Lambly Creek Community Watershed

Source Assessment Report

Prepared for

Lakeview Irrigation District

Prepared by

DOBSON Engineering Ltd.

September 2010

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Lambly Creek Source Assessment Report

1. INTRODUCTION

1.1 PROJECT SCOPE

The Lambly Creek Source Assessment Report has been prepared in response to a requirement in the water system Operating Permit issued by the Interior Health Authority to the Lakeview Irrigation District. Lambly Creek is the source of water supply for Lakeview Irrigation District (LID). LID has operated as an improvement district since 1951 and services a population of approximately 11,000 residents. The service area within the District boundaries covers approximately 930 hectares of which 226 hectares are irrigated orchard. There were an estimated 3,300 service connections providing potable water (refer to watershed maps in Appendix A).

The intent of a source assessment is to identify and evaluate the hazards to drinking water quality and quantity, characterize the risks and propose risk management strategies. Water source assessments as referenced in Part 3, section 18 of the *Drinking Water Protection Act* is the first step in Health Canada's multi-barrier approach to safe drinking water. The Ministry of Health and the Ministry of Water, Land and Air Protection, provide guidance in the draft *Comprehensive Drinking Water Source to Tap Assessment Guideline* released in March 2005. The key elements to be considered in this project are: Modules 1, 2, 7 and 8 of the guideline. The four guideline modules are summarized in the following sections.

Module 1

Module 1 includes the following tasks:

- Delineate the watershed and characterize the water source upstream of the intake on Lambly Creek.
- Characterize the watershed including the influences of the mountain pine beetle and proposed harvesting.
- Consider the potential impacts of climate change on the water supply.
- Consider the possibility of developing new storage and diverting runoff into existing reservoirs from outside the watershed.
- Prepare maps illustrating the location of all infrastructure, the source area and assessment area boundaries, and bio-geophysical information; digital mapping should to be compatible with local government and water purveyors GIS systems.

Module 2

Module 2 includes the following tasks:

- Update the *Interior Watershed Assessment Procedure* (IWAP) report. A component of this module will include the update of the 1998/2001 Lambly Creek IWAP reports using the IWAP Guidebook produced by the Ministry of Forests dated April 1999. The update will include a review of works completed from past to present and assessments on peak flows and hydrologic recovery, sediment source survey, reconnaissance channel assessment procedure, and a riparian assessment focusing on impacts to water quality and quantity. The IWAP report includes a summary of the overall equivalent clear-cut area (ECA), and the road density to the end of 2007. The last update of the forest development data was to the end of 2007.
- Conduct a contaminant source inventory of the watershed area upstream of intake based on an office review of potential contaminants and reconnaissance field inspections.

Module 7

Module 7 includes the following tasks:

- Evaluate the public health protection barriers in place in the watershed.
- Provide a drinking water risk assessment based on the identified hazards and barriers.

Module 8

Module 8 includes the following tasks:

- Develop recommendations to improve drinking water safety and sustainability.

Source Assessment Report

- Supply a Watershed Source Assessment Report based on the results from the *Comprehensive Drinking Water Source to Tap Assessment Guideline* Modules 1, 2, 7 and 8 including the results of the updated IWAP and best practices for protection of water quality, that will form the basis of the Assessment Response Plan as required by Part 3, Section 22 of the *Drinking Water Protection Act.*

1.2 PROJECT TECHNICAL ADVISORY COMMITTEE (TAC)

Section 19 of the *Drinking Water Protection Act* provides the authority to the drinking water officer to order a water supplier to prepare an assessment. Since the requirement for a plan has been included as a requirement in the Operating Permit issued by IHA to LID, it was appropriate to create a technical advisory committee that included representatives from IHA and the Ministry of Environment (MoE) as part of the planning process that could provide input and offer review comments as the plan was developed.

The advisory committee for this plan included the following:

Dale Thomas - IHA
Rob Birtles - IHA
Solvej Patschke – MoE

The project consultant was Dobson Engineering Ltd., Kelowna, BC.

1.3 DESCRIPTION OF THE LAKEVIEW IRRIGATION DISTRICTS INFRASTRUCTURE

The infrastructure that has been developed by LID is illustrated on the maps in Appendix A and includes:

- Big Horn Reservoir
- DunWaters Diversion
- Esperon Reservoir
- Lambly Creek intake
- Rose Valley Reservoir
- Rose Valley intake and chlorinator

LID holds water licenses to store approximately 8,634 ML of water. Storage in the Big Horn Reservoir is supplemented with runoff from the DunWaters diversion that diverts runoff from the upper Shorts Creek watershed. LID operates its system by diverting and storing the spring runoff from the high elevation snowmelt in the Esperon and Big Horn Reservoirs. The supply system consists of a diversion works on Lambly Creek approximately ~5.5 km upstream from Okanagan Lake and a 6 km long pipeline to the Rose Valley Reservoir that is the terminal reservoir.

LID has connected the intake on Lambly Creek to its SCADA system and monitors flows and turbidity levels. During turbid flow periods, LID staff can now close the diversion line to prevent turbid water from entering the Rose Valley Reservoir. LID provides chlorination at the distribution system intake at the Rose Valley Reservoir. The reservoir is equipped with an aeration device near the intake to increase the dissolved oxygen levels.

1.4 ASSESSMENT APPROACH

This report presents the results for Modules 1, 2, 7, and 8.

The IWAP update has been included as part of Module 2. The Ministry of Forests described the purpose of a WAP as follows:

> *The Watershed Assessment Procedure (WAP) is an analytical procedure to help forest managers understand the type and extent of current water-related problems that may exist in a watershed, and to recognize the possible hydrological implications of proposed forestry-related development or restoration in that watershed. The WAP considers the cumulative effects of forest practices on the aquatic environment. The assessment of hydrological impacts focuses on: 1) the potential for changes to peak streamflow; 2) the potential for accelerated landslide activity; 3) the potential for accelerated surface erosion; 4) channel bank erosion and changes to channel morphology as a result of logging the riparian vegetation; 5) the potential for change to the stream channel; and 6) the interaction of all of these processes, an evaluation of which indicates the sensitivity of the watershed to further forest development. The assessment also draws attention to natural processes occurring in the watershed. Using the results of a WAP, forest managers can make recommendations to prevent or mitigate the impacts of forestry-related activities in the watershed. Results can also be used to guide watershed restoration activities.*[1]

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[1] Interior Watershed Assessment Procedure Guidebook. Second Edition, Version 2.1, 1999. Ministry of Forests.

The WAP process was modified to include a review of all impacts in the watershed, in addition to forestry, that affect the source water. The WAP process provides useful data on the change in disturbances resulting from forest development over time and this data can also be used to assess the change in other impacts such as grazing and recreation that are related to changes in access.

The purpose and typical content of a source assessment plan as outlined in Section 18 of the *Drinking Water Protection Act* are:

The purpose of an assessment is to identify, inventory and assess:

(a) the drinking water source for the water supply system, including land use and other activities and conditions that may affect that source,

(b) the water supply system, including treatment and operation,

(c) the monitoring requirements for the drinking water source and water supply system, and

(d) the threats to drinking water that is provided by the (water) system.[2]

The results from the 2008 contaminant field inventory are provided in Appendix B as well as the results of the road assessments. A copy of the watershed field map indicating the location of all the identified crossings with identification (ID) numbers is provided as Map 3 in Appendix A. The "Xing ID" refers to the crossing numbers shown on the map.

1.5 REFERENCES

- BC Ministry of Health Services, BC Ministry of Water, Land and Air, 2005. *Comprehensive Drinking Water Source to Tap Assessment Guideline (draft)*.
- BC Water & Waste Association, 2005. *Comprehensive Drinking Water Source to Tap Assessment Pilot Program*.
- BC Water & Waste Association, 2005. *Windermere Water Works Comprehensive Source to Tap Pilot Assessment – Modules 1 & 2*.
- Isaac-Renton, J., Moorehead, W., Ross, A., *Longitudinal Studies of Giardia Contamination in Two Community Drinking Water Supplies: Cyst Levels, Parasite Viability, and Health Impact.*
- Dobson Engineering Ltd., 2001, *Water Quality Project Annual Report for 2000-2001*. TFL 49 Forest Stewardship Project.
- Dobson Engineering Ltd., 2002, *Water Quality Monitoring for the TFL 49 Forest Stewardship Project – 2001 Annual Report*. Riverside Forest Products Ltd.
- Dobson Engineering Ltd., 2003, *Water Quality Monitoring for the TFL 49 Forest Stewardship Project – 2002 Annual Report*. Riverside Forest Products Ltd.
- Dobson Engineering Ltd., 2004, *Water Quality Monitoring for the TFL 49 Forest Stewardship Project – 2003 Annual Report*. Riverside Forest Products Ltd.
- Dobson Engineering Ltd., 2005, *Water Quality Monitoring for the TFL 49 Forest Stewardship Project – 2004 Annual Report*. Riverside Forest Products Ltd.
- Dobson Engineering Ltd., 2006, *Water Quality Monitoring for the TFL 49 Forest Stewardship Project – 2005 Annual Report*. Riverside Forest Products Ltd.

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[2] Section 18. *Dinking Water Protection Act*, 2001. Ministry of Health.

- Dobson Engineering Ltd., 2007, *Water Quality Monitoring for Lambly and Whiteman Creeks (TFL49–2006 Annual Report*. Tolko Industries Ltd.
- Dobson Engineering Ltd., 2008, Water Quality Monitoring for Lambly and Whiteman Creeks (TFL49)–2007 Annual Report. Tolko Industries Ltd.

1.6 ABBREVIATIONS

CFU	Colony Forming Unit	MoFR	Ministry of Forests & Range
DWK	District of West Kelowna	MTCA	Ministry of Tourism, Culture and the Arts
GIS	Geographical Information System	NTU	Nephelometric Turbidity Unit
HAA	Haloacetic Acid	Q	Refers to volume over time (L/s, m^3/s, CFS)
IMAC	Interim Maximum Acceptable Concentration	RDCO	Regional District of Central Okanagan
IHA	Interior Health Authority	SCADA	Supervisory Control and Data Acquisition
IWAP	Interior Watershed Assessment Procedure	TCU	True Color Units
km^2	square kilometre	THMs	Trihalomethanes
L	litre	TOC	Total Organic Carbon
L/s	litres per second (flow rate)	µg/L	micrograms / litre (parts per billion)
m	metres (length)	WAP	Watershed Assessment Procedure
m^3/s	cubic metre per second, (flow rate)	LID	Lakeview Irrigation District
mg/L	milligrams/litre (parts per million)	SCHR	Stream Crossing Hazard Rating
ML	megalitre (one million litres)	WSC	Water Survey of Canada
MoE	Ministry of Environment		

2. MODULE 1 – CHARACTERIZATION OF THE LAMBLY CREEK SOURCE

2.1 DESCRIPTION OF PROJECT AREAS

2.1.1 SOURCE AREAS

Lambly Creek

The Lambly Creek community watershed is located on the western shore of Okanagan Lake near the District of West Kelowna and has a watershed area upstream of the intake of approximately 232 km^2 (Map 1). Elevations in the watershed range from 342 m above at the mouth of the creek to over 1,900 m at the summit of Terrace Mountain. The watershed is a designated community watershed under license to the Lakeview Irrigation District that was formed in 1951.

The watershed has been divided into the buffered areas and the unbuffered areas. The buffered areas are those areas upstream of reservoirs where runoff can be stored before being released to the intake. Impacts to water quantity and quality in the buffered areas may be a lower risk at the intake due to opportunities for sediment etc to settle while water is stored in the reservoirs. The unbuffered portions of the watershed are those areas that flow directly to the intake and there is no storage or regulation of flow. Impacts to water quality and quantity in these areas are a higher risk since the intake is directly exposed. The buffered and unbuffered areas are noted on the Map 1 in Appendix A.

Rose Valley

The Rose Valley watershed is a small catchment area of 10 km^2 that drains into the Rose Valley Reservoir (Map 2). Although the TRIM data indicates that there are two streams in the watershed, in reality there are no flowing streams in the watershed. Rose Valley Reservoir is the terminal reservoir for LID and its source of supply is Lambly Creek that is diverted into the reservoir via pipeline. The Rose Valley catchment is mostly undeveloped Crown land. There are several private lots north of the reservoir with the closest residence located approximately 0.5 km away. There are limited roads within the catchment and public access is restricted. The lands to the east of the reservoir are steep slopes with frequent bedrock cliffs. Most of the lands to the east of the reservoir are within the Rose Valley Regional Park administered by the Central Okanagan Regional District as undeveloped parklands. The lands to the west of the reservoir are Crown lands and part of the Westbank First Nation Community Forest. These lands are similar to the east side with steep slopes with bedrock exposures and cliffs. There is a trail network on the west slopes that are used for hiking and by mountain bikes. In 2009 approximately 100 hectares of the west catchment was burned in the Rose Valley Fire.

Although vehicle access is restricted within the catchment, the lands around the reservoir are a favourite area for local residents to walk and for fishing.

2.1.2 INTAKES

Lambly Creek

LID diverts water out of Lambly Creek at an intake located ~5.5 km upstream from Okanagan Lake and stores the water in the Rose Valley Reservoir that is located ~5 km south of the Lambly Creek watershed. LID has installed automated control gates and a turbidity sensor at the intake that are monitored at the

district office. The district can close the intake gates during high turbidity events in the creek to avoid diverting poor quality water into its terminal reservoir. LID manages the water supply by diverting and storing the spring runoff from the high elevation snowmelt in the Esperon and Big Horn Reservoirs.

Runoff upstream of the reservoirs can be buffered at the intake, as it has to pass through a reservoir before entering the mainstem creek. Residence time in the reservoirs will vary depending upon the time of year but typically LID will use approximately half of its stored water during the year so water could reside in the reservoirs for up to two years. The residence time will vary depending on the reservoir and water demand. The buffered area provides a level of protection at the intake from contamination, as long as releases from the reservoir can be controlled. The reservoirs also have the potential to allow for settling of some contaminants such as sediment and cysts. During the spring freshet once the reservoirs are full and spilling, this buffering benefit is substantially reduced.

Rose Valley

The intake to the distribution system is located at the dam at the south end of the Rose Valley Reservoir. The point of intake is located approximately 50 m offshore from the dam at a depth of ~10 m. The control works and chlorinator are located immediately downstream of the dam. The control works and chlorination facility are secured within a locked concrete building but, as indicated previously, the reservoir is accessible to people on foot and to wildlife.

2.2 Licensed Stakeholders and Interested Parties

The licensed stakeholders and parties with a direct interest in the Lambly Creek watershed are:

- Lakeview Irrigation District – Water licensee, water purveyor for domestic and agricultural water
- District of West Kelowna – Local government
- Other water licensees
- Tolko Industries Ltd., Westbank First Nation, BC Timber Sales – Forest licensees
- Ken Regehr, Brian Casorso/Engelbert Sperling – Grazing licensees
- Interior Health Authority – Safe drinking water
- Ministry of Environment - Water licensing, water allocation, fisheries, ecosystems, pollution prevention, source water protection
- Ministry of Forests and Range – Forests and range resources
- Ministry of Energy, Mines & Petroleum – Mineral claims
- Ministry of Tourism, Culture and the Arts – Recreation sites, recreation area
- Regional District of Central Okanagan - Planning and development on Crown land within regional district boundaries
- Okanagan Trail Riders Association – Recreation site stewardship

2.3 Biophysical Characterization of Source Areas

Four biogeoclimatic zones were identified in the watershed; from Interior Douglas Fir (IDF xh1) in the lower elevations to Interior Douglas fir (IDF dk1) and Montane Spruce (MS xk) in mid to high elevations and Engelmann spruce sub-alpine fir (ESSF xc) in the upper elevations. Bedrock consists of metamorphic

rocks of the Nicola Group, volcanic flows of the Kitley Lake Formation and localized outcrops of Lambly Creek Basalt. As a result of Pleistocene glaciation, sources of coarse sediment in the form of colluvial and morainal deposits are relatively abundant throughout the watershed.

The lower reaches of Lambly Creek flow through a narrow rock canyon emerging onto a small delta at Okanagan Lake. The upper watershed is situated the edge of the Thompson Plateau. The Esperon Reservoir and Big Horn Reservoir provide storage in the upper watershed. Tadpole Reservoir located in the headwaters of North Fork Creek is licensed to the Westbank Irrigation District where freshet runoff is stored and diverted into the Powers Creek watershed. It is the upper watershed area above the 1,400 m elevation that is considered to be the snow sensitive zone that produces most of the spring runoff and is the source of the peak flows during the spring freshet.

The terrain in the upper watershed is generally benign, gently rolling plateau with no evidence of slope instability. The main stem of Lambly Creek downstream from the Lambly Reservoir (the reservoir outflow is permanently diverted into Powers Creek) flows through a broad u-shaped valley to the confluence with Terrace Creek where the channel becomes confined. Downstream from Bald Range Creek it flows through a narrow bedrock canyon until it emerges onto the fan at Okanagan Lake. There have been slope failures along the canyon wall that have impacted the creek. The soil erosion hazard is variable from low in areas of bedrock to very high on the lacustrine terraces. The watershed has been sub-divided in three sub-basins, North Fork, Terrace, Bald Range, and a residual area. The point of interest is the Lakeview Irrigation District intake (refer to Map 1 in Appendix A).

The Rose Valley catchment is typically within the interior dry belt zone with steep slopes and frequent bedrock exposures. There are no flowing streams within this watershed.

