Powers Creek

Source Assessment Report

Prepared for

Westbank Irrigation District

Prepared by

DOBSON Engineering Ltd.

July 2010

Powers Creek Source Assessment Report

FIGURES

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Powers Creek Source Assessment Report

1. INTRODUCTION

1.1 PROJECT SCOPE

The Powers 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 Westbank Irrigation District. Powers Creek is the source of water supply for Westbank Irrigation District (WID). WID has operated as an irrigation district for over 85 years, and services a population of approximately 13,000 residents. Its service area includes; the community of Westbank south to Gellatly Road South; east to Angus Road and the boundary of Westbank First Nation Indian Reserve No. 9; north to Copper Ridge Drive in the community of Smith Creek; and west to the Gates Road area of the community of Glenrosa (refer to Watershed Map 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.
- Characterize the watershed including the influences of the mountain pine beetle (MPB) and proposed retention and salvage logging.
- Consider the potential impacts of climate change on the water supply.
- Consider the possibility of developing new storage and the impacts of raising existing dams.
- Prepare project maps illustrating the location of the intake, source area, assessment area boundaries and bio-geophysical information, in a format compatible with the WID GIS system.

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 Powers Creek IWAP using the IWAP Guidebook produced by the Ministry of Forests dated April 1999. The update includes 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), the ECA-by-elevation band, and the road density to 2007. The last update of the forest development data was to the end of 2007. There has been limited additional development in the watershed since that date.
- Conduct a contaminant source inventory within the watershed area upstream of intake based on an office review of potential contaminants and reconnaissance- level 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
- 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, it was appropriate to create a technical advisory committee that included representatives from IHA and the Ministry of Environment (MoE) and Ministry of Forests and Range (MoFR) 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 includes:

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

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

1.3 DESCRIPTION OF THE WESTBANK IRRIGATION DISTRICTS INFRASTRUCTURE

The current infrastructure that has been developed by the WID is presented on the Watershed Map in Appendix A and includes the following works:

- Intake and water treatment plant
- Jackpine reservoir
- Paynter reservoir
- Horseshoe reservoir
- Dobbin reservoir
- Harding Creek Diversion
- Bit Creek Diversion
- Alocin Creek Diversion

WID holds water licenses to store approximately 9,891 ML in its reservoirs. This includes 222 ML of storage not developed on Webber Lake. It also is licensed to divert runoff from Sandberg Creek, Whiterocks Creek, Alocin Creek, Bit Creek, and Powers Creek via ditches/pipelines. Active applications are on file for an additional 7,120 ML of storage and diversion.

WID operates the Powers Creek water supply by diverting and storing the spring runoff from the high elevation snowmelt in the Tadpole, Dobbin, Horseshoe (Islaht), Paynter, Jackpine, and Lambly Reservoirs. The intake is located approximately 7 km upstream from Okanagan Lake (refer to Watershed Map in Appendix A).

1.4 ASSESSMENT APPROACH

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]

The WAP review was modified to consider all impacts in the watershed that affect the water source including forestry. The WAP process provided useful data on the change in disturbances resulting from forest development over time and this data was also used to assess the change in other impacts such as cattle movement and recreation that are related to changes in access.

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

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

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

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

A 1:50,000-scale map of the watershed detailing the hydrography, waterworks infrastructure, historical forest development and TRIM data is provided in Appendix A.

The results from the 2008 fieldwork are summarized in Appendix B. The locations of all the identified crossings in the watershed with identification (ID) numbers are provided on the Watershed Map in Appendix A. The column "Xing ID" on the tables in Appendix B 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.*
- Health Canada, 2003. *Public Health Initiatives Related to Drinking Water Quality in Canada*.
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- Meays, C., Broersma, K., et al, 2006. *Diurnal variability in concentrations and sources of Escherichia coli in three streams*, Canadian Journal of Microbiology: 52: 1130-1135.
- U.S. Environmental Protection Agency, 1992. *Framework for Ecological Risk Assessment*.
- Kerr, Wood Leidal Associates Ltd. & Dobson Engineering Ltd. *Duteau Creek Watershed Assessment Final Report,* 2008.
- Ministry of Environment, Lands and Parks, 2000. *Water Quality Assessment Objectives for Powers Creek Community Watershed.*

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

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

Abbreviations cont'd.

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)	WID	Westbank Irrigation District
mg/L	milligrams/litre (parts per million)	SCHR	Stream Crossing Hazard Rating
ML	megalitre (one million litres)	WTP	Water Treatment Plant
MoE	Ministry of Environment	WSC	Water Survey of Canada

2. MODULE 1 – CHARACTERIZATION OF THE POWERS CREEK SOURCE

2.1 DESCRIPTION OF PROJECT AREA

2.1.1 SOURCE AREA

The Powers Creek watershed flows southeast into Okanagan Lake approximately two kilometres south of Westbank, BC and encompasses an area of 139 km^2 with an elevation range from 340 m at Okanagan Lake to 1,860 m at the summit of Whiterocks Mountain. The *Powers Creek Community Watershed* is that portion of the watershed upstream of the WID intake with a source area of approximately 131 km^2. The Alocin Creek community watershed has a source area 4.7 km^2 and is situated within the Nicola River watershed. The Alocin community watershed is only that part of the Alocin Creek drains into the diversion channel that connects the Tadpole Reservoir with the headwaters of Powers Creek. This watershed is identified on the Watershed Map in Appendix A.

For this assessment the watershed has been divided into the buffered areas and the unbuffered areas. The buffered areas are those areas upstream of a reservoir where runoff is stored before being released to the intake. Impacts to water quantity and quality in the buffered areas may be a lower risk as measured at the intake due to the benefits of the storage. 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 Watershed Map in Appendix A.

2.1.2 INTAKE

Water is delivered from the storage reservoirs via Powers Creek to the intake located just north of the municipal boundary. The intake is not buffered from runoff below the reservoirs and the travel time for runoff in the unbuffered zone to reach the intake is typically a matter of hours. Activities and contaminants from this unbuffered area pose the greatest risk from turbidity[3] and bacteriological contamination.

Runoff upstream of the reservoirs is buffered from the intake, as it has to pass through the reservoir system before entering the mainstem creek. Residence time in the reservoirs will vary depending upon the time of year but typically WID will use approximately 50% of its stored water during the year. This would suggest that water could reside in the reservoirs for up to two years; however, the residency time depends on the characteristics of the reservoir and operating conditions and the climate conditions for a particular year. The buffered area provides a greater level of protection from contamination at the intake as long as releases from the reservoir can be controlled. Also, the reservoirs 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.

[3] Turbidity has been used in this report as a surrogate for suspended sediment. Refer to the paper *Establishing the Relationship between turbidity and Suspended Sediment Concentrations,* 2003, C.P. Holliday, T.C. Rasmussen, and W.P. Miller, Proceedings of the 2203 Georgia Water Resources Conference for details on the relationship between turbidity and suspended sediment.

2.2 LICENSED STAKEHOLDERS AND INTERESTED PARTIES

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

- Westbank Irrigation District – Water licensee, water purveyor for domestic and agricultural water
- District of West Kelowna – Local government
- Other water licensees
- Tolko Industries Ltd., Heartland Economics LP, BC Timber Sales – Forest licensees
- Kevin Day, Thomas Lewis, Russell Ensign – Grazing licensees
- Interior Health Authority – Safe drinking water
- Westbank First Nation – Land stewardship
- 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
- Regional District of Central Okanagan - Planning and development on Crown land within regional district boundaries

2.3 BIOPHYSICAL CHARACTERIZATION OF SOURCE AREA

Biogeoclimatic zones range from Ponderosa Pine (PP xh1) and Interior Douglas Fir (IDFxh1) at lower elevations near Okanagan Lake to Montane Spruce (MSdm2) and Interior Douglas Fir (IDFdk2) at mid elevations, to Engelmann Spruce Subalpine Fir (ESSF dc) in the upper slopes.

The upper two thirds of the Powers Creek community watershed is located on the eastern edge of the Thompson Plateau that is generally benign, gently rolling plateau terrain with limited evidence of instability. Several small to medium sized lakes are located in the upper portion of the watershed that has been developed into storage reservoirs. Lambly Lake that was formerly part of the headwaters for Lambly Creek has been permanently diverted into Powers Creek and is now the Lambly Reservoir. Jackpine Lake, Paynter Lake, West Lake, Dobbin Lake and Islaht Lake have all been developed as storage reservoirs and are no longer natural lakes.

