk of damage to the Carmi Road and FSR infrastructure, and associated inputs of sediment to streams from problem sites noted above as a result of expected culvert washouts during high flow events. Structure replacement or improvements as described above will address the issue in all cases.

There is a low risk of changes in water quantity and the timing of flows at the irrigation intake as a result limited forest development to date and good regeneration in old cutblocks. Past harvesting related effects on water yield and the timing of runoff are considered negligible at this time.
There is currently a moderate risk of damage to or loss of public and private property and infrastructure during high flow events on the fan within the City of Penticton. Avulsions on the fan are possible as a result of the use of alluvial materials in channel containment levees, reductions in riparian function on the fan, and high sediment loads, but the peak flow hazard is low for the watershed and the city has the ability to prevent or minimize disturbance associated with avulsions or other high flow related damage within city limits through the mobilization of heavy equipment on short notice.

Currently there is a high risk of negative effects on fish and fish habitat resulting from the high sediment load situation, reductions in riparian function on the fan, efforts to contain the channel within city limits, and restrictions or barriers to fish passage created by concrete structures within the fan channel and head pond containment dam at the fan apex [Photo 16].

**4.3 Mountain Pine Beetle Scenarios and Expected Condition**

Pine in the Ellis Creek watershed has recently been affected by mountain pine beetle. Mortality levels have been low so far but ongoing attack is expected by BCTS staff. To understand the potential for attack and likelihood of mortality, stand susceptibility was determined using stand age, species composition, and biogeoclimatic zone considerations. Results indicate pine leading stands occupy 56% of the watershed [Appendix A]. Of the total pine leading stands 33% are considered highly susceptible to some level of attack and mortality, 55% are considered moderately susceptible, and 11.6% have a low susceptibility. Some mortality is expected in all and large portions of the area above the snowline are expected to be affected to some degree.

The result of MPB infestation in Ellis Creek will be a reduction in forest cover over time as dead pine become defoliated and eventually fall and deteriorate on the forest floor. Reductions are offset by non-pine overstory in the stand or understory that is released by the demise of pine. Regeneration within the dead stand can also occur helping to offset effects over time. Reductions in forest cover will result in increases in snow accumulation and snow melt rates in openings, making more water available for runoff earlier, and potentially increasing the frequency and magnitude of high flow events (i.e. peak flows) particularly where reductions occur above the snow line. Water yield can also increase over the short to medium term as water use by trees is reduced as the stand is replaced. The opposite situation can also occur with reduced water yield over the medium to long term if large areas affected by pine beetle regenerate at the same time creating a single dominant seral stage situation. In the latter case, large areas of young vigorous regeneration can be expected to uptake or use more water than that used by the older pre-MPB stand resulting in lower
groundwater levels and less water available for runoff. Low flows can be affected by increased water use during the growing season.

Riparian areas can be affected by MPB if pine are present but the effect on channels is expected to be beneficial provided accumulations of woody debris do not create hazardous situations with respect to jams, avulsions in fan or floodplain areas, and resources at stake. Input of MPB killed woody debris to the mainstem in the residual area is a concern in this regard as materials input to the channel in this area can be transported to the fan during high flow events. Salvage of pine from this area is not likely based on operability so this affect should be anticipated and managed for by stakeholders in downstream areas (i.e. City of Penticton).

Salvage of affected or potentially affected stands using clearcut or selective methods essentially expedites the reduction in forest cover making more water available for runoff in the short term but can also expedite the recovery process if sites are planted shortly after harvest. Salvage also requires the construction and use of additional forest roads. Salvage in riparian areas is not considered appropriate for reasons provided above and salvage in adjacent areas can result in wind related damage to management and reserve zones.

**Un-salvaged scenario**

Under the un-salvaged scenario MPB effects are allowed to progress through the Ellis Creek watershed unchecked by salvage activity.

**Hazards**

Under the un-salvaged scenario riparian function should not be significantly affected by MPB attack but the hazard will remain high for the watershed based on prior disturbance along the lower mainstem and on the fan in the City of Penticton. Riparian hazards in the basins should remain low. Non-pine species make up a strong proportion of stands in riparian areas, particularly those on fan and floodplain features. Pine that is killed in riparian areas can contribute large woody debris to channels which is seen as a natural process; episodic in nature in fire and insect dominated stands.