Annual precipitation for the watersheds is considered to be similar to those reported for the Environment Canada climate stations *Peachland* and *Peachland Brenda Mines*. The average annual precipitation for the lower watershed is in the range of 370 mm and for the upper watershed 635 mm.

2.4 HYDROLOGIC CHARACTERIZATION OF SOURCE AREA

Lambly Creek is a snow-dominated hydrologic system with peak flows occurring from mid-April to late-June. There were two Water Survey of Canada (WSC) hydrometric stations operated in the watershed between 1919 and 1975; *Lambly Creek near the Mouth* (Stn # 08NM003), and *Lambly below Terrace* (Stn # 08NM141). Typical annual hydrographs for each station are presented in Figures 1 and 2.

Although the annual peak flow typically occurs between April and June, intense summer and fall rainstorms can cause increased stream flows. However the magnitude of the rain related stream flow events is less than the annual snowmelt related peak flow events.

Figure 1. WSC Station 08NM003 – Lambly near the Mouth
(Mean daily discharges based on data from 1919 to 1975)

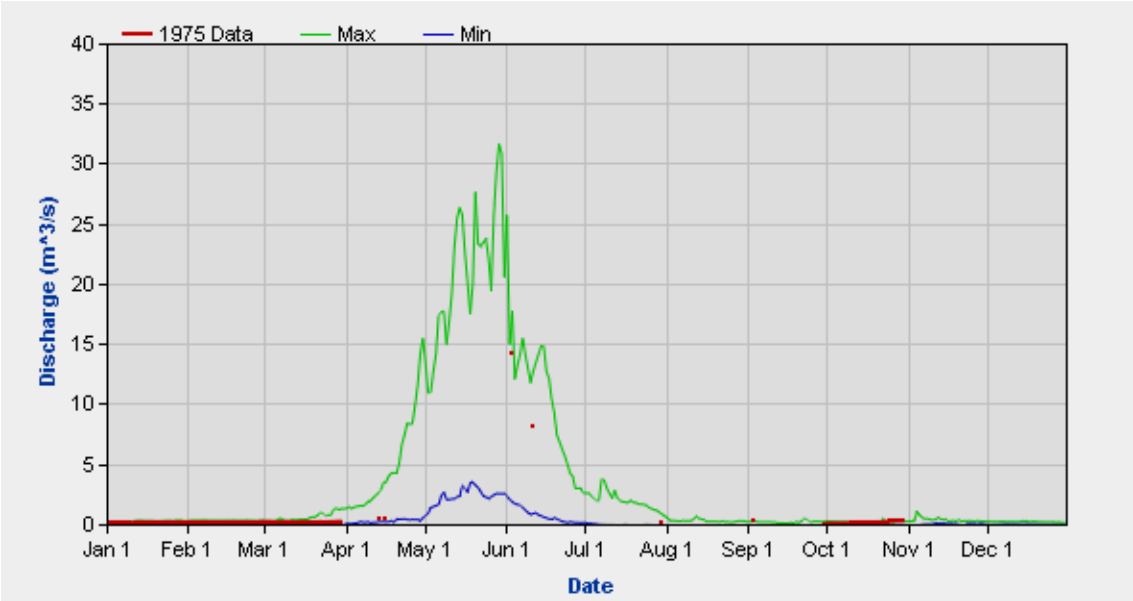
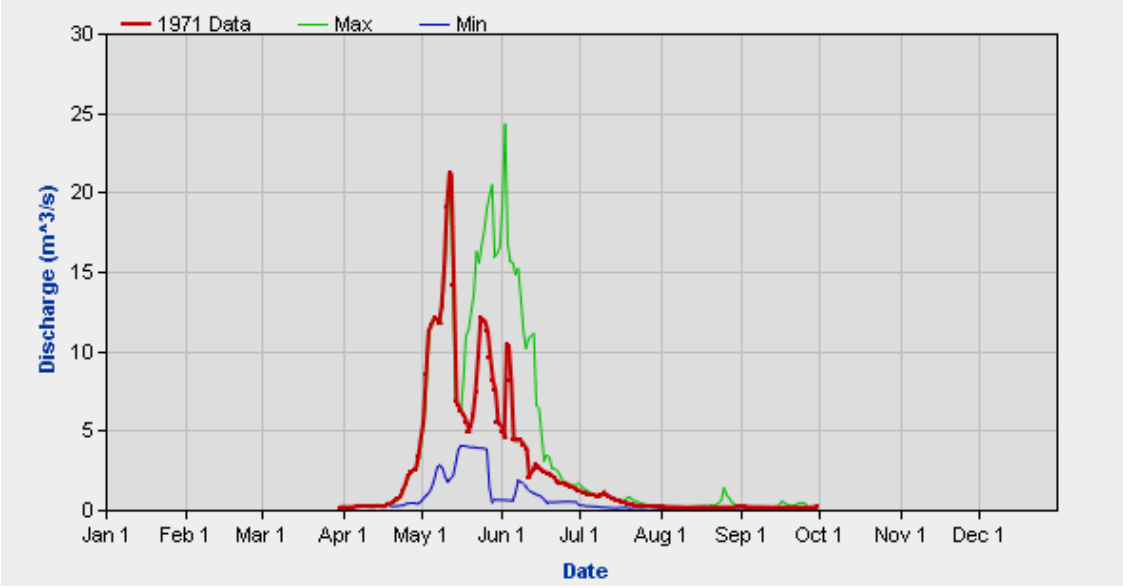


Figure 2. WSC Station 08NM141 – Lambly below Terrace
(Mean daily discharges based on data from 1967 to 1971)



The Lambly watershed has been separated into two hydrologic zones. Zone 1 is the unbuffered area immediately upstream from the intake. In this zone any sediment or contaminant material that enters streams will be transported directly to the intake. Zone 2 is the watershed upstream from the reservoirs. The area upstream from the Big Horn Reservoir is the largest buffered area and includes Esperon Reservoir. The Rose Valley Reservoir is all one zone – unbuffered.

The reservoirs have the potential to act as settling ponds for sediment and contaminants. The hydrologic effect of these reservoirs is to desynchronize the runoff period and peak flows through storage. Depending on the volume and timing of runoff, the reservoirs will vary downstream peak flows. For example, peaks will be reduced or eliminated during low runoff years but may be unaffected during high runoff years.

LID manages its water supply by storing the spring runoff during the snowmelt period from April through June in the upland reservoirs. Runoff from the DunWaters diversion is stored in the Big Horn Reservoir. Flow from Lambly Creek is diverted via a pipeline into the Rose Valley Reservoir. Water demands during the spring runoff period are normally met from stream flows from unregulated portions of the watershed below the reservoirs. As the water system demand increases, additional demand is met by releases from the reservoirs.

2.5 SOURCE HAZARDS TO DRINKING WATER QUALITY AND QUANTITY

The identification of potential hazards to drinking water prior to commencing fieldwork was an important component of Module 1. This involved reviewing the activities that occur in the watershed and the potential hazards that they may pose to drinking water, including consultation with the water purveyor to confirm the likely hazards. The hazards to source water quality in the watershed include, motorized off-road recreation use, dispersed recreation use throughout the watershed and around reservoirs, range use, forest development, and a limestone quarry. The results of this review are the basis for the field assessment tasks undertaken in Module 2.

Although dispersed recreation can affect source water quality, concentrated recreational activities near watercourses are more likely to affect the source water quality. The Okanagan-Shuswap LRMP Recreation Management Zone (RMZ) includes a large portion of the LID source area. The RMZ is outlined in the Okanagan Shuswap Land and Resource Management Plan as an area for recreational motorcycle and off road vehicle use (http://ilmbwww.gov.bc.ca/slrp/lrmp/kamloops/okanagan/plan/files/oslrmpfull.pdf). The Ministry of Tourism, Culture and Arts (MTCA) has designated the RMZ as a recreation site. With the recreation site designation, user groups must apply for permits to host organised recreational events in the area. Although this designation is in place, environmental damage continues to occur from un-authorized/unregulated recreation within the RMZ and the damage has the potential to degrade source water quality for the LID.

The reservoirs in the watershed provide recreational angling opportunities which attract outdoor recreationalists throughout the year and increased recreational activity at the reservoir results in increased risk to the drinking water supply. This increased risk has not been well defined and research is

underway to quantify these risks. There is a cabin on the Esperon Reservoir however there is no indication that this is adversely affecting drinking water quality.

Range use occurs throughout the upland areas of the watershed. The fecal coliform and sediment loading at the intake is a function of the level of activity in the watershed and stream discharge. A review of the results from water quality monitoring undertaken by Larratt Aquatic Consulting for LID upstream of the intake, and sampling at the intake have confirmed the linkage between upstream disturbance and impacts at the intake[3]. Following the spring freshet, as flows decline, activity increases in and around streams from wildlife, cattle and humans resulting in sediment disturbance and fecal deposits. This activity continues through the fall until the onset of winter. As the snow melts in the spring and the flows begin to increase, it will mobilize the disturbed sediment and fecal material resulting in increasing levels at the intake. The highest sediment and fecal coliform levels normally occur at the peak of the hydrograph when stream flows are high.

Ongoing forest development in the Lambly Creek watershed has the potential to increase road densities and increase sediment delivery to the stream network. In addition, the pine beetle epidemic is spreading in the watershed and the loss of canopy will result in changes to the watershed hydrology and may result in potentially damaging peak flows. The LID has a good working relationship with the major forest licensees and comments on and makes recommendations on forest development plans to protect its water supply. Current forest development practices are less likely to have adverse affects on water quality and quantity than in the past, however any forest development has the potential to adversely affect the water resource.

Larratt Aquatic Consulting has monitored water quality in the watershed for years under contract to LID. The results in the report *Summary of Lakeview Irrigation District's (LID) Bacteriological Monitoring of Lambly Creek and Bald Range Creek, 2007 and 2008* [3] indicate that the levels of fecal coliform and E.coli are a health concern at the intake. The potential hazards to the drinking water at the intake, as determined as part of Module 1, are summarized in Table 2-1.

There is no industrial development within the Rose Valley catchment although there was wildfire suppression activities on the west slopes above the reservoir in 2009 including the use of fire retardant dropped from aircraft. According to information provided by the Ministry of Forests and Range, the retardant does not pose a threat to water quality. Subsequent to the wildfire Dobson Engineering Ltd.[4] assessed the risks to the reservoir for LID. It was determined that there were post wildfire risks to the water quality and the Provincial Emergency Program funded the installation of remedial works to reduce the potential risks.

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[3] *Summary of Lakeview Irrigation District's (LID) Bacteriological Monitoring of Lambly Creek and Bald Range Creek, 2007 and 2008.* Draft; Larratt Aquatic Consulting.

[4] *Rose Valley Fire (K50747) Post-fire Risk Assessment.* August 2009. Dobson Engineering Ltd.

Table 2-1. Module 1 – Potential Hazards to Drinking Water Quality and Quantity at Lambly Creek and Rose Valley Intakes

Hazard Type	Drinking Water Hazard	Possible Effects
Physical	Natural sediment load from channel erosion and mass wasting	- Compromised disinfection process - Risk to human health
	Sedimentation from industrial roads and road crossings	- Compromised disinfection process - Risk to human health
	Sedimentation from range use in and around streams	- Compromised disinfection process - Risk to human health
	Sedimentation from recreation activity on roads, road crossings and in/around streams and reservoirs	- Compromised disinfection process - Risk to human health
	Organic material	- Risk to human health
	Water quantity	- Lack of adequate supply could result in public health issues - Interruption to water supply could occur if a failure occurred at a critical infrastructure location. - Increased peak flows due to loss of forest cover and associated increase in sediment transport.
	Wildfire	- Increased sediment and nutrient loads - Increased heavy metals, phosphate and nitrate loading in streams
Biological	Bacteriological contamination from wildlife/cattle/human presence in and along streams and reservoirs	- Contravention of DWP Regulation for fecal coliform bacteria, E.coli, and total coliform in drinking water - Risk to human health
	Protozoa (Giardia, Cryptosporidium)	- Risk to human health
	Viruses	- Risk to human health
	Algal blooms in reservoirs	- Risk to human health - Cytotoxin contamination, Trihalomethanes (by-product of disinfection process) - Increased turbidity from algal cells reaching intakes
Chemical	Total Organic Carbon	- Risk to human health
	Petroleum contamination from an industrial fuel spill or vehicle accident and gas powered boats on reservoirs	- Contamination of drinking water - Risk to human health
	Herbicides	- Contamination of drinking water - Risk to human health
	Wildfire	- Degraded water quality related to fire retardants

Notes:
1. Health Canada, *Guidelines for Canadian Drinking Water Quality (May 2008)* - http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/revised-revisees-eng.php#tbl1

2.6 SOURCE WATER QUALITY AND QUANTITY

2.6.1 WATER QUALITY

Lambly Creek

During the period 1969 - 1971 limited water quality data was collected on Lambly Creek as part of the Okanagan Basin Study. In 1990 the Ministry of Environment published an overview report titled *Ambient Water Quality Objectives for the Tributaries to Okanagan Lake near Westbank* that included the following comments on water quality in Lambly Creek:

Lambly Creek had a basic pH, with low sensitivity to acidic inputs. Water would be considered to be soft and metals concentrations were generally less than criteria to protect aquatic life. Nitrogen compounds were well below criteria, but phosphorus concentrations were high enough to cause algal growths and this may explain some very low dissolved oxygen percent saturation values. Dissolved solids were well below criteria, and fecal coliform concentrations were so low that only disinfection of the water would be required.

In 1996 the Ministry of Environment established a water quality monitoring station on Lambly Creek near the LID intake to collect water quality data to be used to establish water quality objectives for the watershed. In 2001 Riverside Forest Products Ltd. assumed the responsibility for the station as part of the TFL 49 Forest Stewardship Project and it was operated until the end of 2002. The data collected for the period 1996 - 2002 included; turbidity, water temperature, conductivity, pH, and dissolved oxygen. A summary of the results is provided in Table 2-2.

Table 2-2. Water Quality Summary

Parameter	MoE Water Quality objectives for Lambly Creek	Average for Period	
		1972-2000	2001-2007
Turbidity (NTU)	95th %ile of at least 5 samples in 30 days ≤ 5 NTU July 1 – March 31 95th %ile of at least 5 samples in 30 days ≤ 5 NTU April 1 – June 30	4.18 NTU for 46 samples	Clear flow 0.54 Turbid Flow 1.24
Temperature	15 ^{o}C	n/a	9.3 ^{o}C
Conductivity	700 µS/cm	209	143 µS/cm
pH	6.5-8.5	8.04	n/a
Dissolved Oxygen	8 mg/L 30-day mean (aquatic)	11.01 mg/L	n/a
Fecal Coliform	≤10 CFU/100 mL (90th percentile based on a minimum of 5 weekly samples collected over a 30-day period)		
Phosphorous	10µg/L	0.049 mg/L	n/a

In 2001 the report *The Effects of Recreation on Drinking Water Quality within the Lambly, Kelowna and Mission Creek* was released by the MoE. The ribosomal RNA for E.coli results reported for the watershed is summarized in Table 2-3. The table below indicates a significant wildlife and human fecal contribution.

Table 2-3. E.coli Sources and Distribution in Lambly Creek

Source	No. of Samples	Percent
Cattle	3	12
Wildlife	11	44
Humans/domestic animals	8	32
Unknown	3	12

Bacteriological monitoring has also been carried out by Larratt Aquatic Consulting and the results for 2007 and 2008 are summarized in the report *Summary of Lakeview Irrigation District's (LID) Bacteriological Monitoring of Lambly Creek and Bald Range Creek, 2007 and 2008*[3].

Rose Valley

There is a history of algal blooms (cyanobacteria) in the Rose Valley Reservoir associated with increased nutrients in water diverted from Lambly Creek and elevated water temperatures in the reservoir. The concern with increased algae in the reservoir is the potential for the by-products of decaying algae affecting drinking water quality.

2.6.2 WATER QUANTITY

LID is concerned about its water supply sustaining the increased future demand for water within its service area. There are three key issues relative to quantity: the amount of spring runoff in the upper watershed upstream of the storage reservoirs; the amount of developed storage; and the opportunity to increase the volume of water available to meet future demands. LID has developed additional runoff into the Big Horn Reservoir by diverting runoff from the Shorts Creek watershed using the DunWaters diversion. It is also collecting runoff data at the Esperon Reservoir, Big Horn Reservoir and North Fork Creek to determine if it is feasible to increase the storage volumes in those sub-basins.

Mountain pine beetle infestations have been a concern in the watershed since the early 1970s. Extensive harvesting of beetle-infested stands was undertaken in the watershed in the 1970s and these areas are nearing hydrologic recovery. There are stands of mature lodgepole pine remaining in the watershed that are under attack at this time by the pine beetle and it is projected by the MoFR that most of the mature lodgepole pine will be killed by the beetle over the next 3 – 5 years during which time the runoff will gradually increase. The loss of the forest cover will result in increased runoff and increased peak flows. It is estimated that there will be increased runoff for several decades until the stands recover[5]. Additional details on the impacts of the pine beetle are provided in section 2.8.

Increased water yields could however be compromised by the potential decrease in snow pack as a result of the changing climate. Recent estimates by the Atmospheric Environment Service for the April 1st snow pack in the Okanagan indicate that by 2020 the mid-elevation snow pack may be reduced by 11%, by

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[5] *Cumulative Hydrologic Impact Assessment of Mountain Pine Beetle Infested Stands and Proposed Retention Plan*. 2008. Prepared for Tolko Industries Ltd. Dobson Engineering Ltd.