The eastern portion of the watershed, downstream of the Lambly Reservoir, is located on the western slopes of the Okanagan Valley where the mainstem channel descends through a bedrock canyon extending downstream to the area of the intake where it crosses the post-glacial terraces to Okanagan Lake. There is a post-glacial delta at the mouth of the creek that extends into Okanagan Lake. The average gradient of the mainstem channel is four percent.

Bedrock in the watershed generally conforms to the following:

- West Powers, Okanagan Batholith comprised of massive, equigranular to porphyritic, unfoliated to weakly foliated, biotite granodiorite and granite.
- North Powers, Black pyritic slate, phyllite and argillite.
- Residual Area, Felsic volcanics including volcanic breccia, pyroclastic rocks, trachyandesite, trachyte and rhyolite.

Precipitation normals for the watershed are similar to those for Environment Canada's *Peachland* and *Peachland Brenda Mines* weather stations with the average annual total precipitation being ~370 mm for the lower elevations and ~635 mm for the upper elevations. The Powers Creek watershed is located in the interior dry belt zone with a snow dominated hydrologic regime. Elevations for the watershed range from 340 m at Okanagan Lake to 1,860 m at the summit of Whiterocks Mountain.

Approximately 8% of the Powers Creek watershed is private land with the majority located in the lower portion of the watershed, mostly below the intake. The most significant private land development adjacent to the creek occurred before the 1950s with the clearing of the lower delta for agricultural use. The remainder of private land situated directly adjacent to the creek is relatively undeveloped due to the deep canyon in the lower portion of the watershed.

2.4 HYDROLOGIC CHARACTERIZATION OF SOURCE AREA

Powers Creek is a snow-dominated hydrologic system with peak flows occurring from late-April to mid-June. Hydrometric records were only available from 1969 to 1982 for the Water Survey Canada station *Powers Creek at the Mouth* (Station No. 08NM157). A summary of the stream flow records is presented in Figure 1. The runoff hydrographs for normal, low and high flow periods are illustrated in Figure 2.

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

A hydrometric study for the Powers Creek watershed addressing the impacts of the mountain pine beetle and future harvesting was completed by Dobson Engineering Ltd for Tolko Industries Ltd. Dobson also completed a project for the WID to determine the relationship between groundwater and surface runoff in the upper Powers Creek watershed as part of an assessment of the potential impacts of proposed groundwater well located near west Powers Creek upstream of the confluence with north Powers Creek. The well was proposed by the owners of the Crystal Mountain Ski Resort to supply the ski resort with domestic water. Preliminary results suggest that the groundwater at the observation well is under the influence of surface water.

As indicated previously the watershed can be separated into two hydrologic zones. Zone 1 is the unbuffered 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 watershed upstream of the reservoirs. This upper zone has the greatest buffering due to the combined storage in the Tadpole, Dobbin, Horseshoe, and Lambly reservoirs.

The reservoirs have the potential to provide some settling of 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.

WID manages the water storage through the collection of spring runoff during the snowmelt period from April through June in the six upland reservoirs. Runoff from the Sandberg and

Whiterocks diversion ditches is stored in the Tadpole Reservoir. Unregulated flow from Powers Creek downstream of the reservoirs can be diverted into the Lambly Reservoir by a pipeline to

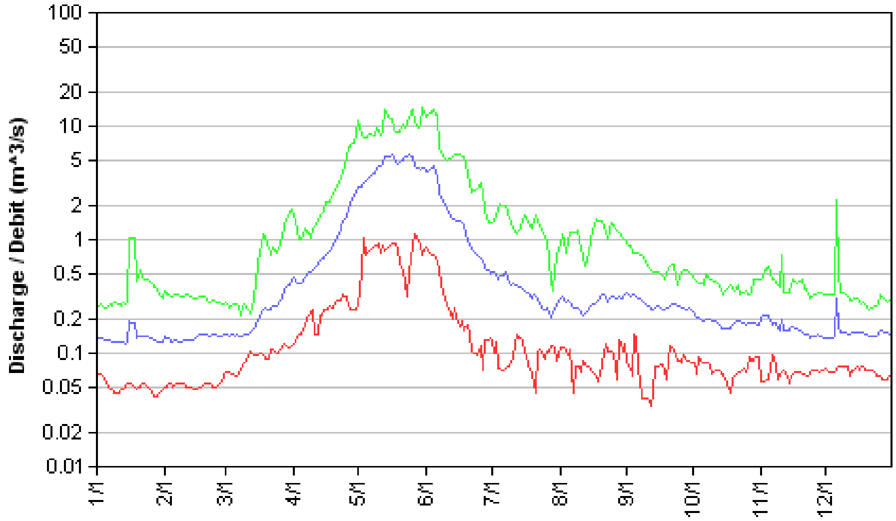

Figure 1. Daily discharge statistics for "Powers Creek near the Mouth" – 08NM157 (1969 to 1982)

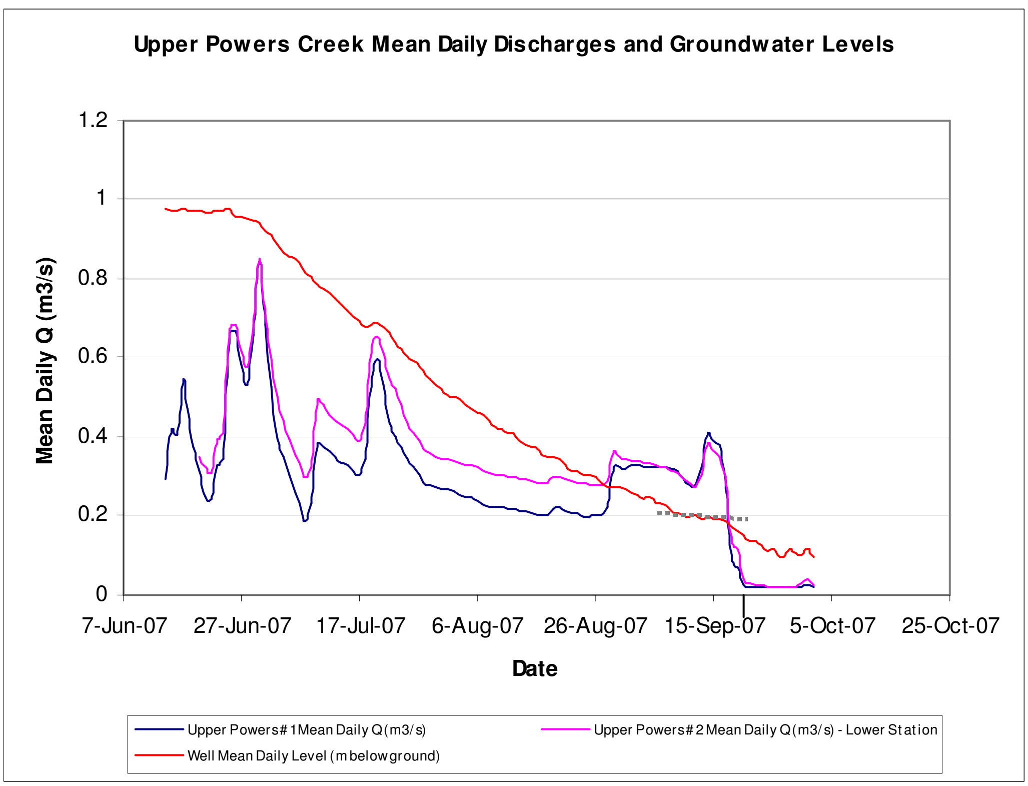

Figure 2. Upper Powers Creek Station #1 and #2 - 2007 Mean daily discharges and ground water levels

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Harding Creek. Water demands during the spring runoff period are normally met from stream flows from those unregulated portions of the watershed below the reservoirs and from water spilled from the reservoirs once they have reached full pool. As the water system demand increases, additional demand is met by increasing releases from the reservoirs.

The Ministry of Environment holds a water licence for the fish flows in Powers Creek of 0.085 m^3/s (3 cfs) below the WID intake that is maintained by WID all year.

2.5 SOURCE HAZARDS TO DRINKING WATER QUALITY AND QUANTITY

Potential hazards to drinking water were identified prior to commencing fieldwork as 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, and identification of any that may have been overlooked. The results of this review were the basis for the field assessment tasks that will be undertaken in Module 2.