The peak flow hazard for the watershed will increase to moderate under the un-salvaged scenario *[Figure 1]*. The equivalent clearcut area (ECA) above the snowline for the watershed will reach a maximum of 45% under the full MPB situation; 29% if only moderate levels of mortality occur. The ECA will remain in the moderate hazard category (25-50%) for approximately 40 years under the full MPB situation; approximately 10 years under the moderate situation. Recovery could be expedited by under-planting affected stands using Forests For
Tomorrow (FFT) funding. Peak flow hazards will also increase in the basins [Figures 2 – 4] with high hazard levels being reached in the E2 basin under the full MPB situation. The peak flow hazard in E5 will decrease from moderate to low over time [Figure 5] as the extent of pine is limited.

The sedimentation hazard for the watershed will increase to very high based on natural background levels and an expected increase in channel bed and bank erosion resulting from an increase in the frequency and magnitude of high flow events. Large inputs of sediment to the mainstem may also occur as banks are undercut in the canyon. The poor water quality situation will be exacerbated by this increase in the flow and sedimentation hazards. Sedimentation hazards in the basins will also increase to moderate where affected by MPB as a result of increased in bed and bank erosion and likelihood of washout at problem road sites.

![Figure 1. Equivalent clearcut areas for Ellis Creek watershed above the snowline under moderate and full attack situations for four scenarios – un-salvaged, WTP 80+ %Pl, Full salvage, and Complete salvage.](image)
Figure 2. Equivalent clearcut areas for the E2 basin above the snowline.

Figure 3. Equivalent clearcut areas for the E3 basin above the snowline.
Risk

The risk of water quality impairment with respect to its intended use will remain moderate under the un-salvaged scenario despite an expected increase in sedimentation at the intake. The system is currently being managed effectively for irrigation with no intent to treat the water for domestic purposes.

The risk of washout and associated input of sediment to channels will increase to high at problem sites on the Carmi Road and FSR’s mentioned previously under
the un-salvaged scenario. Risk can be mitigated in all cases by replacing or improving the crossings as described.

There is a low risk of changes in water quantity at the irrigation intake over the short term, increasing to moderate over the medium term as large areas affected by MPB regenerate naturally. Water yield can be expected to increase over the short term under the un-salvaged scenario as increases in snow accumulation will occur with defoliation. Runoff and peak flows can also be expected to occur earlier during the freshet period. Increases in the loss of snow through sublimation should also be expected over the medium term combined with increased uptake as sites regenerate making less water available for runoff in the future. This should be a concern for the water purveyor (City of Penticton) that could be partly offset by increasing or developing new storage in the watershed.

The risk of damage to or loss of public and private property and infrastructure during high flow events on the fan within the City of Penticton will increase to high under the un-salvaged scenario. Sediment and debris transport to the fan will increase with increases in peak flow, bank erosion, large woody debris input, and possible landslides into the channel upstream of the fan. At a minimum, increased maintenance of the head pond facility will be required. In the worst case channel avulsions on the fan occur resulting in widespread flooding within city limits. Risk can be mitigated by improving channel fortification, facilitating sediment and debris transport through the system, and preparing quick response plans for use during high flow periods.

The risk of negative effects on fish and fish habitat on the Ellis Creek mainstem and Okanagan River downstream of the confluence will increase to high under the un-salvaged scenario. Expected increases in stream sedimentation will further degrade instream habitats and reduce water quality, generally. Little can be done to offset this situation given the condition of the fan within city limits but reductions in sediment input to channels from road and spillway related sources could be achieved.

**Full salvage scenario**

Under the full salvage scenario areas shown as pine leading and economic and operable on the overview map [Appendix A] are clearcut with no retention; wildlife tree patch (WTP) or otherwise.

Under the full salvage scenario the key consideration is incremental effect(s) on domestic water quality and quantity as defined in the BCTS FSP that may result from primary forest activities. As Ellis Creek is not used for domestic water purposes, despite the community watershed designation, incremental effects of development on domestic water quality and quantity are impossible. The City of
Penticton has no intention of treating Ellis Creek water for domestic purposes. If additional supply is required they will look to Okanagan Lake and not additional surface sources.

However, other resource values on the Ellis Creek fan in particular warrant a cautious approach as incremental effects on hazard and risk are likely under the full salvage scenario.