2050 by 40% and by 2080 by 50%[6]. These decreases in snow pack combined with increasing summer temperatures may result in long-term supply issues for the LID.

If there is a long-term trend for lower water yields, then there will be an increased hazard in the reservoirs associated with lower water levels and the increased transport of sediment from the exposed soils within the reservoir pool area during spring runoff and during summer rainstorms. There may also be the problem of increased sediment production resulting from human disturbance of exposed soils within the reservoir pool area. A related issue will be increased water temperatures in the reservoirs as a result of decreased runoff and increased summer temperatures. Higher water temperatures combined with increased turbidity levels will result in increased biological activity in the source waters and likely more frequent algae blooms.

2.7 INTEGRITY AND VULNERABILITY OF THE LAMBLY CREEK INTAKE WORKS

The intake on Lambly Creek is an on-stream intake that is vulnerable to impacts from runoff. LID has a very small intake pond that allows only minimal opportunity to settle sediment. However the district recently installed automated head gates and automated turbidity sampling instrumentation at the Lambly intake. These are linked with the district's SCADA system that is programmed to automatically close the head gates if the turbidity exceeds a pre-set level. This upgrade permits the district to avoid diverting turbid (nutrient rich) water into the Rose Valley Reservoir. The Rose Valley Reservoir, a large terminal reservoir, provides the district with a further barrier (~1 year residence time) that permits some suspended solids (including protozoan cysts) to settle, and protect its water users in the event of contamination (pers. com. H. Larratt). LID has an inter-connection with the Westbank Irrigation District system that can provide an alternate water supply for the LID's customers for limited domestic indoor use only, during an emergency.

2.8 FOREST DEVELOPMENT

Forest development has occurred in the watershed since the mid-1960s. Early harvesting efforts were directed towards the control of mountain pine beetle infestations and clear-cutting has been the dominant harvesting system utilized in the watershed. Current harvesting efforts are again focusing on the beetle infestations with most activity occurring in the Terrace Creek sub-basin. The equivalent clear-cut area (ECA) in the watershed was 19% to the end of 2007.

In the 1990s Dobson Engineering Ltd. completed a number of assessments and restoration work on high risk sites in the watershed related to past forest development and water quality issues with funding from Forest Renewal BC[7].

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[6] Friscka, G., Atmospheric Environment Service, 2007, Presentation to City of Kelowna.
[7] Dobson Engineering Ltd. 1999, *Lambly Creek Watershed/Road Deactivation Prescriptions*.

Currently, three licensees operate in the Lambly Creek watershed; Tolko Industries Ltd. (TFL 49), Westbank First Nation (WFN) dba Heartland Economics LP, and BC Timber Sales (BCTS). Future forest development is proposed in the watershed, and details are provided in Module 2, Section 3.5.1.

2.9 HISTORY OF WATER USE

The first water license in the Lambly Creek watershed was granted for irrigation purposes in 1932; in 1951 the Lakeview Heights Irrigation District was formed. The Rose Valley Reservoir was constructed in 1949, with storage of 2,960 ML of water. The diversion system, which consisted of open ditches and wood flumes to deliver water from Lambly Creek was removed in 1969. The system was replaced with a 34-inch diameter steel pipeline from Lambly Creek to Rose Valley Reservoir. In 1977 Rose Valley Dam was raised 15 feet increasing storage to 5,674 ML. The chlorination plant was also added at that time.

The Big Horn Reservoir was completed in 1994, and was raised an additional 3 meters in 2004. The area draining to Big Horn Dam was increased by ~7 km^2 with the construction of the DunWaters diversion. The project was completed in 2008. LID holds water licenses to store approximately 8,634 ML in its reservoirs, including the DunWaters diversion.

2.10 SUMMARY

The intent of this section is to characterize the Lambly Creek and Rose Valley watersheds. The community watersheds are located on the west side of Okanagan Lake near the District of West Kelowna. The contributing area for the Lambly Creek watershed is ~232 km^2, and for Rose Valley 10 km^2. Elevations in the watershed range from 342 m at the Okanagan Lake to over 1,900 m at the summit of Terrace Mountain. Lambly Creek and its major tributaries are typically incised in narrow valleys. The Esperon and Big Horn Reservoirs provide storage in the upper watershed. Rose Valley Reservoir is a large terminal reservoir that is located outside of the watershed approximately 5 km south of the intake. Tadpole Reservoir that is located in the headwaters of the North Fork Creek provides storage for the Westbank Irrigation District with water diverted into Powers Creek.

The reservoirs have the potential to act as settling ponds for sediment and fecal material. The hydrologic effect of these reservoirs is to modify the runoff period and peak flows through storage. Watershed maps are provided in Appendix A.

The watersheds include four biogeoclimatic zones. The terrain ranges from canyons upstream of intake to rolling plateau in the uplands. Lambly Creek is a snow dominated hydrologic regime with peak flows occurring from mid-April to late-June. There are no active Water Survey of Canada hydrometric stations in the watershed but LID has installed four private hydrometric stations to collect runoff data to be used in planning future storage options.

The watershed has been divided into two hydrologic zones. Zone 1 is the un-buffered area immediately upstream of the intake. In this zone any sediment and fecal material that enters streams will be transported directly to the intake. Zone 2 is the buffered zone upstream of the reservoirs. The Westbank

Irrigation District permanently diverts outflow from the Lambly Reservoir into Powers Creek. The Rose Valley watershed has no flowing streams and the reservoir is supplied with water diverted from Lambly Creek.

There are 12 licensed stakeholders/agencies and other parties with interests in the watershed. The hydrology is snow dominated with peak flows occurring between late-April to mid-June. There are no active Water Survey of Canada hydrometric stations in the watershed. There are three seasonal hydrometric stations being operated privately for LID to determine the surface runoff in the upper watershed.

The long-term hazards to drinking water include: sediment from roads, recreation and grazing; bacteria, protozoa and viruses from humans, wildlife and cattle, cytotoxin from algae; wildfire as the fuel loads increase from the death of the lodgepole pine increasing nutrient load; herbicides from the application on noxious weeds; and hydrocarbons from a fuel spill. The present raw water quality is considered to be at risk as a result of the high levels of fecal coliform and E.coli detected at the intake.

Forest development in the watershed has taken place since approximately the mid-1960s. Early harvesting efforts were directed towards the control of mountain pine beetle. Clear-cutting has been the dominant harvesting system in the watershed. Current harvesting efforts are again focusing on the beetle infestations with most activity occurring in the Terrace Creek sub-basin. Tolko recently completed a retention plan for the watershed that focuses on salvaging lodgepole pine attacked by the mountain pine beetle. A retention plan is a forest development planning process that considers all the resource values in the watershed, timber and non-timber, and identifies what stands need to be retained to protect the non-timber values such as water, wildlife, fish, recreation, etc. These are the stands that will be retained, i.e. not harvested in the short-term (next 10 years). This planning process was developed to assist in planning salvage logging of mountain pine beetle infested stands. The plan included a review of the hydrologic impacts that may occur as a result of the loss of forest cover in the upper watershed that is the source of peak flows. The ECA for the snow sensitive zone above the intake after the mature pine dies is estimated to increase to ~50% (if there was no salvage logging), that would result in a high peak flow hazard at the intake.

3. MODULE 2 – RESULTS OF CONTAMINANT INVENTORY

Lambly Creek

The objectives of Module 2 are to inventory the land uses and impacts within the community watersheds and inventory the potential sources of contamination associated with these land uses that could affect drinking water quality within the watershed. In addition it includes an update for the Interior Watershed Assessment Procedure (IWAP) for the watershed to the end of 2007, as well as a review of the results of the Sensitive Habitat Inventory Monitoring (SHIM) collected for LID. The combination of the watershed characterization and the preliminary hazard inventory provided in Module 1 and the contaminant inventory (hazard identification) were used to evaluate the risks to the drinking water supply required in Module 7. Field inspections were completed as part of Modules 2 that included approximately six field days.

3.1 INTERIOR WATERSHED ASSESSMENT PROCEDURE UPDATE

As summarized in Section 1.4, the WAP procedure is an analytical tool designed to help forest managers understand the water-related problems associated with past forest development that may exist in a watershed, and to recognize the possible hydrological implications of proposed forestry-related development. The original IWAP was completed for the Lambly Creek watershed in 1998, and updated in 2001. The following sections provide a summary of the results of the IWAP results.

The IWAP procedure has evolved since the original guidebook was released in 1995 and revised in 1999 to a professional assessment process used in 2008 that relies on the judgment of a qualified professional (PEng, PGeo, or RPF) with demonstrated experience in watershed assessments in the interior of BC. The 1999 guidebook is used for guidance only. It is important to note that the hazard ratings in the IWAP process are directed at forest development impacts and do not necessarily reflect the hazards that are of concern for the protection of drinking water.

Since the 2008 update was initiated as part of the Source Protection Plan, the update focused on more than just forestry impacts. The fieldwork included inspections and assessments of all forms of human impacts in the watershed that could affect drinking water quality including recreational use, and hunting and fishing impacts. It also assessed the impacts from recreation and grazing on the water sources as well as other industrial activities such as mining.

3.1.1 RECOMMENDATIONS FROM THE 1998 LAMBLY CREEK IWAP

The following recommendations related to water quality were presented in the 1998 Lambly Creek IWAP report. Following each recommendation is a comment on whether or not any action was taken on the recommendation.

- Following the completion of the proposed development, roads associated with the cutting permits should be deactivated or maintained to a level appropriate with their anticipated future use. Natural drainage should be maintained or restored within all blocks and on access roads.

  Action: Part of current Forest Stewardship Plans.

- Riparian management strategies should be developed to protect streambank stability, fish and fish habitat. Particular attention should be focused on those areas logged adjacent to streams to determine the state of streamside conifer regeneration.

  Action: Part of current Forest Stewardship Plans.

- Inactive roads at stream crossing should be deactivated or maintained to minimize the delivery of sediment into streams. One year after deactivation, these roads should be inspected to determine the effectiveness of deactivation measures. For those roads that may be maintained, periodic monitoring should be scheduled based upon potential risks of the delivery of sediment into streams.

  Action: Of the 414 km of road identified, approximately 41% (171 km) were deactivated, typically to a semi-permanent level. All high priority sites on status and non-status roads noted in the 1997 Sediment Source Survey were addressed through the Forest Renewal BC funding program.

- Permanent channel monitoring sites should be established within the mainstem of Lambly Creek and the three major tributaries to provide information with regards to channel stability.

  Action: Channel monitoring stations have not been established on the Lambly mainstem or its three major tributaries.

- A combined long-term forest development plan should be developed for the watershed that incorporates the results of the Complan work developed by Riverside Forest Products Ltd. along with the portion of the watershed that is outside of the TFL.

  Action: Long-term forest development planning has been completed in licensee retention plans.

- The decommissioned hydrometric station located on Lambly Creek above Terrace Creek should be reactivated to provide a long-term streamflow record that could assist in making future forest development decisions in the Lambly Creek watershed as well as nearby watersheds.

  Action: This WSC station has not been re-activated but LID operates its own station at the intake.

- The long-term sustainable level of harvest and associated ECA's for the watershed should be based on information collected from the channel monitoring sites, streamflow information and the long-term forest development plan (e.g. Complan) to ensure that stream channel stability and water quality are protected.

  Action: Long-term planning is based on Forest Stewardship Plans for Tolko and BCTS. WFN uses Forest Development Plans and is addressed as part of licensee retention plans.

3.1.2 RECOMMENDATIONS FROM THE 2001 LAMBLY CREEK IWAP

The following recommendations related to water quality were presented in the 2001 Lambly Creek IWAP report. Following each recommendation is a comment on what action was taken on the recommendation.

- The ECA for the North Fork sub-basin should not be increased in the future unless a detailed channel assessment confirms that it is appropriate to do so.

  Action: The reported ECA as of January 1, 2001 was 40.5% for the North Fork sub-basin, recovery since has resulted in a current ECA of 34.9%. The current beetle infestations threaten to increase the ECA to ~47% due to the loss of the mature pine in the sub-basin and slightly higher at ~50% with salvage logging.

- Deactivate or maintain inactive permitted roads in accordance with the Forest Practices Code.

Action: Part of current Forest Stewardship Plans.

- Address the remaining high priority sediment sources on non-status roads as identified in the 1997 Sediment Source Survey (if funding is available).

  Action: Not known if all high priority sites have been addressed however the 2008 field assessments noted that some sites were unchanged from 1997.

- Establish permanent channel monitoring sites on Lambly Creek and on North Fork Creek as a first priority and the two other major tributaries as a second priority (if funding is available).

  Action: Channel monitoring stations have not been established on the Lambly mainstem or its three major tributaries.

- Establish permanent channel monitoring photo sites on the aggraded section of Bald Range Creek (if funding is available).

  Action: Permanent channel monitoring photo sites were not established on Bald Range Creek.

- Reactivate the hydrometric station located on Lambly Creek above Terrace Creek to provide information for forest development and watershed planning (if funding is available).
  Action: This WSC station has not been re-activated.

3.1.3 2008 LAMBLY CREEK IWAP UPDATE

The GIS data for the 2008 IWAP update includes forest development data current to December 2007, which is the latest year that data was available at the time that the update was completed. In addition, hydrological recovery predictions are provided, but actual future ECA's cannot be predicted as they depend on future harvest schedules, pine beetle effects and potential wildfires. The watershed was subdivided into the same three sub-basins as used in previous assessments, North Fork, Terrace, and Bald Range. There was also a residual area above the intake that was assessed but the ratings are included in those for the total watershed. The zones previously mentioned (Zone 1 and Zone 2) are referenced only to areas upstream and downstream from the reservoirs. These zones are not specifically addressed in the IWAP. Table 3-1 lists parameters that were considered when assessing the impacts of forest development on the watershed. Following each parameter is a brief description of the importance of the parameter. These parameters are used to develop hazard ratings for the impacts of past forest development on peak flow, surface erosion, riparian buffers (i.e. channels), and landslides.

Table 3-1. Watershed Parameters used in Assessing Forest Development Impacts

Parameter	Significance
Gross watershed area	Used to calculate ECA
Total harvested area	Used to calculate ECA
Current equivalent clear-cut area (ECA)	Used to assess logging impacts on peak flows
ECA below the H40 elevation	Part of watershed ECA
ECA above the H40 elevation	Peak flow sensitive zone
Total road density	Part of surface erosion assessment
Total road length	Part of surface erosion assessment
Length of road deactivated	Part of surface erosion assessment
Length of road rated as high and moderate sediment sources	Part of surface erosion assessment
Number of landslides entering a stream	Used to assess watershed slope stability
Amount of road of class IV and V terrain	Used to assess watershed slope stability
Number of stream crossings	Part of surface erosion assessment
Length of stream logged to the bank	Used to assess channel stability
Length of mainstem channel with non-functioning riparian area	Used to assess channel stability
Length of disturbed mainstem channel	Used to assess channel stability

3.1.4 WATERSHED CONCERNS

The following list summarizes the types of concerns that development and recreation uses can pose to drinking water quality and quantity:

- Impacts of forestry and range activities on water quality and quantity;
- Increases in turbidity levels and presence of pathogenic organisms as a result of increased recreational activity and grazing activity in the watershed that may require additional treatment of drinking water;
- Increased access for recreation and range use that may result from forest road construction in and around streams;
- Slope stability issues in the lower residual area adjacent to the canyon reaches that is the most sensitive area with respect to forest development;
- Hydrologic effects from increased wildfire risk related to the impacts from the mountain pine beetle; and
- Increased runoff rates into the upper reservoirs if accelerated by forest development and the impacts from the mountain pine beetle.
- The primary purpose of the storage reservoirs is to store water for domestic and irrigation uses, they should not be considered as settling ponds nor are they meant to be used for intensive recreation purposes.
- Recreation uses on and about storage reservoirs and diversion ditches increase the risks of contamination with bacteria, viruses and chemicals.
- Bank erosion along un-vegetated/armoured sections of diversion channels.
- Unregulated recreational use including off road vehicles (i.e. motorcycle, ATV, 4wd), camping/parties, refuse disposal, and other activities in or about a watercourse, stream, lake or reservoir.

3.1.5 2008 IWAP REPORT CARD

The watershed report card was updated as part of this project. The results provided in Table 3-2 summarize the data for the watershed area above the intake works by elevation band (above and below the snow sensitive zone) and road density at the end of 2007.

3.1.6 HAZARD INDICES SUMMARY

Using the results provided in the watershed report card, hazard ratings are derived for the four hydrologic hazards, peak flow, surface erosion, riparian buffers and landslides that are summarized below and in Table 3-3. The following summaries are based on GIS data to December 2007. More recent data was not available for inclusion in this report.

Peak Flow

IWAP results indicate that in all three sub-basins and for the watershed above the intake, ECA's have decreased since 2001; North Fork declined from ~40% to ~35%, Terrace from ~31% to ~26%, Bald Range from ~17% to ~6%, and for the watershed above the intake from ~27% to 19%. Road densities also deceased since 2001 in all sub-basins and the watershed as a whole from 1.5 km/km^2 to 1.0 km/km^2. Field assessments in 2008 did note numerous roads and trails not included in the mapping files. Based on the field assessments it is likely that road density has not decreased since 2001.