The hazards to drinking water quality are limited in the watershed as it is entirely Crown land with limited private or commercial activities. Compared to many other community watersheds, WID is fortunate that there are not extensive private lands, subdivisions, highways, recreation developments, etc. upstream of the intake. The intake is located near the Crown land/private land interface. The primary activities on the Crown land in the watershed are forest development, range use, and recreation - both dispersed and concentrated.

Ongoing forest development in the Powers 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 trees and canopy cover may result in changes to the current hydrograph and may cause potentially damaging annual peak flows. The WID has a good working relationship with the major forest licensees and is given the opportunity to comment and make recommendations on forest development plans to best protect its water supply. Current forest development practices are less likely to have adverse affects on water quality and quantity than past forest practices; however any forest development has the potential to adversely affect the water resource.

Range use occurs throughout the upland areas of the Powers Creek watershed. The fecal coliform and sediment loading at the intake is a function of the level of physical activity in the watershed and stream discharge. 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, increasing flows 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.

Dispersed recreation and concentrated recreational activities near watercourses can affect water quality if they are not planned, constructed and maintained properly. A portion of the Okanagan-Shuswap Land and Resource Management Plan (LRMP) Recreation Management Zone (RMZ) includes some of the WID source area (primarily near Lambly Reservoir). The RMZ is outlined in the LRMP 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 been successful in designating the RMZ as a recreation area. With the recreation area 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 WID.

There is a small private resort along the west side of Lambly Reservoir and there is a maintained BCFS recreation site with 18 campsites, boat launch and pit toilets along the west shoreline near the north end of the reservoir. Lambly Reservoir is stocked annually with 10,000 rainbow trout and has also been illegally stocked with yellow perch, refer to: (http://www.bcadventure.com/adventure/explore/ok/kelowna/lambly.htm) and (http://www.tsa.gov.bc.ca/publicrec/docs/sites.)

The recreation opportunities at Lambly Reservoir attract numerous outdoor enthusiasts every 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 to date has been unable to fully quantify risks to water quality from recreational activity on/near reservoirs.

There is a small resort at Jackpine Reservoir that offers camping, boats, motors, equipment and seasonal RV sites. Water hook-ups and grey water disposal facilities are available on RV sites (http://jackpinelake.com/). There is also a serviced BCFS recreation site at the north end of the reservoir with 6 campsites, pit toilets and a boat launch (http://www.tsa.gov.bc.ca/publicrec/docs/sites.). These facilities also attract many recreational and outdoor enthusiasts to this reservoir.

The Crystal Mountain Ski Resort has proposed to expand the development at the ski hill including an all-year village community with golf course. A portion of the development is within the Powers Creek watershed and could impact the water quality at the intake. There is an agreement in principle between WID and the resort regarding water supply.

The potential hazards to the drinking water at the intake, as determined as part of Module 1, are summarized in Table 2-1.

Table 2-1. Module 1 – Potential Hazards to Drinking Water Quality and Quantity at Intake

Hazard Type	Drinking Water Hazard	Possible Effects
Physical	Natural sediment load from channel erosion and mass wasting	- Risk to human health
	Sedimentation from industrial roads and road crossings	- Increased sediment load resulting in a change in turbidity level exceeding 1 NTU immediately prior to disinfection - Compromised disinfection process - Risk to human health
	Sedimentation from range use in and around streams	- Increased sediment load resulting in a change in turbidity level exceeding 1 NTU immediately prior to disinfection - Compromised disinfection process - Risk to human health
	Sedimentation from recreation activity on roads, road crossings and in/around streams and reservoirs	- Increased sediment load resulting in a change in turbidity level exceeding 1 NTU immediately prior to disinfection - 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	- 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. In addition, there could be a loss of control at the intake resulting from evacuation order and/or fire damage to the intake and treatment plant.
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 resulting in pathogen loading beyond the water system treatment capacity
	Protozoa (Giardia, Cryptosporidium)	- Risk to human health resulting in pathogen loading beyond the water system treatment capacity
	Viruses	- Risk to human health resulting in pathogen loading beyond the water system treatment capacity
	Algal blooms in reservoirs	- Risk to human health resulting in pathogen loading beyond the water system treatment capacity - Cytotoxin contamination, Trihalomethanes (by-product of disinfection process) - Increased turbidity from algal cells reaching the intake
Chemical	Total Organic Carbon	- Risk to human health resulting in pathogen loading beyond the water system treatment capacity.
	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 chemicals from fire retardants

2.6 SOURCE WATER QUALITY AND QUANTITY

2.6.1 WATER QUALITY

During the period 1969 - 1971 there was limited water quality data collected at the WID intake 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 Powers Creek.

Powers Creek also had a basic pH, with a low sensitivity to acidic inputs. The water was moderately hard, with all metals being at concentrations less than water quality criteria to protect aquatic life. Nitrogen compounds were well below criteria to protect aquatic life; however, phosphorus concentrations were high enough to possibly cause algal growths. It is not known if algal problems occur. Dissolved oxygen concentrations were high. Both dissolved and suspended solids concentrations can be high, with the former below drinking water criteria. Bacteriological quality was such that complete treatment should be provided for drinking water supplies.

In 1996 the Ministry of Environment established a water quality monitoring station on Powers Creek near the WID 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 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	**Objective**[4]	**Average Value for Period**		
		1969-71	1996-99	2001
Turbidity	95th %ile of at least 5 samples in 30 days ≤ 4 NTU July 1 – March 31 95th %ile of at least 5 samples in 30 days ≤ 5 NTU April 1 – June 30	38.8 JTU[1] for 85 samples	<5NTU 95% of the time	Clear flow 0.8NTU Turbid Flow 2.4 NTU
Temperature	15 °C	N/a	8.5°C	8.8 °C
Conductivity	700 µS/cm	N/a	87 µS/cm	78 µS/cm
pH	6.5-8.5	8.0	7.3-8.6	7.4
Dissolved Oxygen	8 mg/L 30-day mean (aquatic)	11 mg/L	>9mg/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)		>10/100mL for 11 out of 70 samples	>10/100mL for 6 out of 10 samples
Phosphorous	10µg/L	0.04mg/L	0.028 mg/L	N/a
True Colour	15 TCU maximum (long term)		22.5 TCU	N/a
Nitrate	45 mg/L NO_3 10 mg/L N	N/a	0.03 mg/L	N/a

[1] Jackson Turbidity Unit (measure of turbidity, cannot be accurately converted to NTU)

[4] MoE, Water Quality Objectives

2.6.2 Water Quantity

Water quantity is a concern to the WID as a result of the increased demand for water within its service area and the fact that the Ministry of Environment registered a proposed reserve on the watershed in 1989 restricting further water licenses. The mean annual runoff or volume at the WSC station Powers Creek near the Mouth (located downstream of the WID intake) is approximately 32,700 ML/year. The WID holds water licenses for 831.4 ML of water for domestic and 4,705 ML for irrigation uses and 6,806 ML of storage licenses.

There are three key factors 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 storage to meet future demands. The WID has recently reviewed its storage capacity and has an application pending to increase its storage in the Lambly Reservoir by 5,000 acre-feet. WID is licensed to divert and store water in the Lambly watershed and divert water into the Powers Creek watershed.

The mountain pine beetle is killing most of the mature lodgepole pine stands in the upper watershed. The loss of the forest cover will result in increased runoff and increased peak flows. The pine will likely die over the next three to five years, during which time the runoff will gradually increase. It is estimated that there will be increased runoff for several decades until the stands recover. Preliminary estimates indicate that the peak flows could increase to 56% if all the mature pine was to die. 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 2050 by 40% and by 2080 by 50%[5]. These decreases in snow pack combined with increasing summer temperatures may result in long-term supply issues for the WID.

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 reservoirs 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 WID Intake Works

The WID intake is an on-stream intake that is vulnerable to impacts from Powers Creek. Powers Creek flows through the intake pond and although the actual point of diversion to the water treatment plant is located to the side of the pond and is protected by a concrete barrier, it is still

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[5] Friscka, G., Atmospheric Environment Service, 2007, Presentation to City of Kelowna.

vulnerable to impacts from extreme sediment loads. In its current design it is not possible to isolate the intake from the flow in the creek. WID has an inter-connection with the Lakeview Irrigation District system that can provide an emergency supply for domestic use only, should the intake be damaged.