**Hazards**

A total area of 3,700 ha or 25% of the watershed is pine leading and economic and operable from a salvage perspective; 1785 ha of which is located above the snowline. The peak flow hazard would increase to high for the watershed (ECA>50% above the snowline) with development under the full salvage scenario and full MPB attack and mortality situation [Figure 1] which represents an incremental increase in hazard over the un-salvaged scenario. The peak flow hazard would remain in the moderate category (ECA 25-50% above the snowline) under the moderate MPB situation but ECA does increase. In the basins, peak flow hazards will increase incrementally under full salvage in E2, E3, and E4 under the moderate situation but E4 only under the full MPB situation [Figures 2 – 4]. Basin E5 is unaffected. The incremental effect is greater under the moderate situation as stands that may not be affected by MPB are salvaged in anticipation of a heavier attack. It is important to also note that recovery does not occur sooner under the full versus un-salvaged scenario. Recovery differences that do appear in the figures are considered within the margin of error for the analysis.

The sedimentation hazard remains very high under the full salvage scenario. The incremental increase in peak flow is expected to further exacerbate an already very high hazard situation. Sedimentation hazards in the basins are expected to increase from moderate to high in E2 and E4 as a result of the increased peak flow hazard, and expected increase in bed and bank erosion and likelihood of washout at problem road sites. Additional road construction and use required to salvage MPB affected areas is not expected to affect sedimentation levels beyond problem sites mentioned above.

The riparian function hazard is high and should not be affected under the full salvage scenario provided critical riparian areas, particularly those in fan and floodplain areas, are retained and protected from wind related damage in particular.

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8 Personal communication, Len Robson, Public Works Manager, City of Penticton.
Risk

The risk of damage to public and private property and infrastructure in the City of Penticton can be expected to increase to very high under a full salvage scenario. This result is the function of a high peak flow hazard (ECA >50% above the snowline) under the full MPB attack and mortality situation and a high consequence rating. Risk can be mitigated by retaining a portion of the economic and operable pine leading stands above the snow line in the watershed, and E2 basin in particular to maintain the moderate peak flow hazard level expected under the un-salvaged scenario. The E2 basin is expected to be the main contributor of runoff during the highest flows as a result of its northerly aspect and high potential ECA level under the full salvage scenario.

The WTP 80%+Pl scenario may provide some direction in this regard. Under this scenario all susceptible stands with 80% or more pine are clearcut salvaged with 10% retained in wildlife tree patches, as per current legislation. The remaining susceptible pine is left to die with no additional salvage effort. Most of the stands that meet these criteria are located in moderate and high MPB susceptibility areas as shown on the overview map [Appendix A]. If the moderate MPB attack and mortality situation occurs, the WTP 80%+Pl scenario would minimize the incremental effect of salvage over the un-salvaged scenario and provide the quickest recovery from a medium and long term ECA perspective. Similar effect would be realized in the E3, and E4 basins but not the E2 basin. More retention above the snowline in E2 would be required to minimize incremental effects of salvage over the un-salvaged scenario. It is important to note that these beneficial effects with respect to ECA under the WTP 80%+Pl scenario would not be realized under the full MPB attack and mortality situation. Careful monitoring of MPB attack and mortality would therefore be required to effectively implement this risk mitigation strategy.

The risk to fish and fish habitat on lower Ellis Creek and the fan will also increase to very high under the full salvage scenario. This result is also the function of high hazard and high consequence ratings and can be mitigated as above.

The risk of damage and associated stream sedimentation at the Carmi Road and FSR problem sites is expected to remain high under full salvage. Risk can be mitigated in all cases by replacing or improving the structures as described above.

Full salvage would not affect the risk of changes in water quantity at the City of Penticton intake nor water quality given use for irrigation purposes only.
5.0 RECOMMENDATIONS

5.1 Stewardship

- Make other stakeholders in the Ellis Creek watershed aware of the extent of mountain pine beetle infestation, expected increase in peak streamflow and sedimentation levels on Ellis Creek and its tributaries, and BCTS intent to salvage some of the affected stands in the watershed using guidelines provided in this assessment. Specifically:

- Notify the City of Penticton with regard to:
  - Location and extent of the Ellis Creek alluvial fan, natural processes to be expected in alluvial fan environments, expected increase in channel bed and bank erosion on and upstream of the fan, increase in sediment and debris transport to the head pond and required maintenance activities, and increase in the likelihood of major channel forming flows that could result in sediment and debris accumulation at existing structures within city limits leading to possible diversions and flood related damage. The highest flows should be expected in years with average or higher snow accumulation, a late melt, and a rain on snow event. High peak flow hazard conditions should be expected to persist for up to 30 years regardless of any planned salvage activity.
  - Sediment production associated with the undersized and un-armoured spillway channel from Reservoir #4 and mitigation opportunities that include:
    - limitations on use achieved by drawing reservoirs down in the early spring period in an attempt to minimize spillage during the fresht, and
    - armouring of the channel between the reservoir outlet and confluence with Ellis Creek.
  - Opportunity to mitigate potential MPB effects on channel stability and flooding within city limits by decreasing erodability of existing levees and other containment structures on Ellis Creek, improving the system’s ability to pass sediment and mobile woody debris during high flow events, and preparing quick response plans for flood protection.
  - Opportunities to offset reductions in water yield expected with MPB over the medium term by increasing storage in the watershed.
  - Opportunities to reduce sediment input to Ellis Creek within city limits by placing additional sediment control constraints on the private gravel pit near the fan apex, and either filtering storm water
runoff or making less material available for input to the system from within city limits during rainfall and snowmelt periods.

- Make the BC Ministry of Forests aware of undersized and/or damaged structures at priority sites on Forest Service Roads under their care in the Ellis Creek watershed, and associated opportunities for mitigation that include:
  - replacement with span structures better suited to channels with mobile sediment and debris,
  - use of armoured fords on inactive roads, or
  - armouring of fill through existing crossing sites to prevent erosion and/or diversion in the event of structure failure.

- Make the BC Ministry of Transportation aware of the following items on the Carmi Road:
  - high priority crossings on the E4 mainstem and reservoir #4 outlet channel and opportunities for mitigation that include replacement with span structures better suited to streams with mobile sediment and debris, or armouring, and
  - high priority section between the lower watershed boundary and E4 mainstem crossing associated with low cross-drain (culvert) frequency resulting in drainage diversion and concentration above steep slopes connected to Ellis Creek.

- Make BC Ministry of Environment aware of potential fish passage issues associated with a known sewer line related barrier to Kokanee passage within city limits and the head pond containment dam.

- Make application to the BC Ministry of Environment to have Ellis Creek de-listed as a community watershed based on its use for irrigation purposes only according to City of Penticton staff, and no intent to treat the water for domestic purposes over the long term.

### 5.2 Forest Management

- Address moderate and higher risk road sites on Forest Service Roads under BCTS care using a combination of crossing structure upgrades, culvert installations, and armour application as described above. Works should be completed prior to or in conjunction with any planned salvage activity – there may be opportunities to recover some cost associated with the work through the appraisal program on roads to be used for salvage activity.
• Focus forest development effort in Ellis Creek on the salvage of mountain pine beetle affected stands with the objective to minimize any incremental effects on risk by:
  
  o Targeting stands below the snowline in all basins and the residual area where no effect on peak streamflow levels are expected. There are approximately 1,900 ha of potential pine salvage in this area according to the susceptibility model.
  
  o Monitoring MPB attack and mortality above the snowline to determine if the moderate or full attack situation is occurring.
    
      ▪ In the event of moderate attack, target dead or dying stands in the residual and E3, E4 (North Fork), and E5 basins with 80% or more pine as determined by field surveys. Based on high expected ECA’s in the E2 basin regardless of attack level only 10% of the basin area above the snowline (~200 ha) should be salvaged with a preference for 100% pine if possible. Pre-emptive salvage is not recommended in any of the basins.
    
      ▪ In the event of full attack as described by the model target dead or dying stands in the residual, E3, E4, and E5 basins with 80% or more pine as determined by field surveys, but with a preference for solar aspects near the snowline. Salvage should be avoided above the snowline in the E2 basin.
    
  o Retaining and protecting critical riparian areas as part of any salvage activity, particularly those associated with mapped alluvial fan and floodplain areas. Windthrow in retained riparian areas will be an important consideration in this regard.

• Look for opportunities to enhance pine growth or re-growth in areas that are not salvaged for economic reasons. Treatments could include thinning to release un-economic green pine stems and/or under-planting in dead pine areas to facilitate recovery. Both activities are eligible for Forests For Tomorrow (FFT) funding.