Channels in the watershed did not indicate peak flow related disturbance occurring since 2001. Although it was previously noted in smaller tributary channels, where harvesting had impacted riparian areas, these channels appeared to be in a stabilizing trend. The Lambly mainstem channel is mainly boulder/cobble dominated and robust to potential impacts from increases in peak flows (Photo 11, Appendix B). Terrace Creek and the North Fork are similar with boulder cobble dominated sections. Large wood and logjams were present in all mainstem channels storing sediment and shifting flows. Bald Range Creek was similar on the lower reaches (below the Bear Main FSR) but the middle reaches were slightly to moderately aggraded. Many homogeneous sections were noted consisting of sand and gravel, inherent in the system but exacerbated by cattle and recreational use.

In addition, based on the analysis presented in the 1998 IWAP report, reservoirs in the watershed may act to reduce peak flows through water storage. The ECA as of December 31, 2007 (assuming no loss of mature pine) of ~37% and ~33% for the snow sensitive zone of North Fork and Terrace respectively result in moderate peak flow hazard ratings. Bald Range is considered a low peak flow hazard based on the 22% ECA identified in the snow sensitive zone. The ECA for the watershed upstream of the intake was 31% with a peak flow hazard rating of moderate for the snow sensitive zone.

The peak flow hazard for the snow sensitive zone if all the mature pine was to die would remain moderate for the North Fork sub-basin and the watershed with ECA's of ~47% and ~50% respectively, and increase to high (~51% ECA) for the Terrace sub-basin and moderate for the Bald Range Basin (~35%). The projected increase in the 30-year peak flows may be in the range of 16-24%[4].

Surface Erosion

The road densities and the number of stream crossings deceased significantly since 2001 in all sub-basins and the watershed as a whole from 1.5 km/km^2 to 1.0 km/km^2. Field assessments in 2008 identified roads and trails that were not included in the mapping files. Based on the field assessments it is likely that road density has not decreased since 2001.

Many of the roads in the watershed are rated as moderately erodible due to the sub-grade material. The sources of sediment identified at stream crossings were typical and scored low to moderate based on the stream crossing quality index calculations. Although generally well maintained, stable, and most of the eroded surfaces disconnected from the channel system, numerous stream crossings were identified as slight to moderate sediment sources. Typical problems were related to road surface drainage directed towards culverts or bridges during wet conditions (rain/snowmelt). Traffic volume (industrial and recreational) and grazing impacts are also connected to the likelihood of sediment delivery at each crossing. Running surfaces on roads with high traffic volume (industrial) were noted with 1 cm to 2 cm of loose material. Dust from these roads is a source of fine sediments specifically active roads and was noted stored on channel beds/banks and on vegetation.

Based on the 2008 field assessments in the Bald Range sub-basin, roads appear in good condition, however there were some problems with the old roads in the upper basin near sites 249, 250, 251, and 252. These sites were identified as encroachment issues on the stream channel causing bank erosion. Most branch and spur roads were noted as having some level of deactivation and are not significant sediment sources to the channel network. Bald Range had the fewest number of mainstem and tributary crossings, however there are trails and roads that are not included in the GIS database. The SHIM project, completed in 2008, identified 51 sources of sediment (ranging from low to high) connected to Bald Range Creek; 19 were related to recreational activities (motorcycles/ATVs), 18 were related to cattle use (bank trampling all along stream channel corridor), 10 were identified as being road related, while 4 were considered natural occurrences. A summary of the field inspections is provided in Appendix B.

In 2007, an extreme rain event over the lower reaches of Bald Range (upstream of the Bear Main FSR crossing) caused significant sediment to enter the channel system. Rainfall from this event was channelized down motorcycle trails, which eroded deep trenches and eventually delivered sediment to Bald Rage Creek. Remedial work was completed on the trail and near the creek as well as upslope at the upper motorcycle staging area. Efforts were minimal and considered short term in the expectation that a more complete plan would be prepared, which would include new proposed motorcycle trail networks and rehabilitation plans for old ones. In the fall of 2009 the old road on the west side of Bald Range Creek from the Bear main FSR upstream to the former motorcycle trail crossing of the creek was reactivated by MTCA to construct a bridge crossing to provide an improved crossing of the creek for motorcycles. This crossing was opposed by LID.

Based on the erosion in the lower reaches, old road related problems and motorcycle crossings, this sub-basin is considered to have a moderate surface erosion hazard rating. The 2009 Terrace Mountain Fire burned the upper portions of the sub-basin and the disturbance from fire suppression activities will result in an increased potential for sediment delivery to streams. The overall surface erosion hazard for the sub-basin is rated as moderate.

Based on the 2008 field assessments in the Terrace sub-basin, roads appear in good condition with limited production and delivery potential (well back from mainstem channel). Typical problems related to forest development included the delivery of road surface fines during inclement weather (Photo 15, Appendix B), and dust fall along active road crossings. Most tributary and mainstem crossings along the mainline roads were receiving some level of sedimentation (typically low production but direct delivery or weakly filtered). Secondary roads with the exception of the areas currently being harvested are mostly deactivated to a semi- permanent state with most culverts still in place. Surface erosion at sites along these roads is related to steep sided ford crossings on tributary streams and recreational and grazing disturbance. Overall the sediment production is typically low. The SHIM project identified 10 sources of sediment (ranging from low to high) connected to the Terrace Creek mainstem channel; one was related to recreational activities (camp), three were identified as being road related, six were considered natural, and none were related to cattle use. Based on current field conditions the surface erosion hazard for the Terrace sub-basin is rated as low. The surface erosion hazard rating based on the proposed harvesting is also considered low, as all of the proposed harvest is on/or near an existing road.

Based on the 2008 field assessments roads in the North Fork sub-basin appear in fair condition with limited production and delivery potential to the mainstem channel. Problems related to forest development are similar to those in the Terrace sub-basin. Most tributary and mainstem crossings along the mainline roads were receiving some level of sedimentation (typically low production but direct delivery or weakly filtered). Surface rills and ditch flow from seepage were noted along the mainline roads in the sub-basin. Deactivation and water control structures were not abundant on branch/inactive roads, riling and ditch flow were noted. Log culverts are still present in the sub-basin and although most are located at non-classified drainages, public safety issues may exist as some show advanced stages of decay. The SHIM Project identified 15 sources of sediment (ranging from low to high) connected to the North Fork mainstem channel; one was related to recreational activities, eight were considered natural, four were related to cattle use, and no road related disturbances were identified. Based on the field conditions the current surface erosion hazard rating for the Terrace sub-basin is rated as low. With the proposed harvest occurring along existing road corridors, the surface erosion hazard remains low.

As in all other sub-basins and based on the 2008 field assessments, the residual area upstream of the intake has typical problems related to forest development. Most tributary and mainstem crossings along the mainline and branch roads were receiving some level of sedimentation (typically low production but direct delivery or weakly filtered). Road drainage issues along steeper road sections of Bear Main FSR where fill erosion is transported towards Bear Creek. The SHIM also identified points of sediment delivery from Bear Main FSR fill erosion. Deactivation and water control structures were noted mostly on the south side of the residual area within the WFN operating area. Water control structures appeared functional, although minor sediment delivery is still evident at crossings where structures have been removed. Numerous roads and trails located on the north side of the residual area were not mapped; but considered low hazard. The SHIM identified 39 sources of sediment ranging from low to high connected to the Lambly Creek mainstem channel; four are related to recreational activities (motorcycle crossings), one was related to cattle use, five were road related, and 24 were from natural sources. The surface erosion hazard rating for the residual area is rated as low.

Riparian Buffers

The riparian buffer, as represented by the extent of stream logged to the bank remained unchanged since the 2001 IWAP. For streams that require buffers or reserves under the *Forest and Range Practices Act*, the riparian area will be intact. Any increase in streams logged to the bank ratings will be for the small streams classified as "non-classified drainages" where, although there may have been harvesting to the bank, the streams are normally protected by no machine buffers. The riparian hazard rating remains low for all sub-basins, and for the entire watershed.

Landslides

The landslide hazard ratings were identified as low for all of the sub-basins and the entire watershed in the 2001 IWAP. A total of seven landslides have been identified none of which impacted the mainstem channel. These failures and the previously reviewed failures were not impacting the overall hydrologic condition of the watershed.

A slope failure was identified in the Bald Range sub-basin related to an intense rainstorm event in 2007. The failure was relatively small and although the majority of the material was deposited on a mid-slope bench sediment entered Bald Range Creek and completely obstructed the channel for a period of time after the storm. There were several other erosion sites along the slope related to the storm though not all of them delivered sediment to Bald Range Creek.

The current landslide hazard ratings remain low for all the sub-basins and the watershed. The hazard rating should remain low for proposed harvesting are located in the upper watershed areas away from the steep slopes along the mainstem channels.

Table 3-2. Lambly Creek 2008 IWAP Update Watershed Report Card

Watershed Inventory Category	North Fork	Terrace	Bald Range	Residual above Intake	Watershed above Intake
Gross area (ha)	4,213	8,019	4,072	6,943	23,247
Total area harvested (ha/%)	2,499/59	4,462/56	1,166/29	2,524/36	10,651/6
ECA (ha/%)	1,472/35	2,085/26	262/6	635/9	4,455/19
ECA below the H_{40} (ha/%)	268/30	336/12	214/5	580/9	1,407/10
ECA above the H_{40} (ha/%)	1,196/36	1,749/33	48/22	55/7	3,048/32

Table 3-2 cont'd. Lambly Creek 2008 IWAP Update Watershed Report Card

Watershed Inventory Category	North Fork	Terrace	Bald Range	Residual Above Intake	Watershed Above Intake
Total road density [8](km/km2)	1.4	0.4	1.1	1.5	1.0
Total road length (km)	96	122	67	128	414
Road deactivation (km)	35	88	23	25	171
High/moderate sediment source roads (km)	0	0	0	0	0
Landslides entering streams	0	0	0	0	0
Roads on class IV or V terrain (km)	0	0	0	0	0
Number of stream crossings	128	105	36	51	325
Length of stream logged to the streambank (km)	62	83	18	32	195
Length of mainstream channel with non-functional RMA	0.3	0	0	0	0
Length of disturbed mainstem channel (km/km)	0	0	0	0	0

Table 3-3. 2007 Hazard Indices for the Lambly Creek Watershed

Watershed Sub-unit	Hazard Category			
	Peak Flow above SSZ	Surface Erosion	Landslides	Riparian
Current North Fork	Moderate	Low	Low	Low
North Fork with Salvage	Moderate	Low	Low	Low
Current Terrace	Moderate	Low	Low	Low
Terrace with Salvage	High	Low	Low	Low
Current Bald Range	Low	Moderate	Low	Low
Bald Range with Salvage	Moderate	Moderate	Low	Low
Current Watershed above Intake	Moderate	Moderate	Low	Low
Watershed above Intake with Salvage	Moderate	Low	Low	Low

*Note: Hazard indices for the residual area have not been included in this table. Based on IWAP guidelines, hazard ratings are not to be calculated for residual areas. Development data collected for the residual area have instead been included in the calculation of hazard indices for the watershed above the intake. Any concerns identified in the residual area are addressed in the sections of the report referring to the entire watershed.

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[8] Total road density may not be as reported based on roads observed in the 2008 field assessment that did not appear in the GIS database.

Table 3-3. 2007 Hazard Indices for the Lambly Creek Watershed

Watershed Sub-unit	Hazard Category			
	Peak Flow above SSZ	**Surface Erosion**	**Landslides**	**Riparian**
Current North Fork	Moderate	Low	Low	Low
North Fork with Salvage	Moderate	Low	Low	Low
Current Terrace	Moderate	Low	Low	Low
Terrace with Salvage	High	Low	Low	Low
Current Bald Range	Low	Moderate	Low	Low
Bald Range with Salvage	Moderate	Moderate	Low	Low
Current Watershed above Intake	Moderate	Moderate	Low	Low
Watershed above Intake with Salvage	Moderate	Low	Low	Low

*Note: Hazard indices for the residual area have not been included in this table. Based on IWAP guidelines, hazard ratings are not to be calculated for residual areas. Development data collected for the residual area have instead been included in the calculation of hazard indices for the watershed above the intake. Any concerns identified in the residual area are addressed in the sections of the report referring to the entire watershed.

3.2 CHANNEL CONDITIONS

Most of the major tributary channels to the Lambly Creek mainstem as well as the middle and upper reaches of Lambly Creek are generally stable with limited channel disturbance related to past forest development. Natural disturbances are the dominant sediment sources along mainstem channels in all the sub-basins including the residual with the exception of Bald Range sub-basin. The Bald Range sub-basin has multiple areas of impact along the mainstem channel related to motorcycles/ATVs access and cattle.

The Lambly Creek mainstem channel is mainly boulder/cobble dominated and robust to potential impacts from increases in peak flows. The Terrace Creek and North Fork Creek channels are similar with boulder cobble dominated sections. Large wood and logjams were present in all mainstem channels storing sediment and shifting flows. Bald Range Creek was similar on the lower reaches (below Bear Main FSR) but the middle reaches were slightly to moderately aggraded. Many homogeneous sections were noted consisting of sand and gravel, inherent in the system but exacerbated by impacts from recreational use and cattle activity.

The channel stability hazard ratings were rated as low for all sub-basins with the exception of the North Fork, that was moderate in 2001. The current ratings also remain low as the ECAs in the sub-basins have decreased and no new disturbances were noted.

3.3 OVERVIEW OF POTENTIAL CONTAMINANTS AND INVENTORY PROCESS

The potential contaminants to drinking water are typically a function of land use. As has been summarized in Section 2.5 the land uses within the Lambly Creek watershed are related to water supply,

forest development, grazing, industrial access, recreation, and private land. The primary contaminants associated with these land uses are:

- Sedimentation to streams from forest access roads (including dust);
- Sedimentation to streams from grazing activity and off-road vehicle use at stream crossings and along stream banks;
- Bacteriological and pathogen contamination from cattle/wildlife and human activity around streams, diversion ditches, and reservoirs;
- By-products from algal blooms in reservoirs resulting from increased nutrient loading, e.g. sediment;
- Bacteriological and pathogen contamination from human activity around streams, diversion ditches, and reservoirs; and
- Petroleum spills.

The contaminant inventory process involved the following four-step process:

- Step 1 – Office review of past reports and IWAP results, the updated IWAP report card, changes in forest development since last assessments and review of forest development maps, review of historical and recent air photographs.
- Step 2 – Preparation of new field maps indicating all road crossings and updated forest development, prepare field cards to record results.
- Step 3 – Complete field assessment to identify and record contamination related to anthropogenic activities in the watershed, e.g. roads, stream crossings, channel conditions, recreational use, recent logging, as well as those from natural sources, e.g. unstable channels, unstable slopes, etc.
- Step 4 – Evaluate and summarize results.

The risk of the contaminants entering the drinking water increases with increased activity. The most likely points of contamination are those sites that permit direct access to the stream network at stream crossings. Pierre Beaudry and Associates developed a method to numerically assess the impact of stream crossings on water quality called the *Stream Crossing Quality Index*. This method considers potential erosion sites at each assessed stream crossing; the road surface on either side of the crossing and the ditches/cutslopes/fill slopes on the high and low sides of the stream at each crossing (refer to Appendix C for details on the procedure). For this project a simplified field ratings approach was developed and is referred to as the *Stream Crossing Hazard Rating* (SCHR) that follows the general methodology described in Appendix C.

The SCHR system permitted a consistent rating of sediment production, sediment delivery and cattle disturbance that resulted in a final overall hazard rating for each crossing. The condition of roads with regard to intercepting and diverting runoff and sediment was noted for all roads assessed. In addition, channel assessments were completed for selected reaches using sites that had been assessed during previous work where practical. Riparian condition was also assessed at a sufficient number of locations to characterize the sub-basins. Recreational use was recorded throughout the assessment area with additional emphasis placed on areas of concentrated use around lakes and reservoirs.

3.4 NATURAL FACTORS THAT IMPACT WATER QUALITY AND QUANTITY

This section addresses natural impacts that are occurring or may occur in the watershed that will affect the hazard rating associated with anthropogenic activities.

3.4.1 CLIMATE CHANGE IMPACTS

Climate change is likely to cause significant and long-term impacts to the watershed hydrology. According to research by the Atmospheric Environment Service, temperatures in the Okanagan are increasing by 0.1°C/year over the spring, summer and fall seasons and by 0.2°C/year over the winter season. There is also a projected decrease in the April 1st snow pack of 10% by 2020, 40% by 2050 and 50% by 2080. The decrease in snowfall is accompanied by an increase in rainfall, i.e. the snowfall/rainfall partitioning is shifting towards more rain and less snow during the winter season. The effects on the Lambly Creek water supply and the LID water demand require more study to determine the impacts.

In summary, the research suggests warming summers resulting in increased water demand and less snow (but perhaps more rain) during the winter that may result in less runoff. The climate models also indicate a shift in the snowmelt period by two weeks sooner. Intense summer and fall rainstorms can cause erosion and can increase sediment delivery to the stream channels. These storms are likely to continue in the future with the changing climate.

3.4.2 MOUNTAIN PINE BEETLE IMPACTS

One of the most obvious impacts, currently affecting the watershed, is the mountain pine beetle and the likely loss of most of the mature lodgepole pine in the watershed. Lodgepole pine is the dominant conifer species in the watershed, especially in the upper snow-sensitive zone (upper 40% of the watershed). Analysis of the North Fork sub-basin indicates that for the snow sensitive zone past harvesting has occurred on ~54% of the area, the mature pine >40% accounts for a further 15% of the area. Stands with pine <40% plus the non-pine types account for a total of ~31% of the area.