2.8 FOREST DEVELOPMENT

Forest development has occurred in the watershed since the mid-1940s. Early harvesting was primarily located in the lower portion of the watershed with selective harvesting of ponderosa pine and Douglas fir. The majority of clear-cut harvesting in the upper portion of the watershed started in the 1980s. Approximately 30% of the watershed had been logged 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[6]. Currently, three licensees operate in the Powers Creek watershed; Tolko Industries Ltd, Westbank First Nation and BC Timber Sales. 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 Powers Creek watershed was granted on Jackpine Lake in 1907. Since then, several lakes including, Dobbin Lake, Horseshoe Lake, Paynter Lake, and Jackpine Lake have been dammed to create storage reservoirs. Major diversions have taken place in the watersheds that have increased the effective watershed area. Lambly Lake, now Lambly Reservoir, was part of the of Lambly Creek watershed. The dam constructed at the Lambly Reservoir in 1939 diverts runoff from the reservoir into the Powers Creek watershed. Since that time, Lambly Reservoir has been the main storage reservoir for the WID.

In 1990, a storage dam was constructed on Tadpole Lake (now Tadpole Reservoir) in the Lambly Creek watershed and water diverted into the Powers Creek watershed via the Nicola River watershed. In 2002 the WID constructed a diversion on the west fork of Powers Creek into Lambly Reservoir. Smaller diversions have been constructed on Bit Creek and Paddle Creek to redirect streamflow within the watershed into reservoirs. A diversion pipeline/ditch is proposed to divert water from Paynter Reservoir to the diversion pipeline into Lambly Reservoir.

As previously discussed, the upper portion of the Alocin Creek watershed has been included in this watershed assessment. The portion of the Alocin Creek watershed upslope of the diversion from Tadpole Reservoir has been designated as a community watershed. The purpose of this diversion is to transfer water stored in Tadpole Reservoir into Powers Creek via the Dobbin Reservoir during late summer and fall.

Water is delivered from the storage reservoirs via Powers Creek to the intake. Prior to 2008 when the new water treatment plant was commissioned, water was only screened and chlorinated prior to distribution.

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[6] Dobson Engineering Ltd. 1999, *Powers Creek Watershed/Road Deactivation Prescriptions.*

The WID is planning the following projects in the watershed:

- diversion of water from Paynter Reservoir and upper Powers Creek into Lambly Reservoir via a pipeline to Harding Creek (which flows into Lambly Reservoir);
- increased storage capacity on Lambly Reservoir.

2.10 SUMMARY

The intent of this section was to characterize the Powers Creek community watershed. The watershed area upstream of the intake that is the designated community watershed is approximately 131 km^2 with an elevation range from 340 m at Okanagan Lake to 1,860 m at the summit of Whiterocks Mountain. The community watershed includes the Alocin Creek community watershed at ~4.7 km^2 situated within an elevation range of 1,500 m at the diversion ditch from Tadpole Reservoir to 1,600 m at Tadpole Reservoir.

The reservoirs have the potential to provide some settling of sediment and fecal material. The hydrologic effect of these reservoirs is to modify the runoff period and peak flows through storage. A detailed map of the Powers Creek watershed is provided in Appendix A.

There are 11 licensed stakeholders and other parties with an interest in the watershed. The watershed includes four biogeoclimatic zones and is generally forested. The terrain ranges from a canyon upstream of the intake to rolling plateau in the uplands. 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. Two seasonal hydrometric stations were being operated privately for WID to determine the relationship between groundwater and surface runoff in the upper watershed. Preliminary data suggest that the groundwater in the vicinity of the stations is under the influence of the surface runoff.

From a hydrology perspective the watershed can be considered as having two zones. Zone 1 is the unbuffered 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 watershed upstream of the reservoirs. This upper zone has the greatest buffering due to the storage in the Tadpole, Dobbin, Horseshoe, and Lambly reservoirs. The WID is concerned about the quality of the water at the intake, particularly with regards to bacteria and sediment loads. Stream flows for fish are a concern for the Ministry of Environment downstream of the intake.

The long-term hazards to drinking water include sediment from recreation use, roads and cattle; bacteria, protozoa and viruses from humans, wildlife and cattle; cytotoxins from algae; contaminants in runoff from wildfires resulting from increased fuel loads from the death of the lodgepole pine; herbicides from the application to noxious weeds; and hydrocarbons from a fuel spill. The present raw water quality is not satisfactory for drinking water and has resulted in the WID constructing an advanced water treatment plant at its intake. The intake is a concern since it is vulnerable to obstruction from extreme bed load and also to contaminants.

Forest development in the Powers Creek watershed has taken place since approximately the mid-1940s. There is a high likelihood that the mountain pine beetle will kill most of the mature lodgepole pine in the watershed over the next three to five years. The Westbank First Nation and Tolko recently completed a retention plan for the watershed that focuses on salvaging lodgepole pine attacked by the mountain pine beetle. The loss of the mature pine combined with areas logged will increase the equivalent clear-cut area significantly in the watershed from the current level of ~30% to possibly as high as 56% of the total area above the intake. The peak flow hazard at the intake could increase from low to high as the infested pine stands die and are salvaged.

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.

3. MODULE 2 – RESULTS OF CONTAMINANT INVENTORY

The objectives of Module 2 are to inventory the land uses and impacts within the community watershed 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. 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. Reconnaissance-level field inspections were completed as part of Modules 1 and 2, which included approximately six field days.

3.1 SUMMARY OF INTERIOR WATERSHED ASSESSMENT PROCEDURE UPDATE

As summarized in Section 1.4 the IWAP procedure is an analytical tool designed to help forest planners and managers understand the water-related problems that may result from past forest development in the watershed, and to recognize the possible hydrological implications of proposed forestry-related development. The original IWAP was completed for the Powers Creek watershed in 1998, updated in 2001 and again in 2008 as part of this Powers Creek Source Assessment Plan.

The following sections provide a summary of the results of the 2008 IWAP update. The IWAP procedure has evolved since the original guidebook was released in 1995 and the revised guidebook in 1999 to a professional assessment process used in 2007 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 was 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 Assessment Report, 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 grazing on the water sources as well as other industrial activities such as mining.

3.1.1 RECOMMENDATIONS FROM THE 1998 IWAP

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

- It is recommended that development of proposed cutting permits (CP 869-1, CP 869-2, CP 869-5, CP 869-6, CP 868-1, CP 868-2, CP 868-3, CP 868-5, CP 868-6 and CP 868-7) within the North Powers Creek sub-basin proceed slowly at a rate such that the ECA would not increase by more than 2% in any three year period. In addition channel monitoring sites that have already been established within the North Powers Creek sub-basin should be reviewed annually to provide details regarding possible channel changes and the relationship of any changes that might be associated with the proposed forest development. These permits should also be developed so that potential water quality impacts at the reservoir are minimized (i.e. silt fencing, culvert socks, rip rapping of culvert inlets and outlets and appropriate deactivation of inactive roads)

Action: 2008 WAP results identified a 6% reduction in the ECA for the North Powers sub-basin, from 29% to 23%. Channel monitoring sites were discontinued after 2001 when no significant channel changes were noted. Development measures for specific sites to prevent water quality impacts are unknown.

- If not already carried out, a qualified professional should review the large landslide located below the Glenrosa sub-division to determine if there is a public safety concern. It should be noted that this landslide is not forest development related and is situated within the jurisdiction of the Regional District of the Central Okanagan.

  Action: Completed by Dobson Engineering Ltd. for the Regional District of Central Okanagan in 1999.
- Inactive roads throughout the watershed should be assessed and rehabilitated by taking appropriate measures to reduce the number of wood culverts and restore natural drainage patterns. Wood culverts crossing over the main channel in the Alocin Creek community watershed are of particular concern and should be removed as soon as possible.

  Action: Deactivation has occurred within the watershed but typically at a semi-permanent level. High priority sites have been addressed. Three culverts were replaced along Alocin Creek. Numerous wood culverts still exist, although typically installed at non-classified drainages; most are to the point of failure. Wood culverts over the main channel in the Alocin Creek community watershed have been removed based on site visits. A wood culvert located on Paynter Creek directly downstream Paynter Reservoir should also be noted as in the process of failing.
- Maintain or deactivate roads (i.e. status roads) upon completion of harvesting to minimize surface erosion and mass wasting.

  Action: Should be addressed in licensees Forest Stewardship Plan.
- 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 and natural drainage should be maintained or restored within all blocks and on access roads.

  Action: Should be addressed in licensees Forest Stewardship Plan.
- Long-term forest development plans should be developed for the watershed that incorporates the results of the Complan work developed by Riverside Forest Products Ltd. as well as for that portion of the watershed outside the TFL that includes the BC Timber Sales and Heartland Economics LP operating areas.