• In areas that are not treated as per the above recommendation, plan for site preparation and planting after deadfall has occurred if the site has not regenerated naturally. Deadfall can be expected to occur in these areas between 10 and 20 years from the date of report completion.
6.0 CLOSURE

This report dated January 2010 has been prepared exclusively for BC Timber Sales Okanagan-Columbia Business Area. M.J. Milne & Associates Ltd. accepts no responsibility for use of this document for purposes other than the management of forest and water related resources on behalf of BCTS in the Ellis Creek watershed.

This concludes the hydrologic risk assessment of the Ellis Creek watershed. We trust that the information contained herein is complete and consistent with the scope of work assigned to M.J. Milne & Associates Ltd.

Michael J. Milne  M.E.S.  04/12/10
Watershed Hydrologist
ABCFP Limited Licensee #0004
**Alluvial Fan**

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<tr>
<th>Polygon Type</th>
<th>Description</th>
<th>Management considerations</th>
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<tr>
<td>Alluvial Fan</td>
<td>Conical-shaped landscape feature formed by the deposition of sand, gravel, cobbles, boulders and organic debris when confined streams enter a larger valley. Found most frequently in lower slope locations but can occur wherever small streams join larger channels, or streams flow into lakes or onto low gradient floodplain or terrace areas. Deposition on fans can be strictly alluvial (flowing water related), a combination of alluvial and debris flow related, or strictly debris flow related. Alluvial fans can have active and relic (inactive or historic) areas, with active areas normally incised into and smaller in extent than relic areas. Relic fans or portions of fans are normally stable, built during earlier periods when the watershed had either higher streamflows and/or sediment transport levels, or in the case of lake or marine deposition during higher stage periods (i.e. higher water levels). Numerous old, abandoned, or high flow (distributary) channels can be present in active fan areas that provide valuable fish habitat during high flow periods. It is important to note that fish may access these channels from their confluence with the larger valley bottom stream or water body. The active portion(s) of alluvial fans are sites of constant interplay between supply of water and sediment. Aggradation occurs if sediment load increases, gradually in the case of alluvial or fluvial action, rapidly in the case of debris flow deposition (either naturally or due to land-use activity). Degradation or scour occurs if sediment load is reduced. Aggradation is the primary cause of channel re-alignment or avulsion on fans. Both standing and downed trees and understory vegetation on fans and in fan channels play an important role in fan stability and the dissipation of energy; both flow and sediment related. Forest development on alluvial fans and within large woody debris contribution areas for fans can reduce channel bank and fan stability, restrict fish access, and increase both short and long-term erosion. Alluvial fans can be the most sensitive depositional feature on the landscape and if de-stabilized can take one full tree crop rotation (50 to 250 years) to recover depending on fan size, stream power, and sediment load.</td>
<td><strong>Goal:</strong> Maintain short and long-term fan and fan channel stability and fish access to off-channel habitat areas. <strong>Management:</strong> The presence and extent of active fan and large woody debris contribution areas should be confirmed in the field and mapped prior to any road or cutblock layout. Little or no road and trail construction should occur within active fan areas. Road crossings on fan channels should be placed above or as close to the fan apex as possible (uppermost point where the tributary channel enters the larger valley). Where roads and trails are required on fans overland construction methods are recommended with careful route selection to minimize effects on fan drainage and fish access to off-channel habitat areas. Climbing and descending grades on fans should be avoided at all times. Crossings on active and high flow channels should be designed to contain flow and minimize erosion in the event of failure or overtopping of the road surface. Maintenance of un-logged stand characteristics should be the primary objective in active fan areas and within large woody debris contribution areas. Retention rates should range from 70% retention to full retention with a preference given to large trees. Where harvesting is considered, single tree selection, group selection, or small patch cuts are best suited to meet riparian stand structure requirements. Windthrow in large woody debris contribution and active fan areas should be an important consideration in any harvesting plans that are prepared within or near to these features.</td>
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| Floodplain   | Defined as the area adjacent to stream channels that is either inundated or saturated during high flow periods. Floodplains are normally bounded by a distinct break in slope and obvious transition in vegetation type. Floodplain deposits are alluvial (transported and deposited by flowing water) in nature and erodable if riparian vegetation is not present and/or functional. Floodplains typically contain many side channels, old channels, and other depressions that provide valuable fish habitat during high flow periods. Road construction in floodplain areas can restrict or prevent fish access to these habitat features. A stream channel can change course on its floodplain several times within a harvest rotation via active bank erosion and channel avulsion. Bank erosion and avulsion processes can be accelerated by forest harvesting that removes vegetation required for bank and floodplain stability. Standing and downed trees and understory vegetation on the floodplain play a critical role in reducing flood flow velocity, and reducing potential erosion and downstream sedimentation. Mature timber within a minimum of one tree length from the floodplain margin (referred to as the large woody debris contribution area) also plays a role in floodplain stability and erosion control. Floodplains are highly sensitive to disturbance and if de-stabilized, recovery may take up to one full tree crop rotation (50 to 250 years) depending on stream power, proximity to major sediment sources, and sediment load. | **Goal:** Maintain short and long term channel and floodplain stability, and fish access to off-channel habitat areas.  
**Management:** The extent of active floodplain and large woody debris contribution areas should be confirmed in the field and mapped prior to any road or cutblock layout. Little or no road and trail construction should occur within floodplain areas. Where roads and trails are required overland construction methods should be used with careful route selection to minimize effects on floodplain drainage and fish access to off-channel habitat features. Crossings on active channels should be designed to pass all flow with entrained sediment and debris, or fail in a safe manner such that sediment production and effects on natural drainage patterns are minimized. Fish are an important consideration in this regard. Maintenance of un-logged stand characteristics should be the primary objective on floodplains and within large woody debris contribution areas. Retention rates should range from 70% retention to full retention with a preference given to large trees. Where harvesting is considered, single tree selection, group selection, or small patch cuts are best suited to meet riparian stand structure requirements. Windthrow in large woody debris contribution areas and on the floodplain should be an important consideration in any harvesting plans that are prepared within or near to these features. |
Photo 1. Fine sediment accumulation at City of Penticton head pond in lower residual area. Accumulations are considered high and expected to increase with MPB related increases in streamflow and subsequent bed and bank erosion in upstream areas.