For the Terrace sub-basin, in the snow sensitive zone past harvesting has occurred on ~55% of the area, the mature pine >40% accounts for a further ~19% of the area. Stands with pine <40% plus the non-pine types account for a total of ~26% of the area. For the Bald Range sub-basin in the snow sensitive zone past harvesting has occurred on ~71% of the area, the mature pine >40% accounts for a further 7% of the area. Stands with pine <40% plus the non-pine types account for a total of ~22% of the area. For the watershed above the Intake the analysis indicates that for the snow sensitive zone past harvesting has occurred on ~52% of the area, the mature pine >40% accounts for a further ~20% of the area. Stands with pine <40% plus the non-pine types account for a total of ~28% of the area. The area that will impact the hydrology will total ~72% of the entire snow sensitive zone area. These are the stands that will have the greatest impact on peak flow increases due the high percentage of mature pine where the loss of canopy closure will result in increased snow accumulation and water yields.

The loss of the mature pine will likely provide greater water yields for the next several decades, and could result in significantly increased peak flows as well as a shift in the timing of the runoff to earlier in the spring. There is a risk that the magnitude of peak flows will increase as the lodgepole pine dies and

that the frequency of larger flow events will increase. There is a potential for the larger peak flows could exceed the design criteria of existing stream culverts and bridges leading to increased risk of failures of these structures. Increased peak flows could also result in increased channel erosion and subsequent sediment transport that would degrade water quality. Depending on reservoir levels during freshet and rain events buffering of the increased peak flows may occur.

As a result of the epidemic pine beetle activity, there will be a significant increase in timber harvesting focused on salvaging infested pine stands while there is still economic value to the wood. As stands die and are salvaged there will be increased access to streams and wetlands for wildlife and cattle as grasses and brush species that may dominate many sites temporarily until conifer stands recover. As a result of the potentially increased wildlife and cattle use, there will be the associated increases in sediment and fecal loading in the streams.

Combining the impacts of the loss of forest cover to the pine beetle and climate change, there may be some benefits from less snow in the short-term that might offset the potential increase in peak flows associated with the loss of forest cover. However, the snowmelt period could be advanced by as much as four weeks resulting in the LID having to rely on storage for a much longer period of the year. Over the long-term, indications are that there will likely be less water yields in the watershed to meet increasing demand.

3.4.3 WILDLIFE IMPACTS

Wildlife movement in the watershed is unknown but it is likely that during the course of a year most of the stream crossings are used by wildlife. However, during the fieldwork very little evidence of wildlife impacts was noted. Where pine stands die or are salvaged there will likely be increased forage for wildlife. Where natural barriers to animals are lost in the dead and salvaged stands it will be important to assess the requirement for strategically locating replacement barriers to protect the source water quality.

3.4.4 WILDFIRE IMPACTS

The risk of wildfire in the watershed has been increasing as the fuel loading increases associated with the mortality of the mature lodgepole pine to the mountain pine beetle. The Terrace Mountain Fire and Rose Valley Fire in 2009 reinforced these risks. The Terrace Mountain Fire burned portions in the Esperon Creek sub-basin and the Bald Range Creek sub-basin. The Rose Valley Fire burned steep slopes on the west side of the Rose Valley Reservoir. Soils exposed by the wildfires and by fire suppression activities will increased the risks of sediment delivery to streams and may also increase the potential for increased loading of heavy metals, phosphates and nitrates in the surface runoff. There may also be increased surface runoff due to water repellent soils caused by the wildfires. If increased sediment and nutrients are delivered to the Rose Valley Reservoir there will be an increased potential for more frequent and persistent algae blooms in the reservoir that have the potential to degrade the drinking water quality.

3.5 ANTHROPOGENIC USES THAT IMPACT WATER QUALITY AND QUANTITY

3.5.1 FOREST DEVELOPMENT IMPACTS

Past forest development in the watershed was discussed in Module 1, Section 2.8. Water quality impacts from forest development are typically related to increased sediment delivery to streams as summarized in Section 3.1. Tolko, BCTS and the WFN currently have harvesting rights in the watershed. Tolko operates within TFL 49, which includes the area north of the Lambly Creek mainstem, as does BCTS. The WFN operates on the south of the Lambly Creek mainstem and entirely within the residual area. The future impacts from forest development, for the short-term, that is the next three to five years will result from the proposed salvage harvesting of pine beetle affected stands.

Tolko completed a retention plan dated January 2008 for the watershed that focuses on salvaging lodgepole pine attacked by the mountain pine beetle. A retention plan is a forest development planning process that considers all the resource values in the watershed, timber and non-timber, and identifies what stands need to be retained to protect the non-timber values such as water, wildlife, fish, recreation, etc. These are the stands that will be retained, i.e. not harvested in the short-term (next 3-5 years). The remainder of the stands not required to protect other resource values are those stands that would be considered for harvesting. This planning process was developed to assist in planning salvage logging of mountain pine beetle infested stands. The plan included a review of the hydrologic impacts that may occur as a result of the loss of forest cover in the upper watershed that is the source of peak flows.

The impacts from salvage harvesting of the pine beetle affected stands are likely to be minimal compared to the larger scale hydrologic impacts that will occur as a result of the loss of the mature lodgepole pine especially in the snow-sensitive upper watershed that is the source of peak flows. Since there will be limited additional road required to support the salvage logging, the impacts on water quality should be minimal. The loss of forest through natural causes and salvage logging will result in increased exposure of streams for recreational use and wildlife and cattle access. As the forest cover is reduced there is greater opportunity for increases in forage due to improved light, moisture and nutrients. The expansion of these species will encourage greater use by wildlife and cattle into areas along streams not previously accessible to these animals. Increased animal presence will result in increased sediment and fecal coliform loading.

The sources of sediment in the watershed include roads at stream crossings, channel erosion due to increased peak flows, and from landslides that impact stream channels. These sources will likely increase as a function of the loss of forest cover to the pine beetle. Channel erosion can also be a natural function of the system, as woody debris moves and shifts flow or undercut banks fail. The dominant forest development impact is from roads. Prior to initiating the 2008 fieldwork the road network in the watershed was reviewed using GIS that identified road crossings and assigned each an identifier number. The GIS analysis identified 325 crossings. During the fieldwork, 86 sites were identified as stream crossings, 82 were non-classified drainage crossings or crossdrains, and 157 were not assessed. Based on the combined ratings for the sites assessed, 156 sites (93%) were ranked as low to very low hazards, 12 sites (7%) were low to moderate hazards. There are no high hazard road crossing sites identified within

the watershed. There were five wood culverts identified in various stages of failure at non-classified drainages (Sites 3, 57, 80, 189, and 191).

The sites in Table 3-4 are the results for the 12 sites that had moderate hazard ratings. The detailed assessment tables and related photographs for all the sites assessed are provided in Appendix B. Map 3 provided in Appendix A includes the numbered stream crossings referred to in this section.

Table 3-4. Road Crossings with Moderate Hazards

Crossing No.	Hazard	Likelihood	Hazard Rating	Photograph No.
31	Sediment delivery from road surface	During Freshet and rain events	Low to Moderate	
56	Fillslope erosion	During Freshet and rain events	Low to Moderate	Photo 23
113	Sediment delivery from road surface / cattle presence	During Freshet and rain events	Low to Moderate	Photo 24
126	Fillslope erosion/cattle presence	During Freshet and rain events	Low to Moderate	Photo 25
128	Fillslope erosion / cattle presence	During Freshet and rain events	Low to Moderate	Photo 26
155	Sediment delivery from road surface / cattle presence	During Freshet and rain events	Low to Moderate	
159	Sediment delivery from road surface / cattle presence	During Freshet and rain events	Low to Moderate	
175	Fillslope erosion / cattle presence	During Freshet and rain events	Low to Moderate	Photo 27
205	Sediment delivery from road surface / cattle presence	During Freshet and rain events	Low to Moderate	
219	Sediment delivery from road surface / cattle presence	During Freshet and rain events	Low to Moderate	Photos 16 and 17
275	Fillslope erosion / cattle presence	During Freshet and rain events	Low to Moderate	Photo 18
313	Sediment delivery from road surface / cattle and recreational presence	During Freshet and rain events	Low to Moderate	Photo 15

Increased harvesting activity is likely to occur in the watershed over the next several years if forest licensees implement the proposed salvage logging plans. Increased industrial activity, timber harvesting and logging truck traffic will increase the likelihood of water quality impacts.

Proposed harvest in the Bald Range sub-basin is located near existing road systems and is limited to small headwaters areas. The current ECA for the snow sensitive zone is 22% and will increase to ~35% with the proposed salvage harvest. Roads in the sub-basin appear in good condition, however some problems were identified on old roads near sites 249, 250, 251, and 252 where the road encroaches on the stream channel near headwaters area (refer to the Map 3 in Appendix A). Most branch roads were deactivated and are not significant sediment sources.

Proposed harvest in the Terrace sub-basin is located near existing road networks mainly in the Lean-to and Esperon Creek areas above the H_{40} line. The current ECA for the sub-basin in the snow sensitive zone of ~33% will increase to ~54% with the proposed salvage harvesting. Roads in the sub-basin appear in good condition with limited sediment production and limited sediment delivery to the channel, however this is likely exacerbated during intense rainstorms and the snowmelt period. Dust fall from all vehicles using the road system has the potential to affect drinking water quality.

Proposed harvest in the North Fork sub-basin is located mainly in the southern portion of the basin above Whiterocks FSR, with a smaller portion near Tadpole Reservoir. The ECA to December 31, 2007 in the snow sensitive zone of the sub-basin is ~36% and will increase to ~50% with the proposed salvage harvest. Roads in the sub-basin appear in fair condition with limited sediment production and sediment delivery to the mainstem channel. Surface rills and ditch erosion from seepage were noted along the mainline roads in the sub-basin. Deactivation and water control structures were not abundant on branch/inactive roads, rills and minor ditch erosion were noted. Some log culverts are still present in the sub-basin.

Proposed harvesting in the Residual area is located on the south side of the residual area near the height of land. The current ECA is ~7% for the sub-basin in the snow sensitive zone. A small portion of harvest is proposed in the upper Riel Creek area. Logging traffic is concentrated along the Bear Main FSR. Heavy traffic along the Bear Main FSR results in the increased potential for road surface sediments transported in ditches and also the amount of dust accumulations on vegetation.

As noted previously, the loss of forest cover to the mountain pine beetle may result in significant changes to the watershed hydrology. The Ministry of Forests and Range Forest road design requirements are that major culverts and bridges must have a capacity to pass the Q_{100} peak flows. These design flows may increase after the pine dies and it is likely that there may be stream crossings downstream from the areas affected by the beetle that may be under capacity. The failure of a culvert or bridge on a mainstem, particularly in the non-buffered zone upstream of intake could result in serious impacts to the water quality at the intake.

Table 3-5 summarizes the potential ECA's within the snow sensitive zone related to various harvest/salvage/beetle kill scenarios. The data in the table accounts for all past and proposed harvesting as well as the pine that will die but not be salvaged.

Table 3-5. ECA Comparison at December 31, 2007 for no beetle, loss of all mature pine, and proposed retention plan for the Snow Sensitive Zone

1 Catchment	2 Area above SSZ (ha)	3 ECA assuming no beetle (ha/%)	4 ECA assuming all mature Pl dies (ha/%)	5 ECA for proposed harvesting (ha/%)	6 ECA for retention plan (ha/%)
North Fork	3,295	1,238/38	1,560/47	1,471/45	1,644/50
Terrace	5,318	1,818/34	2,731/51	2,494/47	2,850/54
Bald Range	218.9	64/29	77/35	70/32	77/35
Lambly Creek	9,574.9	3,178/33	4,763/50	4,122/43	4,977/52

For the entire watershed above the intake there are ~ 1,585 ha of mature pine in the snow sensitive zone. It is proposed that ~944 ha or ~59% of the stands above the intake will be harvested. The ECA for the snow sensitive zone above the intake after proposed harvesting is estimated to be ~52% as compared to an ECA of 50% if there was no salvage logging.

Based on preliminary research results on snow accumulation and melt in the Okanagan[9], there may be little difference hydrologically in the approximate equivalent clear-cut area between areas retained but dead and stands salvaged. That is to say that whether or not there was any salvage harvesting, the impact of the death of the remaining mature pine combined with the past harvesting will have affected more than 60% of the forested area in the snow sensitive upper watershed. Areas that are harvested and prepared for either natural regeneration or planted should have significant hydrologic recovery in approximately 30 years. For those areas not logged, left to recover naturally, hydrologic recovery will likely take 50-60 years[10]. At the end of 30-years the no salvage option would have recovered to ~22% versus 19% for the salvage and plant option above the intake.

3.5.2 RANGE USE IMPACTS

Cattle activity was noted throughout the watershed. According to the information provided by the Ministry of Forests and Range there are currently five active grazing licences issued over the Lambly and Powers watersheds with a total of 3,086 AUMs (animal unit months, equivalent to one cow with one calf). The dates of use vary, but in general cattle are permitted to graze the watershed from June 1 through October 30. Each tenure holder has a Grazing License issued by the Ministry of Forests and Range. The presence/absence of cattle impacts were noted at each road crossing assessed. Cattle frequently use road corridors and primary access routes through the watershed. Stream crossings along the roads offer

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[9] Research in the Ashnola River watershed undertaken for Gorman Bros. Lumber Ltd. By Dobson Engineering Ltd. In 2007 and 2008 – not published.

[10] ibid

easy access to water as well as to the riparian areas along streams where there is often preferred grasses.

Field observations indicate there is low sediment disturbance on roads at streams in the North Fork and Terrace sub-basins. Upland reservoirs and open diversion ditchlines showed signs of cattle activity; although disturbances were minimal they included fecal matter below the high water mark in streams and around reservoirs. With increased cattle use there is also the associated increase in manure deposits in the reservoirs, diversion ditches, stream channels and adjacent riparian area unless increased cattle management keeps them away from these areas.

During the 2008 field inspection it was identified where cattle were contributing sediment and fecal material at 74 (44%) of the 168 sites assessed. With the exception of Bald Range Creek[3], no moderate or high disturbance sites were attributed to cattle activity at major stream crossings or tributary channels. The details for all the sites are provided in Appendix B. Bald Range Creek however is experiencing moderate activity resulting in moderate channel disturbances.

3.5.3 RECREATIONAL USE IMPACTS

In 2001 the Okanagan Shuswap LRMP created the Bear Creek Intensive Recreation Zone for off road motorcycle/ATV use. The area encompasses approximately 30,000 hectares within the Lambly Creek and Powers Creek Community Watersheds. In 2007 the Ministry of Tourism, Culture and the Arts created a recreation site designation over the Bear Creek zone in the LRMP that delegated administrative control of all organised recreation activities within the zone to that ministry.

The Lambly Creek watershed is entirely contained within the MTCA Bear Creek Recreation Site. Recreational use was noted throughout the watershed to varying levels and uses. Recreational disturbance was considered low in the North Fork sub-basin in comparison to the conditions encountered in the Bald Range and Terrace sub-basins based the results of the Sensitive Habitat Inventory Mapping completed for LID in 2008. Motorcycle/ATV/4wd activity was noted along branch and mainline roads. Damage was considered low although activity at/near the Tadpole Reservoir and the diversion ditches are a concern. Vehicle disturbance was noted below the high water mark and along the diversion ditches. The MTCA has prepared a Bear Creek Operating Plan for the development of motorized recreation trails in the Bear Creek Recreation Site that has not been accepted by LID.

Recreational use in the Terrace sub-basin is moderate based on the activity noted around all the reservoirs in the area. Motorcycle/ATV use was noted along most branch roads and some unmapped trails, particularly in the Lean-to Creek area. Motorcycle/ATV/4wd use was also observed below the high water mark around the Big Horn Reservoir. Other outdoor recreation use was evident based on the numerous fire pits present in the area. The Bear Main FSR crossing at Terrace Creek is also a concern due to the unregulated use by campers and off road vehicles.

Recreational use in Bald Range sub-basin is high based on the volume of well-documented problems due to motorcycles/ATVs, campers, and "bush party locations". These concerns were supported by the conditions observed during the field assessment. Although the majority of the motorcycle/ATV activity

occurs within the lower reaches of Bald Range Creek area, numerous trails and branch roads in the upper sub-basin provide riders and cattle access to other areas including in the Lean-to and Riel creek areas and beyond.

The Residual area has dispersed and concentrated recreational disturbances, with most activity located along the upper slopes; riders are also utilizing access from McDougall Creek to reach the watershed. Four sites were attributed to recreational activities in the SHIM results; most are unmapped crossings by motorcycles and ATVs. Campsites were noted throughout the watershed at regulated and unregulated sites. Esperon and Big Horn reservoirs had very little evidence of disturbances from camping activities.

3.5.4 MINING AND QUARRIES

There are 30 mineral tenures within the Lambly Creek watershed based on the 2004 (last update) Mineral Titles Map. Currently the only active site is the limestone quarry located in the Bald Range sub-basin. Burnco Ltd. proposes a gravel pit north of the Bear Main FSR and east of Bald Range Creek. The proposal has been reviewed by LID and it has no objection to the proposal.