  Action: Completed.
- The long-term sustainable level of harvest and associated ECAs for the watershed should be based on information collected from the channel monitoring sites, streamflow information, and the long-term retention plans to ensure that stream channel stability and water quality are protected.

  Action: Completed

3.1.2 RECOMMENDATIONS FROM THE 2001 IWAP

The following recommendations related to water quality were presented in the 2001 IWAP report. Following each recommendation is a comment on whether or not any action was taken on the recommendation.

Forest Development Plan (FDP) Related Issues

- Maintain the ECA for the drainage of North Powers Creek upstream from Lambly Reservoir at or below 42.5% in order to limit the potential for peak flow impacts and to facilitate channel recovery. Annual monitoring of the channel section upstream from Lambly Reservoir should continue and the rate of future forest development should be based on the information obtained.
  Action: Current ECA is less than 42.5% as per recommendations; the channel monitoring program has been discontinued.
- Deactivate or maintain inactive permitted roads in accordance with the Forest Practices Code.
  Action: Should be addressed in licensees Forest Stewardship Plan.
- Remove or upgrade any remaining failed wood culverts on non-status roads in order to reduce the delivery of sediment to channels (if funding is available).
  Action: Incomplete. Many wood culverts still in place (i.e. Site 81 on Paynter Creek below Paynter Reservoir).
- Westbank Irrigation District should consider increasing the channel capacity of Harding Creek downstream from the outlet of the proposed pipeline in order to reduce the potential for increased sedimentation into Lambly Reservoir caused by increases in stream flows.
  Action: Powers Creek Diversion pipeline complete and functioning.

3.1.3 2008 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. Prior to undertaking a watershed assessment the watershed is subdivided into separate sub-basins based on the main watershed tributaries and hazard ratings are derived for each of them. For the Powers Creek watershed there were two sub-basins, Powers Creek and North Powers Creek. There is also a residual area above the intake that is assessed and the results are addressed in the ratings for the total watershed. In addition the WAP update also addressed that portion of Alocin Creek referred to as Alocin above the diversion. Alocin Creek is a tributary to the Nicola River.

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. The following table (Table 3-1) lists the parameters that are 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

Param	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 H_{40} elevation	Part of watershed ECA
ECA above the H_{40} elevation	Peak flow/snow 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/riparian stability
Length of mainstem channel with non-functioning riparian area	Used to assess channel/riparian 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 management on water quality and quantity;
- Increases in turbidity levels and presence of pathogenic organisms that may require special treatment of drinking water;
- Increased access for recreation and range use that may result from forest road construction in and around streams;
- Increased risk of water contamination and wildfires risks from increased off-road vehicle use in the upper watershed;
- Hydrologic effects from increased wildfire risk related to the impacts from the mountain pine beetle;
- 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. Although the reservoirs have the potential to act as settling ponds, development upstream from them should not consider them as settling ponds, nor are they meant to be used for intensive recreation purposes;
- Unauthorized construction of over road vehicle trails on sensitive soils near streams, lakes or reservoirs resulting in sediment and pathogen contamination of source waters;

- Poorly constructed or maintained off road vehicle trails near streams, lakes or reservoirs resulting in sediment and pathogen contamination of source waters;
- Recreation uses on and about storage reservoirs and diversion ditches increase the risks of contamination with bacteria, viruses and chemicals;
- Wildfire risks from unmanaged off road vehicle and camping during periods of high fire danger; and
- Bank erosion from exposed soils along sections of diversion channels.

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 H_{40}/snow sensitive zone) and road density to 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 summarized in the following sections and in Table 3-3. The following paragraphs are based on GIS data that is current to December 2007. More recent data was not available when this report was prepared.

Peak Flow

IWAP results indicate that in the West Powers and Alocin sub-basins the ECAs and road density have decreased since 1998, from 24% to 17% and 34% to 23% respectively. Channel surveys in the sub-basin did not identify peak flow related channel disturbance. The peak flow hazard rating is low for the West Powers sub-basin (rated as moderate in 1998 and low in 2001) and is maintained at low for the Alocin Creek watershed. The mainstem channels in these basins are typically stable with low gradient swampy sections and boulder/cobble dominated sections. The channel conditions are similar to those observed during the 1998 and 2001 assessments. Both channel types are relatively insensitive to peak flow increases. In addition, reservoirs in the West Powers sub-basin reduce peak flows through water storage, which reduces the potential for peak flow impacts. The stable channel conditions observed during the field investigations warrant low peak flow hazard ratings for the West Powers Creek sub-basin and the Alocin Creek watershed.

The ECA for the North Powers sub-basin has also decreased since 1998, from 29% to 23%. Road density has also decreased, however the number of stream crossings identified has increased from 22 to 54. The peak flow hazard rating is moderate for the North Powers sub-basin (rated as high in 1998 and moderate in 2001) and is maintained at moderate for the entire Powers Creek watershed. The channel conditions are similar to those observed during the 1998 and 2001 assessments.

The ECA for the watershed (above the intake) has decreased from ~22% in 1998 to ~16% (the ECA increased in 2001 by 2% above the 1998 level). Although the ECA for the entire Powers Creek watershed is low at 16%, the hazard rating for the watershed above the intake remains at moderate due to the sensitivities to peak flow increases in the lower reaches identified in 2001.

Surface Erosion

The road density has decreased from 1.7 km/km^2 (1998) to 0.9 km/km^2 for the entire watershed above the intake at the end of 2007. In contrast the number of stream crossings have increased in the watershed from 79 in 1998 to 142 in 2007, due to a significant increase in crossings in the North Powers sub-basin with current harvesting in this area.

Many of the roads in the watershed are rated as moderately to highly erodible due to the sub-grade material. Although generally well maintained, stable, and most of the eroded surfaces are 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 culvert crossings or bridge sites during wet conditions (rain/snowmelt). Although quantities are typically small (road rills $\leq$10 cm), delivery can be considered chronic. Traffic volume (industrial recreational and cattle) also appears to be connected to the likelihood of sediment delivery at each crossing; running surfaces on roads with recent high volume traffic (industrial) were noted with 1 cm to 2 cm of loose material. Dust from these roads is also a source of fine sediments, specifically active roads, and was noted stored in channels and on banks and vegetation.

Deactivated roads were traveled as part of the stream crossing assessments. Deactivation measures appeared to be generally functioning as designed and typically at a semi-permanent level. A total of 15 wood culverts were identified in the watershed over the three sub-basins, and all of which were at various stages of failure (holes in road, sunken sections). Of the 15, all were rated low to moderate based on the Stream Crossing Hazard Rating (SCHR) scores; Site 81 is a concern for future sediment delivery to the mainstem channel, as the culvert will likely fail. The age of the wooden structure is not known but the decay at the ends of the sill logs indicates eventual failure into the channel.

Exposed and eroding banks along the outlet channel from Tadpole Reservoir (flows to Alocin Creek), and the inlets of the Sandberg and Whiterocks diversion ditch lines are still a concern as in past IWAP reports. The general lack of recovery at these sites maintains a moderate surface erosion hazard rating for the Alocin Creek sub-basin. The hydrologic impacts are mostly confined to Alocin Creek since the Alocin Creek flow is diverted into Dobbin Reservoir where the majority of transported sediment can settle.

Based on the observed condition and low stream crossing hazard rating[7] (SCHR) scores the surface erosion hazard ratings are maintained at low for the West Powers and North Powers sub-basins and for the entire Powers Creek watershed. The surface erosion hazard rating is maintained at moderate for the Alocin Creek watershed due to the continued bank erosion downstream of Tadpole Reservoir.

[7] For details on the "stream crossing hazard rating "system refer to Section 3.3.

Riparian Buffers

The riparian buffer ratings, as represented by the extent of stream logged to the bank remains unchanged since the 1998 IWAP. For streams that require buffers or reserves under the *Forest and Range Practices Act*, the riparian area will not be harvested. Any increase in 'streams logged to the bank' will be for the very 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 the West Powers Creek and North Powers Creek sub-basins, the Alocin Creek watershed and for the entire Powers Creek watershed. The 2008 results were consistent with those from 1998 and 2001 the majority of the riparian vegetation in the watershed is intact and contributing to channel stability and complexity. A large portion of the riparian vegetation has been harvested along the diversion channel in the Alocin Creek sub-basin, downstream from the Tadpole Reservoir as a result of the construction of the diversion works.