Photo 2. Recovering riparian area on Ellis Creek mainstem near Carmi Road crossing. All of the vegetation on the floodplain was removed during the 1941 dam break event.
Photo 3. Evidence of significant erosion and down-cutting on City of Penticton spillway from reservoir #4 downstream of the Carmi Road crossing. The presence of some vegetation on mid-channel bars may indicate less activity resulting from efforts to minimize use during the freshet period. Use is expected to increase with MPB related increases in runoff in the upper watershed.

Photo 4. City of Penticton spillway from reservoir #4 downstream of point shown in photo 3.
Photo 5. Large fan at spillway confluence with Ellis mainstem built from materials derived from erosion of un-armoured channel above.

Photo 6. Upstream view of erosion in un-armoured floodplain materials at Carmi Road crossing on E4 mainstem.
Photo 7. Culvert inlet at Carmi Road crossing on E4 mainstem channel. The structure is undersized with respect to natural sediment and debris transport processes in this location.

Photo 8. Outlet of structure at Carmi Road crossing on E4 mainstem. Note erosion in alluvial materials and barrier to fish passage if present.
Photo 9. Erosion at outlet of structure on Carmi Road at E4 mainstem crossing. The structure is too short for the site and as such was installed incorrectly with outflows eroding historic floodplain materials adjacent to the natural channel.

Photo 10. Culvert inlets on Carmi Road at reservoir #4 spillway crossing. The structures are downstream of an actively eroding section of channel where input of large woody debris is common. Accumulation of sediment and debris at inlets can result in blockage and erosion of the road prism.
Photo 11. View of E3 mainstem crossing on Ellis Creek FSR. The site is on a fan where a backup culvert has been installed on the down chain side. The ditch block is low allowing flows to escape down the ditch during high flow periods. Given natural processes in fan environments, armoured crossings or spans may be more appropriate from a potential sediment generation perspective.

Photo 12. Partly blocked culvert on S4 channel in E5 basin – Ellis Creek FSR.
Photo 13. Derenzy FSR crossing on S3 mainstem in E2 basin. A narrow floodplain is present with mobile sediment and debris. Accumulations at the inlet can result in failure with erosion of the road prism or diversion down the ditchline.

Photo 14. Ellis Creek mainstem showing recovering riparian vegetation from 1941 dam break event.
Photo 15. Ellis Creek upstream of gravel pit near fan apex in the City of Penticton. The channel has been dredged and leved using alluvial materials that can be eroded and transported during high flow events. Riparian vegetation is limited but can also become mobile with erosion.

Photo 16. Upstream view of spillway from City of Penticton head pond. This structure may be affecting resident fish passage between the fan and lower mainstem channel.