Development of these tenures, and others in the watershed could be cause for a variety of water quality impacts if there are streams near the sites. There may also be increased industrial traffic on the roads that also increases the risks to the water sources (i.e. dust, run-off). Current developments are a low hazard as current activities are located well back from the mainstem channel, however any activity near a stream could increase the risk. Spring/fall water quality monitoring by Larratt Aquatic Consulting for microbes, phosphates, and turbidity indicates no impacts attributable to the quarry.

3.6 DRINKING WATER HAZARD SUMMARY

Table 2-1 in Module 1 provided an initial summary of the potential hazards to drinking water in the watershed. Table 3-6 expands on the information in Table 2-1 and provides a summary of the current preventative measures in place to reduce the hazards on the drinking water. Additional information on future actions that might be undertaken will be provided in Module 8.

Rose Valley

The Rose Valley catchment has no industrial development and none is planned since the forest stands have no current market value for timber products. There is little to no lodgepole pine in the catchment so there will be no hydrologic impact from the pine beetle. The lands are part of the Westbank First Nation Community Forest License. There lands are not part of any active range permit. There are no active public roads in the catchment. The overall hazards to water quality are limited to possible contamination from people recreating around the reservoir, from limited wildlife and wildfowl use, and from wildfires.

Table 3-6. Module 2 – Hazards to Drinking Water Quality at the Intake and Current Preventative Measures

Hazard Type	Drinking Water Hazard	Impacts	Current Preventative Measures/Responsibility
Physical	Natural sediment load from channel erosion and mass wasting	- Exceed turbidity threshold for treated water - Compromised disinfection process - Risk to human health	- Planning – Avoid development activities in sensitive areas. - Forest licensees - Flow controls have been installed at the Lambly Creek intake to reduce the volume of turbid water diverted to the Rose Valley Reservoir. - LID Staff
	Sedimentation from industrial roads and road crossings	- Increased sediment load would exceed the turbidity threshold for treated water - Compromised disinfection process - Risk to human health	- Planning – Avoid developing roads in sensitive areas. - Forest licensees - Implementation – Use best management practices during development to limit impacts. - Forest licensees
	Sedimentation from range use in and around streams and road crossings	- Increased sediment load would exceed the turbidity threshold for treated water - Compromised disinfection process - Risk to human health	- Planning – Prepare plans to limit cattle/recreation use around streams - Grazing licensee, MoFR, MTCA - Implementation – Aggressive herd management, development of off-stream watering - Grazing licensee, MoFR
	Sedimentation from recreation activity on roads, road crossings and in/around streams and reservoirs	- Increased sediment load would exceed the turbidity threshold for treated water - Compromised disinfection process - Risk to human health	- Education – Inform stakeholders and the public about watershed sensitivities. - LID, MTCA - Signage – Use signs to remind users of the importance of protecting the water quality. - LID, MTCA
	Water Quantity	- Increased peak flows and risks to culverts and bridges. - Lack of adequate supply could result in public health issues	- Review culvert capacities and requirement for revised design guidelines. - MoFR - Plan for additional storage to meet future needs. - LID
	Wildfire	- There will be an increasing risk of wildfire in the watershed as the mature pine dies. A wildfire could cause a serious degradation in water quality related to increased sediment load. There is the potential loss of control at the intake due to evacuation order and/or fire damage to the intake	- Develop a wildfire plan for the watershed to reduce potential impacts. -LID, MoFR - Plan future harvesting to reduce fuel loads and to create defensible zones. - LID, Forest Licensees, MoFR
Biological	Bacteriological contamination from wildlife/cattle/human presence in and along streams	- Risk to human health - Contravention of DWP Regulation for fecal coliform bacteria, E.coli, and total coliforms in drinking water	- Planning – Prepare grazing plans to limit cattle use around streams. - Grazing licensees, MoFR, MTCA - Implementation – Aggressive herd management, development of off-stream watering. - Grazing licensees, MoFR - Education – Educate stakeholders and public about the safe disposal of human waste in the watershed including signs / LID, Agencies
	Protozoa (Giardia, Cryptosporidium)	- Risk to human health - Contravention of DWP Regulation for fecal coliform bacteria, E.coli, and total coliforms in drinking water	- Planning – Prepare grazing plans to limit cattle use around streams. - Grazing licensees, MoFR - Implementation – Aggressive herd management, development of off-stream watering. - Grazing licensees, MoFR - Education – Educate stakeholders and public about the safe disposal of human waste in the watershed including signs. - LID, Agencies
	Viruses	- Risk to human health - Contravention of DWP Regulation for fecal coliform bacteria, E.coli, and total coliforms in drinking water	- Planning – Prepare grazing plans to limit cattle use around streams. - Grazing licensees, MoFR - Implementation – Aggressive herd management, development of off-stream watering. - Grazing licensees, MoFR - Education – Educate stakeholders and public about the safe disposal of human waste in the watershed including signs. - LID, Agencies
	Algae blooms in reservoir	- Cyanobacteria contamination - Trihalomethanes, by-product of disinfection process	- Planning – Limit soil disturbance to limit sediment and nutrient loading in streams upstream of reservoirs. - LID, Agencies - Restrict access by wildlife, cattle and the public in reservoir pond areas. - Agencies, LID, MTCA - Education – Inform stakeholders and the public about watershed sensitivities and the potential to cause algae blooms. - LID - Signage – Use signs to remind users of the importance of protecting the water quality. - LID, Agencies
Chemical	Total Organic Carbon (TOC)	- Reaction of organics (total organic carbon) with water disinfection resulting in formation of Trihalomethanes (THMs) in drinking water - Risk to human health	- Planning – Plan roads and harvesting to limit sediment and nutrient loading that would increase biological activity in water column and subsequently TOCs. – Forest Licensees
	Petroleum contamination from industrial fuel spill or vehicle accident and gas powered boats on reservoirs	- Contamination of drinking water - Risk to human health	- Education – Stakeholders to educate contractors about safe industrial activities including use of spill kits, use of vegetable based lubricants, etc. - MoFR, MTCA, Forest Licensees - Educate public on road safety protocols and spill reporting, - MoFR, Forest Licensees, LID
	Herbicides	- Contamination of drinking water - Risk to human health	- Compliance with Pest Management Regulations. - MoFR
	Wildfire	- Contamination of drinking water from fire retardant application - Risk to human health	- MoFR Wildfire Management Branch standard operating procedures. - MoFR

4. MODULE 7 – RISK CHARACTERIZATION & ANALYSIS

Module 7 considers the hazards to drinking water quality identified in Module 2, along with the consequence to the drinking water should a contaminant or combination of contaminants reach the intake. The following sections review the barriers currently in place and assess the related risks.

Lambly Creek

4.1 EVALUATION OF SOURCE PROTECTION BARRIERS

Source protection is the first barrier in the multi barrier approach to protecting drinking water. The source protection barriers currently in place include regulations and guidelines set out in the *Forest and Range Practices Act, Water Act* and the *Drinking Water Protection Act*. However, regardless of the intent of the regulating agencies and the licensed stakeholders to comply with the legislation and regulations, and to implement best management practices, there is increased sedimentation to all of the streams in the watershed from roads and from disturbances from cattle and recreational use. In addition, there are natural hazards such as contamination from wildlife, increased runoff due to the loss of forest cover due to the mountain pine beetle and wildfires, and impacts from climate change, for which the only effective barrier may be enhanced water treatment.

The requirement for filtration can be deferred if through enhancing barriers to contamination such as improved sediment control practices at forest road stream crossings, improved cattle management, improved reservoir monitoring and management, LID can meet the filtration deferral requirements established by Health Canada[11]. Recognizing the significant challenges to water quality and quantity that LID faces, all the agencies and stakeholders in the watershed should make every effort to limit the impacts on the source water. The higher the raw water quality that arrives at the intake, the lower public health risk and the costs of treatment for those who use this source for their drinking water.

4.2 CONSEQUENCE TO DRINKING WATER QUALITY AND QUANTITY

The impacts from natural factors that affect water quality, such as wildfire, climate change and the mountain pine beetle as well as the anthropogenic activities in the watershed, including recreation, forest development and grazing (all summarized in Section 3) are considered in the risk assessment as the source area "hazards" that could affect the drinking water quality. The intent of this section is to address the issue of the "consequence(s)" to the drinking water quality that will be used to estimate the risks. *Consequence* is defined as the effect on human well-being, property, the environment, or other things of value or a combination of these (adapted from CSA 1997). Conceptually, in the case of drinking water, consequence is the change, loss, or damage to the water quality caused by contaminants. Table 4-1 provides a summary for the ranking of consequences to drinking water quality/quantity, rated from insignificant to catastrophic. Table 4-2 summarizes the consequence ratings for each of the hazards listed in Table 3-6.

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[11] Refer to http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/water-eau/turbidity/turbidity-eng.pdf

For Lambly Creek the most likely consequences to drinking water quality will be as a result of:

- increased sediment loads;
- increased heavy metal loading resulting from wildfires;
- increased fecal material/increased pathogen loading;
- increased organics (THM precursors); and/or
- increased nutrients (algal growth, taste and odour problems and THM precursors).

Table 4-1. Qualitative Measures of Consequence to Drinking Water Quality/Quantity

Level	Descriptor	Description
1	**Insignificant**	Insignificant impact, no illness, little disruption to normal operation, little or no increase in normal operating costs. Manageable changes in water supply, both increased or decreased stream flow
2	**Minor**	Minor impact for small population, mild illness moderately likely, some manageable operation disruption, small increase in operating costs. Restrictions on watering due to drought/decreased supply or increased operating/treatment costs due to regular flow events
3	**Moderate**	Minor impact for large population, mild to moderate illness probable, significant modification to normal operation but manageable, operating costs increase, increased monitoring.
4	**Major**	Major impact for small population, severe illness probable, systems significantly compromised and abnormal operation if at all, high level monitoring required,
5	**Catastrophic**	Major impact for large population, severe illness probable, complete failure of systems. Loss of drinking water and fire suppression supplies.
Based on Module 7 of the *Comprehensive Drinking Water Source to Tap Assessment Guideline* (BC Ministry of Health Services and Ministry of Water, Land and Air Protection 2005).		

Table 4-2. Consequences to Drinking Water Quality/Quantity at Intake

Hazard Type	Drinking Water Hazard	Consequence Level
Physical	**Sediment** - Natural sediment load from channel erosion and mass wasting	3-5*
	Sediment - Sedimentation from industrial roads and road crossings	3
	Sediment - Sedimentation from range use in and around streams and road crossings	3
	Sediment – Sedimentation from recreation activity on roads, road crossings and in/around streams and reservoirs	3
	Water Quantity – Increased peak flows or reduced/loss of supply	1-5*
	Wildfire – increased sediment load and loss of control at intake from evacuation order and/or damage	3-5*
Biological	**Bacteria** - Bacteriological contamination from wildlife/cattle/human presence in and along streams	4
	Protozoa – presence of Giardia, Cryptosporidium	4
	Viruses – presence	4
	Algae – algal blooms in reservoirs	3
Chemical	**Organic material** - (Total Organic Carbon)	2
	Hydrocarbons -Petroleum contamination from an industrial fuel spill or vehicle accident and gas powered boats on reservoirs	2
	Herbicides /pesticides – contamination of water by herbicide spill or misuse	3
	Wildfire – Contamination of drinking water from fire retardant application	2

Notes:
* = These levels are provided as a range rather than a discrete value since the consequence may change over time in relation to the hazard.

The two main drinking water hazards present in the watershed are turbidity and pathogens. High levels of turbidity will increase the risk that viable pathogens could enter the drinking water system. Certain pathogens can be harmful in extremely small concentrations, and ingestion can result in short and long-term illness, and possibly death for vulnerable individuals (e.g. the very young, very old, or those with a compromised immune system).

Physical Hazards

Turbidity alone is not directly harmful but can compromise the disinfection process and therefore the consequence from all sources is assumed to be at least moderate (Table 4-2). The reservoirs in the upper watershed provide some buffering at the intake by settling the sediment loads/turbidity upstream from the reservoirs. The settling action can reduce the consequence from sediment and turbidity introduced

upstream from the reservoirs to drinking water quality at the intake. Sediment loads and turbidity introduced to the watershed downstream from the reservoirs are more likely to affect water quality at the intake, but remains rated as a moderate consequence.

Mass wasting events can cause increased turbidity and have the potential to completely block stream channels and/or destroy infrastructure. The consequence of hazards related to mass wasting events ranges from 3 (moderate) to 5 (catastrophic) depending on the severity of the event (i.e. small landslide impacting the creek, increased turbidity results in a consequence of 3 vs. a large landslide blocking the creek and destroying the water intake resulting in a consequence of 5, catastrophic).

The consequence level for changes in water quantity range from 1-5 depending on the severity of the event and covers everything from manageable increases or decreases in water supplies to complete loss of water due to extreme drought conditions or catastrophic peak flow events that could render the water intake and chlorination works inoperable.

The physical consequences of wildfire in the watershed ranges from 3-5. Increased sediment loads and increased turbidity following wildfires would constitute a 3 or moderate consequence. Interruption of water service resulting from wildfire (evacuation order or order to remove chlorine supplies at the chlorinator) would constitute a level 4 consequence and destruction of the disinfection facility resulting from wildfire could constitute a level 5 consequence.

Biological Hazards

The presence of bacteria, protozoa and viruses represent a level 4 consequence as the potential for small concentrations of these contaminants in drinking water could lead to impaired human health. Algal growth in the reservoirs and stream network constitute a level 3 consequence. Although algae alone is a biological water quality parameter, the presence of algal cells (organics) in water supplies contribute to turbidity readings (physical parameter) and are precursors to THM formation (chemical parameter) when water is disinfected with chlorine/chlorine compounds. Blue-green algae can be problematic as some species are associated with toxic compounds. Algae in drinking water supplies represent a level 3 consequences due to the potential health risks associated with exposure to potentially harmful algae species.

Some blue-green algae produce toxins that could pose a health risk to people and animals when they are exposed to them in large enough quantities. Health effects could occur when surface scums or water containing high levels of blue-green algal toxins are swallowed, through contact with the skin or when airborne droplets containing toxins are inhaled while swimming, bathing or showering.
[http://www.health.state.ny.us/environmental/water/drinking/bluegreenalgae.htm]

Consuming water containing high levels of blue-green algal toxins has been associated with effects on the liver and on the nervous system in laboratory animals, pets, livestock and people. Livestock and pet deaths have occurred when animals consumed very large amounts of accumulated algal scum from along shorelines.
[http://www.health.state.ny.us/environmental/water/drinking/bluegreenalgae.htm]

Direct contact or breathing airborne droplets containing high levels of blue-green algal toxins during swimming or showering can cause irritation of the skin, eyes, nose and throat and inflammation in the respiratory tract.
[http://www.health.state.ny.us/environmental/water/drinking/bluegreenalgae.htm]

Recreational contact, such as swimming, and household contact, such as bathing or showering, with water not visibly affected by a blue green algae bloom is not expected to cause health effects. However, some individuals could be especially sensitive to even low levels of algal toxins and might experience mild symptoms such as skin, eye or throat irritation or allergic reactions.
[http://www.health.state.ny.us/environmental/water/drinking/bluegreenalgae.htm]

There is less information available about the potential health effects of long-term exposure to low levels of blue-green algal toxins. Some limited evidence from human studies suggests that long-term consumption of untreated surface waters containing high levels of blue green algal toxins could be associated with an increased risk of liver cancer. However, people in these studies also were exposed to other factors associated with liver cancer. As a result, it is unknown whether algal toxin exposure contributed to this risk.
[http://www.health.state.ny.us/environmental/water/drinking/bluegreenalgae.htm]

The Rose Valley Reservoir is most likely to be affected by algal blooms during the summer months/growing season. Increased sediment/nutrient delivery to the reservoir can exacerbate the conditions and lead to more frequent and intense algal growth. Increased loading of dissolved and suspended organic compounds increases the risk of taste and odour problems at the intake and are precursors to THM formation following disinfection.

Chemical Hazards

Chemical hazards to drinking water (TOC including hydrocarbons, herbicides/pesticides and potential chemical contamination related to wildfire suppression agents/chemical retardants) constitute a level 2 consequence. The presence of total organic carbon is an indicator of organic compounds that could contribute to THM formation. Small volumes of hydrocarbons from fuel spills can contaminate large volumes of water. The contaminants are typically less dense than water and affect the surface water only (do not penetrate to lower depths of reservoirs). The hydrocarbon compounds associated with petro-chemical spills are also volatile and can evaporate quickly, depending on water and air temperatures.

The toxicity of various herbicide and pesticide products ranges widely. However, in high concentrations these compounds can affect human health when ingested, inhaled or touched. It is unlikely that through proper use, high concentrations of these compounds would be present in drinking water supplies, however chronic exposure to low concentrations can also affect human health. For these reasons, pesticides and herbicides are given a consequence level of 3 or moderate.

The potential for chemical contamination of drinking water from fire retardant application exists, but the compounds are designed to adhere to any substrate they contact (trees, shrubs, rocks) which reduces the likelihood of these compounds being washed into watercourses. In the event they are inadvertently applied directly into streams and/or reservoirs they pose a more significant threat to drinking water

quality. The constituents of concern in fire retardants are primarily nutrients, which are designed to assist plant regeneration following the fires. These nutrients can encourage algal growth and for this reason the consequence on water quality related to fire retardants is rated as level 2.

4.3 QUALITATIVE RISK ASSESSMENT

A qualitative risk assessment has been undertaken for the hazards identified in Module 2 (intrinsic watershed hazards and contaminant sources). Risks are assessed at the point of intake on Lambly Creek. Therefore, the assessed source risk at the intake will be different from the risk at the tap following disinfection. This unabated risk to the drinking water is the worst-case scenario i.e. in the event of a failure of the intake/chlorination works.