Landslides

Six landslides have been identified; five in the 1998 IWAP and one additional landslide was identified in the 2001 IWAP. Four of the landslides are not forest development related and two appear to be road related. All of the landslides are at least partially connected to channels. A stability assessment has been conducted on the most recent failure and the slide has been rehabilitated. This failure and the previously reviewed failures are not significantly impacting the hydrologic condition of the watershed, as reported in the 2001 WAP.

No new landslides have been identified since the 2001 WAP was conducted. Restoration work was completed on a landslide at 26.25 km on Bear Creek FSR, and the failure identified as Landslide No. 1 in the 1998 IWAP report. A cursory field review of these sites did not identify any obvious instabilities or sources of sediment. Minor fill erosion was noted off the Bear Main slide but did not appear to impact the mainstem channel. The landslide hazard ratings remain low for all sub basins and the entire watershed.

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

Watershed Inventory category	Alocin Creek Community Watershed*	West Powers Sub-basin	North Powers Sub-basin	Residual above Intake	Above WID Intake
Gross Area (ha)	407	6,172	3,375	3,127	13,081
Total area harvested Ha /%	209/ 51	1,824/ 29	1,219/ 36	428/ 14	3,679/ 28
ECA ha/%	94/ 23	1,041/ 17	774/ 23	207/ 7	2,117/ 16
ECA below the H_{40} (ha/%)	0/ 0	487/ 14	210/ 13	33/ 1	729/ 10
ECA above the H_{40} (ha/%)	94/ 23	555/ 20	564.7 32	174/ 22	1,387/ 24
Total Road Density (km/km2)	1.5	0.5	1.3	1.1	0.9
Total Road Length (km)	14	82	65	38	198
Road Deactivation (km)	8	59	19	2	79
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	21	58	54	11	142
Length of stream logged to the stream bank (km/km)	7	26	24	2	60
Length of mainstream channel with non-functioning RMA	0.30	0	0	0	0
Length of disturbed mainstem channel (km /km)	0	0	0	0	0

* Only includes the community watershed portion of the Alocin Creek watershed situated above the diversion channel from Tadpole Reservoir to Powers Creek.

Table 3-3. 2008 Hazard Indices for the Powers Creek Watershed

Watershed Sub-unit	HAZARD CATEGORY			
	Peak Flows	**Surface Erosion**	**Landslides**	**Riparian**
West Powers	Low	Low	Low	Low
North Powers	Moderate	Low	Low	Low
POI 2 (w/s upstream from WID Intake)*	Moderate	Low	Low	Low
POI 1 (w/s upstream from OK Lake)*	Moderate	Low	Low	Low
Alocin	Low	Moderate	Low	Low

*Note: Hazard indices for the residual area have not been included in this table. 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 channels tributary to the Powers Creek mainstem as well as the middle and upper reaches of Powers Creek are generally stable with negligible channel disturbance. Recent field visits did not identify new disturbances.

The mainstem channels in the West Powers sub-basin and the Alocin Creek sub-basin are generally stable and unchanged since the 2001 WAP. Natural deposition of sands and gravel are typical along the lower gradient sections and the source of the material appears natural. Beaver activity in the watershed was referenced in past reports; however no significant beaver related disturbance was identified during the 2008 field review.

As in previous reports, North Powers Creek downstream from Lambly Reservoir is considered generally stable; however, the section of North Powers Creek immediately upstream from Lambly Reservoir continues to be moderately aggraded. The level of channel disturbance did not appear to have increased since the 2001 assessment, but the disturbance coupled with the current ECA (32% above the H_{40}/SSZ) still warrants concern for the drainage into Lambly Reservoir.

The channel stability hazard rating is maintained at low for the West Powers sub-basin and for the Alocin Creek watershed. The channel stability hazard rating is maintained at moderate for North Powers Creek sub-basin and the entire Powers Creek watershed. In general, with the few exceptions noted above, the channels in the upper watershed are stable and in good condition and appear unchanged from the previous IWAP.

3.3 OVERVIEW OF POTENTIAL CONTAMINANTS AND INVENTORY PROCESS

The potential contaminants to drinking water are typically a function of land use. The land uses within the Powers Creek watershed are limited to water supply, forest development, grazing, industrial access, and recreation.
The primary contaminants associated with these land uses are:

- Sediment and pathogens along unmanaged off road vehicle trails on sensitive soils near streams and reservoirs;

- Sediment delivery off poorly managed or maintained off road vehicle trails near streams and reservoirs;
- Sedimentation to streams from forest access roads (including dust);
- Sedimentation to streams from cattle disturbance at road crossings and along stream banks;
- Sedimentation and contamination in reservoirs related to vehicle damage within reservoirs when water levels are low;
- Potential increased water temperatures from all land uses/disturbances including the loss of canopy cover resulting from the mountain pine beetle infestation;
- Bacteriological and pathogenic contamination from cattle, recreation use and wildlife activity around streams, diversion channels and reservoirs;
- By-products from algal blooms in reservoirs resulting from increased water temperatures and nutrient loading, e.g. sediment;
- Bacteriological and pathogen contamination from human activity around streams, diversion ditches, and reservoirs; and
- Petroleum spills.

The risk of the contaminants entering the drinking water increases with increased watershed 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 has developed a procedure to numerically assess the impact of stream crossings on water quality. The result of this procedure is called the *Stream Crossing Quality Index*. The procedure 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. The pre-field assumption is that, by default, all stream crossings are considered to be affecting water quality and are given a score of 1. The field assessment results consider soil type, level of road use, and sediment delivery potential to determine the actual score for each crossing (refer to Appendix C for additional details on the procedure used). For this project, the field ratings have been simplified and are referred to as the Stream Crossing Hazard Rating (SCHR).

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.

Since stream crossings represent the most likely point source for contamination especially from sediments and road runoff, a 'stream crossing hazard rating' system was developed that 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 currently occurring or may occur in the watershed that will affect the hazard rating associated with anthropogenic activities. The intent of the descriptions of climate change, mountain pine beetle and wildfire is to provide an overview summary of these natural hazards.

3.4.1 CLIMATE CHANGE IMPACTS

Climate change may have significant impacts on the Powers Creek watershed and the available runoff. According to research by the Atmospheric Environment Service, temperatures in the Okanagan are increasing by 0.1^{o}C/year over the spring, summer and fall seasons and by 0.2^{o}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 Powers water supply and the WID water demand require more study to determine the impacts.

The research suggests that over the next 50 years the basin might experience warming summers resulting in increased water demand by agriculture, and less snow (but perhaps more rain) during the winter that may result in less runoff. The climate models also indicate the snowmelt period could occur up to two weeks earlier. These changes, if they occur as predicted, are likely to occur gradually over the 50 year period. 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 Powers Creek sub-basin in the snow sensitive zone (SSZ) indicates that ~27% of the area has pine leading (i.e. pine >40%), of which ~22% of the area has >70% mature lodgepole pine. For the West Powers Creek sub-basin, ~22% of the area has pine leading of which ~11% of the stands have >70% mature lodgepole pine (Table 3-4). 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.

Table 3-4. Stand Characteristics in North Powers and West Powers Sub-basins

Stand Characteristics	North Powers		West Powers	
	Area (ha)	% of Total Sub-basin Area	Area (ha)	% of Total Sub-basin Area
<40% Pl	187	12	421	21
>70% Pl	341	22	222	11
40-50% Pl	27	2	46	2
51-60% Pl	0	0	78	4
61-70% Pl	52	3	98	5
Area Logged	856	56	929	46
Area Non-Pine	64	4	221	11
	1,527	100	2,015	100

Stands above the H_{40} elevation within the residual area above the intake account for ~15% of the total area within the SSZ of the watershed. For this reason, the residual area has a minor influence on peak flows on the mainstem. At the sub-basin level it is important to consider the effects of increased ECAs on local channels. The stands that die will provide greater water yield 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 to 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. In the North Powers sub-basin, 56% of the area has been logged and a further 27% of the sub-basin has mature pine leading that could significantly increase the area affecting the hydrology to >80% of the sub-basin area. For the West Powers sub-basin the area harvested amounts to 46% of the area and there is a further 22% of the area with mature pine leading. This suggests that ~past harvesting and the pine beetle could impact 68% of the sub-basin. The potential hydrologic impacts are discussed in more detail in section 3.5.1.

As a result of the epidemic pine beetle activity, there may be a significant increase in timber harvesting (focused on salvaging infested pine stands if 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 increased wildlife and cattle use there will be the associated increases in sediment and fecal loading in the streams.