Assessment of Likelihood

Risk is the product of likelihood and consequence. Qualitative measures of likelihood are presented in Table 4-3, as provided in the Assessment Guidelines. A time horizon of 10 years is suggested in the guidelines when attributing likelihood of occurrence to identified hazards.

Table 4-3. Qualitative Measures of Likelihood

Level of Likelihood	Descriptor	Description	Probability of Occurrence in Next 10 Years
A	**Almost certain**	Is expected to occur in most circumstances.	>90%
B	**Likely**	Will probably occur in most circumstances.	71-90%
C	**Possible**	Will probably occur at some time.	31-70%
D	**Unlikely**	Could occur at some time.	10-30%
E	**Rare**	May only occur in exceptional circumstances.	<10%

Reproduced from Module 7 of the *Comprehensive Drinking Water Source to Tap Assessment Guideline*
(BC Ministry of Health Services and Ministry of Water, Land and Air Protection 2005).

Modules 1 and 2 have identified the hazards to drinking water quality that are summarized in Table 2-1. Assessment of likelihood for the hazards is summarized in Table 4-4 followed by a brief summary for each hazard.

Table 4-4. Likelihood of a Hazard Affecting Drinking Water Quality at the Intake

Hazard Type	Drinking Water Hazard	Likelihood
Physical	**Sediment** - Natural sediment load from channel erosion and mass wasting	C
	Sediment - Sedimentation from industrial activity including roads and road crossings	B
	Sediment - Sedimentation from range use in and around streams and road crossings	B
	Sediment – Sedimentation from recreation activity on roads, road crossings and in/around streams and reservoirs.	A
	Water Quantity – increased peak flows; lack of supply	C
	Wildfire – increased sediment load, loss of control at intake from evacuation orders and/or damage	B
Biological	**Bacteria** - Bacteriological contamination from wildlife/cattle/human presence in and along streams	A
	Protozoa – presence of Giardia, Cryptosporidium	A
	Viruses - presence	A
	Algae – algal blooms in reservoirs	B
Chemical	**Organic material** - (Total Organic Carbon)	B
	Hydrocarbons - Petroleum contamination from an industrial fuel spill or vehicle accident and gas powered boats on reservoirs	D
	Herbicides – likelihood of a spill or misuse is unlikely	D
	Wildfire – Retardant chemicals in the water supply	D

4.3.1 PHYSICAL HAZARDS

Sediment/Turbidity

The maximum recommended turbidity level in raw drinking water is 1 NTU[12]. As previously indicated in Table 2-2, turbidity levels at the intake averaged ~0.54 NTU during the clear flow period and 1.24 NTU during the turbid flow period from 2001-2007. During the watershed inspections it was evident that sediment is being contributed to watercourses as a result of resource development activities that increase the amount of soil exposure and disturbance. The sediment and turbidity that reaches the intake is a combination of natural and anthropogenic sources. The likelihood of sediment/turbidity affecting the intake varies depending upon the source. The cumulative risk considering all sources is rated as 'B'.

Water Quantity

As the mature lodgepole pine dies over the next several decades there is a risk of increased peak flows which could result in failures of road crossings that were designed using pre-beetle impact design criteria. Increased peak flows could also result in increased sediment transport as channels adjust to more frequent, larger flows. The impacts on water quality would be increased suspended and bed load

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[12] H. Singleton, 2001. *Ambient Water Quality Guidelines (Criteria) for Turbidity, Suspended and Benthic Sediments*. Ministry of Water, Land and Air Protection.

sediment at the intake. These impacts could continue for decades until undersized structures are replaced and the channel has adjusted to a new state of equilibrium.

Over the longer term possibly 50 years and beyond, if the precipitation and temperature patterns change as suggested by the Atmospheric Environment Service, runoff may decline as a result of less snow and warmer temperatures. Lower water yields would mean less supply and subsequent water shortages if demand exceeds supply. These conditions could persist for an indeterminate period of time. The cumulative risk for changes in water quantity is rated as 'C'.

Wildfire

There is an increasing risk of wildfire in the watershed as the mature pine dies. The 2009 wildfires will have impacts on water quality related to increased sediment load from fire fighting activities as well as post fire effects including the potential for increased loading of phosphates, nitrates and heavy metals. The risks related to wildfires are rated as 'B'.

4.3.2 BIOLOGICAL CONTAMINANTS - FECAL COLIFORM/E.COLI/ALGAE

Fecal Coliform/E. Coli

Wildlife, livestock and humans are all identified potential pathogen and turbidity sources in the watershed. Wildlife movement in the watershed is unknown but it is likely that during the course of a year most of the stream crossings are used by wildlife. Livestock and wildlife activity erodes stream bank and bed material, and may contribute to erosion of fine sediment. Pathogens enter the stream network from manure, evidence of which was noted in the proximity of many watercourses during the field assessment.

Section 3.3 of the Health Canada Guidelines for Drinking Water: Supporting Documentation[13] that addresses the criteria for the exclusion of filtration for waterworks systems indicates that "Prior to the point where the disinfectant is applied, the number of *Escherichia coli* bacteria in the source water does not exceed 20/100 mL (or, if *E. coli* data are not available, the number of total coliform bacteria does not exceed 100/100 mL) in at least 90% of the weekly samples from the previous 6 months." Water quality samples collected at the intake and at selected points throughout the watershed confirm that fecal coliform and E. coli are present at the intake and at each sampling site in the watershed. Based on the LID sampling results, the likelihood of fecal coliform and E.coli being present in raw water at the intake is rated as 'A'.

Algae

There is also a history of algae blooms in the Rose Valley Reservoir. Blooms typically occur as a result of increased nutrient loading into the reservoir, combined with warm water temperature. Increased nutrient loading can occur as a result of heavy spring runoff, and low reservoir levels, or from runoff from intense rainstorms during the summer months. Nutrient loading is also influenced by avian presence (migratory game birds and their droppings) on a reservoir. Increased reservoir water temperature can result from low water levels and from high air temperature during the summer months. Based on the occurrences of algal blooms in the reservoirs, the risk of increased algal growth in the reservoirs is rated 'B'.

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[13] Refer to: http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/water-eau/turbidity/turbidity-eng.pdf

4.3.3 CHEMICAL

Total Organic Carbon

Total organic carbon is of concern during the disinfection process as it can produce a by-product known as Trihalomethanes that may be carcinogenic. The BC Guideline for TOC is maximum 4 mg/L for source water that will be chlorinated (http://www.env.gov.bc.ca/wat/wq/BCguidelines/orgcarbon/ocarbon_over.html#guide). There is no longer a guideline for TOC in the Guidelines for Canadian Drinking Water Quality. The likelihood that there will be elevated TOC levels at the intake is rated as 'B'.

Hydrocarbons

The potential impacts on drinking water from a fuel spill is a concern since there is considerable industrial and recreational vehicle use throughout the watershed. Small amounts of oil or diesel fuel can contaminate large volumes of water. In the event that water at the intake was contaminated by an oil or fuel spill, LID would have to close the intake and provide water for its users from alternate sources. To date there are no reported incidents of fuel or oil being detected at the intake and the likelihood of this occurring is rated as a 'D'.

Herbicides

Herbicides are normally applied by a licensed applicator in accordance with a Pest Management Permit. The permit typically includes detailed requirements for the protection of water sources and the protocols if there was a chemical spill. The likelihood of contamination of the water supply is considered to be 'D'.

Wildfire

There is an increased wildfire risk due to the mountain pine beetle and dying mature pine. In the event of wildfires, there is a risk to water quality from chemical pollution related to fire retardant applications. The risk of chemical contamination of the water supply related to fire retardant application is rated as 'D'.

4.4 RISKS TO DRINKING WATER QUALITY AND QUANTITY

Risk is the product of likelihood and consequence. Using the risk matrix presented in Table 4-5 the risk for each identified hazard is presented in Table 4-6.

Table 4-5. Qualitative Risk Analysis Matrix

Likelihood	Consequence				
	1 Insignificant	**2** Minor	**3** Moderate	**4** Major	**5** Catastrophic
A (almost certain)	Moderate	High	Very High	Very High	Very High
B (likely)	Moderate	High	High	Very High	Very High
C (possible)	Low	Moderate	High	Very High	Very High
D (unlikely)	Low	Low	Moderate	High	Very High
E (rare)	Low	Low	Moderate	High	High

Reproduced from Module 7 of the *Comprehensive Drinking Water Source to Tap Assessment Guideline* (BC Ministry of Health Services and Ministry of Water, Land and Air Protection 2005).

The results of the risk assessment summarized in Table 4-6 indicate that there are risks to the LID drinking water quality at the intake. For the physical hazards, the risk from natural sediment is rated as high since there are numerous natural sources (identified in SHIM) on the mainstem channels other than channel instability related to natural causes such as the pine beetle. Sediment from industrial activity, including roads, is also considered to be a high risk since there is a large inventory of road crossings that are unlikely to be reduced that are the primary source of the sediment. If there is increased industrial activity as a result of salvage logging the risks may increase over the next 3 –5 years. The risk from increased sedimentation from cattle disturbance in and along streams and related increased turbidity levels are both considered to be high since they are related to the increased likelihood of pathogenic organisms contaminating drinking water and affecting public health. Also rated high is the risk to the source water from increased recreational activity in the watershed. Unregulated access for off-road vehicles, ATVs, motorcycles and four-wheel drive vehicles, on inactive roads is resulting in additional sediment delivery to streams on roads that would otherwise be considered low hazard sources of sediment.

The risks for the biological hazards (bacteria, protozoa, viruses and algae) are all rated very high. There is data from water samples that indicate that bacteria and protozoa are present in the source water at levels that exceed the water quality objectives for raw water. The presence of viruses in the water supply is unknown at present, but viruses including hepatitis A, rotaviruses, and other caliciviruses can cause illness if they are present in drinking water. The risk from algae blooms in the upland reservoirs is considered to be very high. There have been blooms in the past and the frequency is likely to increase with warmer summer temperatures and increased nutrient loading into the reservoirs associated with increased peak flows related to the loss of forest cover to the pine beetle. It is not the algae that are the concern but rather the by-products associated with the decay of algae.

The chemical risk from the presence of hydrocarbons at the intake is considered to be moderate. Roads are typically located away from streams except at stream crossings and there is the section of channel

through the canyon to the intake where there is no road access. This risk results from a fuel spill, a rupture of a hydraulic hose on an excavator or from a vehicle accident entering a stream or reservoir. The risk of hydrocarbons entering a stream and affecting the water quality at the intake is considered to be moderate.

Rose Valley

The risks to the source water quality in the Rose Valley catchment are low since there are no flowing surface sources in the catchment. There are however well known and documented water quality concerns in the reservoir related to the natural nutrient conditions within the reservoir pool area and the impact of additional nutrient loading from the Lambly Creek water diverted and stored in the reservoir.

4.5 SUMMARY

This section is focused on determining the risks to water quality and quantity based on the results of the contaminant inventory completed in the previous section and the barriers that are currently in place. The barriers are generally based on the requirements established in the legislation that governs licensed activities in the watershed. These include the *Forest and Range Practices Act*, the *Water Act*, the *Mines Act*, and the *Drinking Water Protection Act.* The barriers are the application of the requirements by the licensees. For example, for forest development it is the application of the expected results for water specified in the *Forest and Range Practices Act* and *Regulations*. Risk is the product of the hazards and the consequences. In this case the consequence of a hazard will be reduction in the drinking water quality. The risk analysis considers the consequence for a specified hazard and the likelihood that it might occur. The results as summarized in Table 4-6 indicate that there are moderate risks associated with water quantity; high risks associated with sediment from cattle, industry, recreation, organic materials, wildfire, and natural sources of sediment. Very high risks are attached to all of the biological hazards (bacteria, protozoa, viruses and algae). The risk rating was low for hydrocarbons and herbicides.

Table 4-6. Lambly Creek Watershed Qualitative Risk Assessment

Hazard Type	Drinking Water Hazard	Likelihood	Consequence	Risk	Comment/Assumption
Physical	**Sediment** - Natural sediment load from channel erosion and mass wasting	C	3	High	The mass wasting risk should be low provided development is restricted on class IV and V terrain. Natural sediment loads will increase with increasing peak flows but the reservoirs and wetlands provide substantial buffering.
	Sediment - Sedimentation from industrial roads and road crossings	B	3	High	It is assumed that there will always be some sediment transport at road crossings.
	Sediment - Sedimentation from range use in and around streams and road crossings	B	3	High	It is assumed that cattle will continue to graze in the watershed.
	Sediment – Sedimentation from recreation activity on roads, road crossings and in/around streams and reservoirs	A	3	Very High	It is assumed that recreational use in the watershed will continue to increase.
	Water Quantity – Increased peak flows as pine dies; decreased runoff from lower snow packs	C	1-5	Low to Very High	Over the next 30 years there could be increased peak flows related to the loss of forest cover to the pine beetle. Over the long-term, 50 years and beyond, if there is a long-term decline in snow packs, there may be a supply problem. Increased peak flows, as well as reduced supply during droughts are possible.
	Wildfire – Increased sedimentation from fire fighting activity and post wildfire effects, plus loss of control at intake due to evacuation order and/or damage	B	3-5	Moderate to Very High	There is an increasing risk of a wildfire as the mature lodgepole pine dies over the next several years. An intense wildfire similar those in 2009 could result in the loss of the watershed for water supply for an extended period of time.
Biological	**Bacteria** - Bacteriological contamination from wildlife/cattle/human presence in and along streams	A	4	Very High	The likelihood for increased contamination will be very high as recreational use increases and as the forest mosaic changes as a result of the loss of the pine.
	Protozoa – presence of Giardia, Cryptosporidium	A	4	Very High	
	Viruses – presence	A	4	Very High	
	Algae – algal blooms in reservoirs	B	3	High	
Chemical	**Organic material** - (Total Organic Carbon)	B	2	High	Organic material in streams will increase as the mature pine stands die.
	Hydrocarbons -Petroleum contamination from an industrial fuel spill or vehicle accident and gas powered boats on reservoirs	D	2	Low	Even with increased activity in the watershed the likelihood of a spill affecting the water at the intake is low.
	Herbicides	D	3	Moderate	Since herbicides should only be used under permit and by licensed applicators, the likelihood of a spill is low.
	Wildfire – Retardant chemicals in the water supply	D	2	Low	With the pine dying due to the pine beetle, there is increased potential for wildfires.

5. MODULE 8 – RECOMMENDATIONS TO IMPROVE DRINKING WATER SOURCE PROTECTION AND SUSTAINABILITY IN THE LAMBLY CREEK AND ROSE VALLEY WATERSHEDS

The foundation for delivering safe drinking water is the use of multiple barriers to limit the exposure of drinking water to a particular hazard. This starts with barriers in the source watershed and source protection is the first barrier in the multi-barrier approach to protecting drinking water quality.

In 2006 seven Provincial ministries, the Office of the Provincial Health Officer and the five B.C. Health Authorities signed a Memorandum of Understanding (MOU) that commits the parties to inter-agency accountability and coordination for the protection of drinking water. A Southern Interior Regional Drinking Water Team (SIRDWT), has been formed as required in the MOU, with representation from the seven Ministries and the Interior Health Authority. The Lambly Creek Source Assessment Plan is supported by SIRDWT. A copy of the MOU and the list of members of the SIRDWT are provided in Appendix D. Establishing an effective working relationship with the SIRDWT is critical to achieving the objectives of this Plan.

The intent of the Source Assessment Plan is to recommend a process to address the hazards that are a threat to drinking water safety and sustainability of the Lambly Creek drinking water supply. The recommendations herein address the documented source hazards. Based on the risks to drinking water quality presented in Section 4, there is a need for protection of the source water quality through the implementation of strengthened and additional barriers in the watershed area.

During 2008 the Lakeview Irrigation District (LID) completed a number of projects designed to improve drinking water quality and quantity. The installation of an automated valve at the north end of the Rose Valley Reservoir and water quality monitoring sensors at the diversion at Lambly Creek allows staff to remotely monitor and open/close the diversion so only the most desirable water is diverted from Lambly Creek to the Rose Valley Reservoir. Another major project in the source water area is the DunWaters diversion. This diversion ditch allows LID to divert up to 1,200 acre-feet of water annually from DunWaters Creek and North Terrace Creek into Big Horn Reservoir.

Section 5.1 provides a SWOT analysis for protection of the Lambly Creek source water quality. Section 5.2 provides a Source Protection Plan with actions to improve the raw water quality in Lambly Creek.

5.1 SWOT ANALYSIS

A SWOT analysis is an effective approach to summarize, understand and balance the *strengths, weaknesses, opportunities* and *threats* to the water source in the Lambly Creek and Rose Valley watershed. Table 5-1 provides a summary of the SWOT analysis based on the information provided in the previous sections of this report.

Table 5-1: SWOT Analysis Summary

Strengths	Weaknesses
- Forest and range uses are regulated by the *Forest and Range Practices Act.* - LID has a good working relationship with the agencies and stakeholders in the watershed. - The *Drinking Water Protection Act* and related regulations provide support for source protection. - There are established comprehensive planning processes for forest and range development in the watershed that include assessment of potential impacts. - The LID has installed an automated valve at Rose Valley Reservoir and automated water quality sensors at the Lambly diversion that can be used remotely to prevent poor quality water from being diverted into Rose Valley Reservoir. - MTCA has designated the RMZ a recreation area allowing more control over organized recreation activity. - The LID monitors hydrometric stations at key source locations to help predict current run-off trends and potential future water supply for their customers. - Recent fencing improvements to reduce cattle impacts around streams.	- Recreation use has limited restrictions - There are limited means to regulate off-road vehicle activity. - The present source protection analysis assesses individual impacts and activities but there is no cumulative impact analysis that combines the impacts from all activities on source water quality and quantity. - Funding for ongoing assessments is limited. - Funding to implement remedial works is limited. - Rose Valley Reservoir has nutrient concentrations that make the reservoir susceptible to algal blooms during the warm summer months. The reservoir is very sensitive to increased nutrient levels from poor quality water that is diverted from Lambly Creek into the reservoir. - There is a motocross track in the watershed; although it is downstream from the intake it attracts more recreational riders into the upper trail network, which is upstream from the intake.
Opportunities	**Threats**
- Funding may be available through the Environmental Farm Plan program to assist ranchers in developing off-stream water sites and construct fencing to limit cattle access to sensitive sites. - There is a significant opportunity for LID and the agencies to improve public education and awareness of the importance of protecting the water source. - Pursue opportunities to have Sections 46 and 58 of the Forest and Range Practices Act applied in the watershed to protect source water. - Pursue opportunities for additional OBWB funding for source protection. - Develop the water license sharing from proposal with range tenure holders for off-channel watering. - Amend Range Use Plans to increase protection to watercourses. - Encourage assistance from the Southern Interior Drinking Water Team to implement source water protection strategies. - Coordinate with other watershed initiatives such as Water Use Plans, Sustainable Water Strategies, Forest Retention Plans, and Environmental Assessments for Development Applications. - Encourage the development of a regional source assessment database availability to local planners. - Use the British Columbia Draft Trails Strategy as a guide for strategies to consider reducing impacts from recreation use in the watershed.	- Wildfire is an increasing threat as the mature lodgepole pine forests die from the mountain pine beetle. - Loss of the mature lodgepole pine to the mountain pine beetle has the potential to cause significant changes to the watershed hydrology resulting in degraded water quality at the intake. - Salvage harvesting of lodgepole pine could increase road density and ground disturbance resulting in impacts on water quality. - Increased deciduous trees and shrubs may dominate riparian areas following the loss of pine. Beaver populations could increase resulting in beaver related problems. - Changes in climate may result in a long-term decrease in water yields and a reduced supply for LID. - Increasing population in the Okanagan Valley will increase recreation pressures in the watershed, increasing the risks to water quality. - Demand for water in the LID service area may increase due to increased population and warmer summer temperatures. - Ongoing unregulated access and the lack of a comprehensive plans for off-road vehicles will result in increased dispersed sources of sediment to streams. - Potential increased cattle and wildlife access to the recently constructed Dun Waters diversion ditch. - Burnco has applied for a gravel pit permit along Bear Main FSR that would increase traffic use and potential sediment delivery to the water supply

5.2 SOURCE PROTECTION PLAN

Several of the following paragraphs have been reproduced from Module 2. The intent is to reinforce the conclusions from Module 2 and support the recommendations made in this Module.

The following sub-headings and recommendations are presented in general order of priority with the objective of reducing risks to the Lambly Creek source water supply.

5.2.1 RECREATION USE

The Okanagan Shuswap Land and Resource Management Plan defines a recreational management zone (RMZ) for off road motor vehicle recreation that includes crown land within both the Lambly Creek and Powers Creek watersheds. The majority of the RMZ is within the Lambly Creek watershed. The Okanagan Trail Riders Association (OTRA) manage several kilometres of trail within the approximately 35,000 ha RMZ.

The Kelowna Dirt Bike Club is responsible for the operation and maintenance of a motocross track adjacent to Bear Main FSR. Although the track is located downstream from the LID intake on Lambly Creek, the track attracts more recreational riders to the upper OTRA area, which is upstream from the intake.

Recreation activity was evident throughout the watershed as indicated by several un-managed campsites, campfire pits and refuse on the ground. Evidence of motorcycle, ATV and 4wd use was observed below the high water mark (HWM) at all reservoirs except Esperon. These site disturbances contribute to the overall sediment load to the source water supply.

There is a small cabin on the south shore at Esperon Reservoir, however it is in very poor condition and not usable. There is a pit toilet approximately 30m away from the reservoir high water mark, however the structure is in very poor condition and is inoperable. This facility showed no obvious signs of pollution to the drinking water supply.

There are fishing opportunities at all the reservoirs in the watershed and recreational activity on the reservoirs increases the risk to the drinking water supply. The risks have not been well defined and research to date has been unable to fully quantify risks to water quality from recreational activity on/near reservoirs.

Recreational users around the Rose Valley Reservoir should be advised that the reservoir is a source of drinking water and how to protect water quality.

Recommendations

- **Ensure that recreation use in the watershed is consistent with the objectives set out in the Okanagan-Shuswap LRMP. (MTCA)**
- **It is recommended that a 'recreation brochure' be prepared that is focused on source protection and distributed with hunting and fishing licenses, firewood cutting permits, to ATV and motorcycle dealers, and by the Ministry of Tourism, Culture and the Arts at recreation sites. (MTCA, LID, MoE, MoFR)**
- **The LID, MoFR and MTCA should continue to communicate with recreation users through local media, signage or verbally on responsible conduct in community watersheds.**
- **It is recommended that LID request that the Ministry of Forests and Range Compliance and Enforcement personnel and the Ministry of Environment Conservation Officers apply Section 46 of the *Forest and Range Practices Act* to charge individuals engaging in any activity on Crown land that results in damage to the environment, as defined in the *Act.* (LID, MoFR, MoE)**
- **The LID should work with other water suppliers in the Okanagan to lobby the government to pass Off Highway Vehicle legislation that would require the licensing of all off highway motorized vehicles and regulations to control the use of these vehicles on Crown land. (LID)**
- **It is recommended that LID request that the Minister of Forests and Range apply Section 58 of the *Forest and Range Practices Act* to restrict the use of motorized vehicles in specified sensitive areas in the watershed including reservoirs. (LID, MoFR)**

5.2.2 RANGE USE

There are currently 5 grazing licences issued over the Powers and Lambly watersheds with a total of 3,086 AUMs (animal unit months). During the 2008 field inspection it was identified (based on presence or absence) that cattle were contributing to the contamination hazard (sediment and fecal material) at 74 (44%) of the 168 sites assessed. No moderate or high disturbance sites were attributed to cattle activity at major stream crossings or tributary channels. Upland reservoirs and open diversion ditch lines also showed signs of cattle activity; although disturbances were minimal there was soil disturbance and fecal matter below the high water mark in the ditches and around the reservoirs.

Salvage logging and the natural loss of beetle affected mature lodgepole pine will likely result in loss of natural barriers that normally limit access to watercourses by cattle. If the pine beetle epidemic and related loss of pine stands results in additional riparian areas becoming available for range use, there is the potential increase in manure deposits and soil disturbance in these areas unless increased cattle management keeps them away from these areas. Controlling cattle movement in the watershed is important, but may become more critical following changes to the landscape related to the pine beetle epidemic.

Range use is common in both Lambly Creek and the adjacent Powers Creek watersheds and cattle herds utilize both watersheds. Specific cattle movement in the watershed is not known, however for Lambly Creek, the Lakeview Irrigation District has applied for a 2009 Okanagan Basin Water Board (OBWB) grant to track cattle movement in the watershed using GPS/radio collars. If this project is approved the data gathered will identify cattle travel routes and watering locations in the Lambly Creek watershed.

Recommendations

- **Review the results of the stream crossing assessments and prioritize sites affected by cattle use for potential remediation to reduce sediment and fecal material loading to the stream network.**
- **Assess the shoreline areas at all major reservoirs to determine if measures to reduce cattle activity can be achieved. Any plans to reduce cattle impacts should be shared with MoFR and the range license holders. Funding for similar projects in the Okanagan has been secured by application to the OBWB for annual water quality improvements grants.**
- **Review and remediate areas around diversion ditches/pipelines to reduce soil disturbance and fecal material loading from cattle use.**
- **Identify riparian areas that may be affected by the pine beetle epidemic and subsequent loss of forest cover. These areas may require increased range management to prevent increased livestock access.**
- **If the LID is successful in their OBWB grant application to track cattle movement, knowledge of cattle travel patterns in the Lambly Creek watershed could help focus efforts for locating sites to install cattle control structures and off channel watering devices for source water protection.**

5.2.3 SEDIMENT/TURBIDITY FROM INDUSTRIAL ACTIVITY

The typical sources of sediment/turbidity from industrial activity are roads, soil disturbance associated with forest development and grazing use. Maintenance of active forest roads is important (especially those sections of road near streams and reservoirs) and is the responsibility of the primary road permit holder. Inactive roads should be deactivated to a level that meets current and future access requirements: temporary, semi-permanent or permanent deactivation.

The Ministry of Forests and Range forest road design criteria is that major culverts and bridges must have the capacity to pass the Q100 peak flow (statistical peak flow event that would occur once in any 100 year period). Stream flows may be greater after the pine dies and it is likely that there are stream-crossing structures in the watershed that will be affected by increased peak flows and will be undersized.

Salvage logging of beetle affected mature lodgepole pine will likely result in loss of natural barriers that limit access to watercourses by cattle and people.

It is the responsibility of the licensed stakeholders to plan, implement, monitor and revise their works consistent with the legislation, regulations and policies established under their permits/licenses for the protection of soil and water.

It is the responsibility of the Ministries that provide the authority to licensed stakeholders, in accordance with the MOU, to ensure that compliance monitoring of activities is undertaken consistent with their respective policies for source protection.

Recommendations

- **Review the results of the stream crossing assessments and implement improvements at moderate hazard sites (no high hazard sites were identified in the field review) to reduce the transport of sediment from roads and ditch lines into streams.**
- **Address the 5 failing wood culverts identified.**
- **Direct road surface runoff away from streams and stream crossings. Ditch lines should include cross drains with ditch blocks so that runoff that accumulates in the ditches is dispersed onto the forest floor away from the streams. In addition, ditch lines and culverts should be kept clear of debris and the ditch lines should be vegetated with grasses to limit erosion and capture sediments. A grass species that discourages grazing would be the preferred species.**
- **Forest licensees should consider developing a wet weather operational guideline that regulates industrial road activity during periods when this activity has a high likelihood of increasing sediment loads to source water supplies.**
- **High use roads adjacent to streams and reservoirs should be considered for surface treatments to control dust during dry periods.**
- **Roads not required for active use should be deactivated to a level that meets current and future access requirements: temporary, semi-permanent or permanent deactivation.**
- **Review the sites in Table 3-4 with moderate hazard ratings and take actions to reduce sediment delivery to streams so that the hazard rating is reduced to low. (Tolko, WFN)**
- **The Ministry of Forests and Range should develop and implement a review of stream crossing structures that are downstream from the beetle affected areas in the Lambly Creek watershed to ensure they are adequately sized to safely convey projected future peak flows. (MoFR)**
- **Access to sensitive areas along watercourses, lakes and wetlands should be restricted as the forest cover changes to protect the water quality. (LID, MoFR, MTCA, Forest and Grazing Licensees). Planning should also consider best management practices where these are available**
- **Tolko Industries Ltd. should consider including recognition of the Lambly Creek Source Protection Plan in their forest stewardship plan. (Tolko, BCTS, LID, Grazing Licensees, Mineral Licensees)**
- **The MoFR should consider providing an annual report to the Drinking Water Officer describing compliance of activities undertaken in the Lambly Creek watershed under its jurisdiction. (IHA, MoFR)**

5.2.4 OTHER ISSUES

The following issues may also require action to protect the Lambly Creek water source.

Reservoirs

The LID has recently completed the Dun Waters Diversion, which allows the LID to annually divert up to 1,200 acre feet from Dun Waters Creek and North Terrace Creek into the Big Horn Reservoir. The diversion uses rock lined open ditches and there are sections of the diversion ditch that are accessible to cattle and wildlife.

- **Implement an action plan to educate the public about the protection of the reservoirs from contamination including proper disposal of human waste when recreating near water sources.**
- **Post the reservoir perimeter areas as prohibited access for vehicles except at designated boat launches.**

Pesticides/Herbicides

- **It is recommended that all applications for the use of herbicides and pesticides in the watershed upstream of LID intake be referred to LID for review.**

Monitoring **-** Monitoring is an essential component of the Source Protection Plan and the LID has a raw water-monitoring program. The program has established baseline monitoring and problem identification. The sampling results should be reported to the Drinking Water Officer, SIRDWT members and stakeholders annually.

- **There should be a co-operative plan to implement source tracking and identification of contaminants similar to that carried out by Cynthia Meays in 2005. The support for the source tracking and contaminant identification program should to come from the ministries that signed the MOU, GVW, and hopefully from the stakeholders**

Watershed Hydrology and Flow Monitoring

- **It is recommended that the LID continue with the stream flow monitoring program (North Fork Creek downstream from Tadpole Reservoir, Esperon Reservoir spillway, Big Horn Reservoir spillway and Lambly Creek at the diversion) to understand the effects of pine beetle attack and climate change on the watershed hydrology and the implications for future water supply.**

Compliance Reporting

Based on results of the source water quality monitoring by LID and the compliance report, appropriate changes can be made to the Source Protection Plan.

- **The Source Protection Plan must have an annual compliance-reporting requirement.**
- **Based on the MOU there should be annual reports provided by the agencies to the DWO that report on source protection.**
- **A summary report should be provided to the SIRDWT and the stakeholders, and be reviewed at an annual watershed meeting.**

Education

- **Install information signs at each of the upland reservoirs that would provide information to the public about the Community Watershed and the importance in protecting the water.**
- **Continue to install and maintain 'Community Watershed' and 'RAPP' signs on all access roads to the upland watershed.**
- **Consider developing a 'Watershed Fact Sheet' that could be supplied to the public, government agencies and stakeholders to provide information regarding the watershed, the importance of protecting the water, and what the reader can do to help, e.g., avoid contaminating the water with human waste and refuse.**
- **Consider establishing an annual 'watershed awareness day' that could be part of Rivers Day, Westside Days, etc to raise awareness of the water supply. This could also be taken to the local schools as well.**

Wildfire

- **Wildfire is a concern in the watershed, and with the advance of the mountain pine beetle, the fuel load will increase as will the risk of fire.**
- **Consideration should be given to developing a wildfire preparedness plan that would address drinking water related concerns. This should include a long-term fuel reduction plan and firebreak plan. Funding for a fuel reduction plan may be available from UBCM through the RDCO to assist in the development and implementation of a fuel reduction plan.**
- **Future harvesting plans should consider the location of new cut blocks as part of a landscape level firebreak plan.**

Mines/Quarries/Mineral Claims

There are a number of mineral claims within the watershed area. The agency responsible for issues permits for these uses is the Ministry of Energy, Mines and Petroleum Resources (MEMPR). MEMPR is also a signatory to the Drinking Water Source Protection Memorandum of Understanding.

A field tour would assist the inspector to appreciate the concerns. All development proposed by MEMPR in the watershed should be referred to the LID for review. Burnco has proposed a gravel pit operation along Bear Main FSR and there is also an active limestone quarry in the Bald Range sub-basin. Industrial road use related to these operations has the potential to increase sediment delivery to the source water.

- **It is recommended that LID contact the MEMPR office in Kamloops that is responsible for claims in the watershed and arrange a meeting to present the Mines Inspector with a copy of this report as well as review the issues and concerns specific to MEMPR with the Inspector.**

Salvage Harvesting

- **It is recommended that LID review the expansion of the pine beetle in the watershed annually with the forest licensees.**
- **It also recommended that LID and the forest licensees review proposed salvage harvesting plans and options to protect the water resources.**

Source Protection Plan Review

- **The Lambly Creek Source Assessment and Source Protection Plan should be reviewed annually by LID and IHA and updated on a five-year basis or as a result of a significant increase in risks to the source water quality.**

5.2.5 IMPLEMENTATION

The implementation stage is the key to a successful source water protection program. As presented in the foregoing SWOT analysis, many agencies and stakeholders, who have a common goal of improved source water quality and public health protection, support the LID. The Technical Advisory Committee (TAC) for this Plan included representation from most of the stakeholder agencies that will be responsible for implementation of this Plan; these parties should consider the merits of continuing forward with members from the TAC, as a steering group or watershed management committee, expanded as needed to suit the implementation matter at hand. As implementation proceeds, the steering group should be responsive to the inevitable unexpected challenges and barriers to implementing the action items.

The authors have indicated a preliminary order of priority for the risk management recommendations. To obtain support and buy-in from all parities, and to provide for the necessary resource planning, it is recommended that LID and the steering committee undertake a prioritization exercise, generally as follows (adapted from the *Source to Tap Assessment Guideline*, Module 8, Section 2.1): confirm the most critical problems for the water supply and public health; direct resources most immediately to those actions with the highest potential for water quality improvement; protect unimpaired areas from degradation; identify areas where there is a need to coordinate multiple remedial or protective priorities; and follow the SMART principles in development and implementation of the risk management activities; specific, measurable, advisable, realistic and time bound. Module 8 of the Source to Tap Guideline contains useful suggestions for prioritizing and assessing effectiveness of risk management activities.

Prepared by:

Original signed by

D.A. Dobson, PEng

STATEMENT OF LIMITATIONS

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