The timing of the impacts of the loss of forest cover to the pine beetle and climate change are likely to be different, with the pine beetle effects being short-term (i.e. the next 30years+/-), and the climate change impacts being long-term (i.e. gradually occurring over the next 50+ years). Over the long-term, based on the current knowledge, indications are that there may be less runoff and an increasing demand.

3.4.3 WILDLIFE IMPACTS

Wildlife movement in the watershed is not well known 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 barriers to protect the source water quality. Beaver activity in the watershed was referenced in past reports; however no significant beaver related disturbance was identified during the 2008 field review. If deciduous stands naturally establish where mature pine once was, the potential for increased beaver activity exists. This may also have to be assessed in the future to prevent excessive beaver related disturbance to the stream network.

3.5 ANTHROPOGENIC USES THAT IMPACT WATER QUALITY AND QUANTITY

3.5.1 FOREST DEVELOPMENT IMPACTS

Past forest development in the watershed was introduced in Module 1, Section 2.8. Forest development impacts on water quality are typically increased sediment delivery by streams from roads as summarized in section 3.1. If the licensees increase the rate of development in response the expansion of the pine beetle, there may be water quality impacts related to increased roads required to access beetle infested stands.

Tolko and the Heartland Economics have completed retention plans for the watershed that focus 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 may 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 peak flow hazard for the watershed upstream from the intake based on past harvesting only is considered to be a low hazard. If all the mature pine was to die as a result of the pine beetle the peak flow risk at the intake would increase to high. The distribution of forest cover for the watershed upstream of the intake is illustrated in Figure 3. The color-coded sections in the pie chart and legend refer to the percentage of mature pine in the forest stands in the Powers Creek watershed. For example, 22% of the forest in the watershed is comprised of stands with less than 40% pine and greater than 60% other tree species. It is unlikely that the loss of mature pine in these stands would have any noticeable hydrologic impact due to the pine being a minor component in the stand. The extent of the proposed logging based on the retention plans totals approximately 973 ha. It is not known how much logging will actually occur due to the current depressed lumber market.

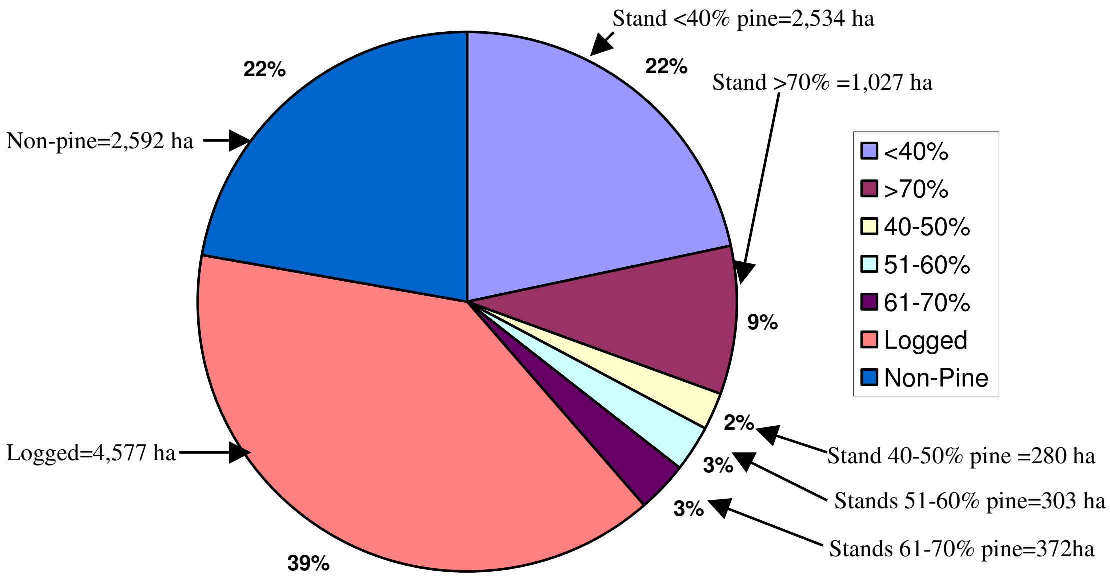

Figure 3. Forest cover distribution upstream of WID intake

The impacts from salvage harvest of the pine beetle affected stands are likely to be minimal compared to the larger scale hydrologic impacts that are going to occur as a result of the loss of all the mature lodgepole pine, especially in the snow-sensitive upper watershed, as it 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 grasses and brush species due to improved light, moisture and nutrients. The expansion of these species will encourage greater use by ungulates and cattle into areas along streams not previously accessible or attractive to these animals. Increased animal presence will result in increased sediment and fecal coliform loading. It is the forest licensee's responsibility to replace natural barriers to cattle movement that are lost as a result of harvesting.

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. This latter source 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 steep undercut banks fail. The dominant forest development impact is sediment delivery to streams from roads. Prior to initiating the 2008 fieldwork, the road network in the watershed was reviewed using GIS and a field map, which identified each road crossing with an identifier number. The GIS analysis identified 144 sites. During the fieldwork, 57 sites were identified as actual stream crossings, 41 were considered to be a non-classified drainage (NCD) or cross drain, and 46 were not assessed. Based on the combined ratings for the sites assessed, 89 sites (62%) were ranked as low to very low hazards, 8 sites (6%) were Low to moderate hazards, and 1 (site 34) was rated moderate. There are no road crossing related high hazards sites identified within the watershed. It should also be noted that 15 wood culverts were identified in various stages of failure, Site 81 in particular is a concern as it located over the mainstem channel downstream from the Paynter reservoir.

The sites summarized in Table 3-5 illustrate the types of active or potential contamination associated with road crossings. The detailed assessment tables and related photographs are provided in Appendix B. The Watershed Map in Appendix A includes the stream crossings ID numbers.

Table 3-5. Typical Forest Road Crossings Hazards Identified in 2008

Crossing No.[8]	Hazard	Likelihood	Hazard Rating	Photograph No.
32 72	Road surface erosion over fill, cattle presence	During freshet and rainstorms	Low to Moderate	Photo 22 Photo 19
45 46 50 51 52 53 81	Failing wood culverts	Constant, although likely increased in wet weather	Low to Moderate	Photo 17 Photo 16 Photo 15 Photo 10
96 103 111 115	Road surface erosion over fill, cattle presence	During freshet and rainstorms	Low to Moderate	Photo 14
34	Surface and ditch erosion to stream, evidence of cattle	During freshet and rainstorms	Moderate	Photo 34

It is likely that there will be increased harvesting activity in the watershed over the next several years if Tolko and Heartland implement their proposed salvage logging plans. Increased industrial activity, timber harvesting and logging truck traffic will increase the likelihood of water quality impacts.

Harvesting is proposed in the Alocin sub-basin along the diversion channel below Tadpole Reservoir. The current ECA for the basin is ~23% and roads in the basin appear in good condition. Some road sections are permanently deactivated with vegetation growing on the road surface.

[8] Refer to Field Map in Appendix A, Crossing No. refers to "Stream Crossing ID" on the map. A summary of the 2008 road assessments is provided in Appendix B in the Road Summary table. The column "Xing ID" in the table in Appendix B refers to the Crossing No. in the table above.

Proposed harvesting in the West Powers sub-basin may occur throughout the sub-basin with a large area surrounding Jackpine Reservoir. The current ECA is ~20%% and could increase to 49% if all the proposed harvesting actually occurs. The majority of the proposed blocks are located above the H_{40} elevation in the snow sensitive zone. Roads in the sub-basin are in fair condition with limited sediment production and sediment delivery potential to the mainstem channel. Typical problems related to forest development include the delivery of road surface sediment at stream crossings during wet weather and dust fall along active road during the summer period. Most tributary and mainstem crossings were receiving some sediment (typically low production but direct delivery or poorly filtered). The Bear Main FSR through the sub-basin encroaches on Powers Creek with some steep sections noted where water management is critical. Branch roads were rated as being in fair condition although limited deactivation was noted.

Proposed harvesting in North Powers sub-basin may occur throughout the sub-basin with a large area located on the west facing slopes above the Lambly Reservoir. Active harvesting was occurring in the Lambly Main FSR area (off Bear Main FSR). The current ECA is ~32% and could increase to ~46% if all the proposed salvage harvesting occurs. Roads in the sub-basin appear in fair condition with low to moderate sediment production and direct sediment delivery potential to the mainstem channel. Typical problems related to forest development include the delivery of road surface fines during inclement weather, dust fall along active road crossings (Bear, and Lambly Main), and 8 failing wood culverts on branch roads off of Lambly Main (Sites 45 to 49 and Sites 50 to 52). Most tributary and mainstem crossings were receiving some level of sedimentation (typically low production but direct delivery or weakly filtered).

Proposed harvesting is limited in the residual area, however some harvest is proposed along the Powers Creek Mainstem channel in the upper reaches. The current ECA is ~7 %. Roads in the residual area are in good condition and are typically well back from the mainstem channel. SCHR scores indicate that sediment production and delivery from the road prism is low in the residual area.

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 standards require major culverts and bridges to have a capacity to pass the Q_{100} peak flows. The flows may be larger after the pine dies and it is likely that there will be stream crossings downstream from the areas affected by the beetle that may be undersized. The failure of a culvert or bridge on a mainstem, particularly in the non-buffered zone upstream of intake could cause serious impacts to water quality at 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 grazing licences issued over the Powers and Lambly watersheds with a total of 3,086 AUM's. Since the grazing licenses cover the combined Lambly and Powers watersheds there is no discrete AUM number for individual watersheds. 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 easy access to water as well as to the riparian areas along streams where there is often preferred grasses.

Observations in this watershed indicate that there is low to moderate sediment disturbance on roads at streams in the Powers Creek watershed. Upland reservoirs and open diversion ditch lines 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 (based on presence or absence) that cattle activity was contributing to the water quality hazard (i.e. sediment and fecal material) at 59 (60%) of the 99 sites assessed. No moderate or high disturbance sites were attributed to cattle activity at major stream crossings or tributary channels. The details for all sites are provided in Appendix B.

3.5.3 Recreational Use Impact

The Bear Creek Recreation Site that has a total area of ~30,000 hectares includes most of the North Powers sub-basin, as well as part of the Alocin and West Powers sub-basins. There are approximately 4,282 hectares of the recreation site within the Powers Creek watershed. The primary use of this recreation site is for intensive motorized vehicle use, i.e. motorcycles and ATVs. The area is managed by the Ministry of Tourism, Culture and the Arts. Development of a trail network is underway but has not yet expanded to include lands within Powers Creek. However, the long-term plan is develop a network of motorcycle trails, rest areas and possibly campsites throughout the recreation area, including in the Powers Creek watershed. Increased public use and recreation use will increase the risks of the introduction of pathogenic organisms and of human caused wildfires.

Recreational disturbance was considered low in the Alocin sub-basin based on limited evidence of extensive recreational use. Recreation activity in the basin is likely limited to camping/hunting/fishing as there were campsites and campfire pits noted in the area. Evidence of motorcycle/ATV use was primarily concentrated near the reservoirs.

Recreational use in the West Powers sub-basin was rated as moderate. Activity is currently concentrated the around reservoirs in the area. The Bear Creek Recreation Site includes the eastern portion of the sub-basin and there may be increased motorcycle use in this area in the future as new motorcycle trails are developed by the Ministry of Tourism, Culture and the Arts that is responsible for managing the site. Evidence of motorcycle/ATV/4wd use was observed below the high water mark at all reservoirs except Jackpine. The impacts to the water quality in the reservoirs resulting from vehicles disturbance below the high water level is a concern and is considered to be a high risk. Impacts from other recreation uses were rated as a moderate risk at this time.

There is a small privately managed resort at Jackpine Reservoir that offers camping, boats, motors, equipment and seasonal RV sites. Water hook-ups and grey water disposal facilities are available on RV sites. At the time this report is produced, it is not known if site inspections of this facility are conducted to ensure compliance with any special use permit regulations that the resort is managed under. There is also a serviced recreation site at the north end of the reservoir with six campsites, pit toilets and a boat launch. There is a small cabin downstream from the outlet of the Dobbin Reservoir. Evidence of camping was noted at all reservoirs including fire pits and garbage below the full pool elevation.

Recreational use in the North Powers sub-basin is rated as low at this time, however there a designated Recreation Site with 18 campsites, a boat launch and pit toilets along the west shoreline near the north end of the reservoir at the Lambly Reservoir. In addition, Bear Lake Resort is a small private resort along the east side of the Lambly Reservoir. Lambly Reservoir is stocked annually by the Ministry of Environment with 10,000 rainbow trout and has also been illegally stocked with yellow perch. This area is a popular destination and increased recreational activity on the reservoir increases the risks to the drinking water supply. This increased risk has not been well defined and research to date has been unable to fully quantify risks to water quality from recreational activity on/near reservoirs. Other “unauthorized” campsites were identified, specifically at the Harding Creek crossing at Bear Main FSR where an old road provides vehicle access.

Recreational use in the residual area is considered low. The watershed is affected by the Okanagan Shuswap Land and Resource Management Plan off road vehicle recreation management zone (RMZ).

3.5.4 MINING AND QUARRIES

There are 15 mineral tenures within the Powers Creek watershed based on the 2004 Mineral Titles Map (most recent update). Although no activity (open quarries) was noted during the field inspections, development of these tenures 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. Currently mining activities are considered a low hazard due to the absence of activity however any activity near a stream would increase the rating.

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 is provided in Module 8.

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 of 0.3 NTU in treated water - Compromised disinfection process - Risk to human health	- Planning – Avoid development activities in sensitive areas /Forest licensees - Water treatment plant at Powers Creek Intake - chemical and multimedia filtration (anthracite and sand)/ WID Staff
	Sedimentation from industrial roads and road crossings	- Increased sediment load resulting in exceeding turbidity threshold of 0.3 NTU in 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 and maintenance to limit impacts / Forest licensees
	Sedimentation from range use in and around streams and road crossings	- Increased sediment load resulting in exceeding turbidity threshold of 0.3 NTU in 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 resulting in exceeding turbidity threshold of 0.3 NTU in treated water - Compromised disinfection process - Risk to human health	- Education – Inform stakeholders and the public about watershed sensitivities / WID, MTCA - Signage – Use signs to remind users of the importance of protecting the water quality / WID, MTCA - Do not permit trail construction along streams or reservoirs, limit stream crossings / 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 / WID
	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 and treatment plant	- Develop a wildfire plan for the watershed to reduce potential impacts / WID, MoFR - Plan future harvesting to reduce fuel loads and to create defensible zones / WID, 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 coliform 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 / WID, Agencies
	Protozoa (Giardia, Cryptosporidium)	- Risk to human health - Contravention of DWP Regulation for fecal coliform bacteria, E.coli, and total coliform 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 / WID, Agencies
	Viruses	- Risk to human health - Contravention of DWP Regulation for fecal coliform bacteria, E.coli, and total coliform 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 / WID, 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 / WID, Agencies - Restrict access by wildlife, cattle and the public in reservoir pond areas / Agencies, WID, MTCA - Education – Inform stakeholders and the public about watershed sensitivities and the potential to cause algae blooms. / WID - Signage – Use signs to remind users of the importance of protecting the water quality / WID, 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, WID
	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.

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 impacts from climate change, for which the only effective barrier will be drinking water treatment.

This is not to suggest that enhancing barriers to contamination, such as improved sediment control practices at forest road stream crossings, improved cattle management, improved reservoir monitoring and management, should be ignored. To the contrary, recognizing the significant challenges to water quality and quantity that WID faces, all the agencies and stakeholders in the watershed should make every effort to limit the impacts on the source water. Simply, 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 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* may be 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.

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

- increased sediment loads;
- increased fecal material/increased pathogen loading;
- increased organics; and/or
- increased nutrients (algal growth, taste and odour problems).

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	2-5*
	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 highest consequences to water quality in the Powers Creek watershed are related to suspended sediment/turbidity and pathogens. High levels of suspended sediment/turbidity will increase the cost of water treatment and increases the risk that viable pathogens could enter the drinking water system if there was an interruption in the treatment process. 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

Suspended sediment/turbidity are not directly harmful but can compromise the disinfection process and therefore the consequence from all sources is assumed to be at least moderate ('3', 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 sediment loads/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 2 (low) to 5 (catastrophic) depending on the severity of the event (i.e. small landslide track reaches creek, increased turbidity results – consequence = 2 vs. large landslide blocks creek and destroys water treatment plant – consequence =5 catastrophic).

The consequence level for changes in water quantity ranges from 1-5. This range depends 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 treatment/distribution system inoperable.

The physical consequences from a 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 for staff at the water treatment plant) would constitute a level 4 consequence and destruction of the water treatment plant resulting from wildfire would constitute a level 5 consequence.

Biological Hazards

The presence of bacteria, protozoa and viruses represents 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 consequence due to the potential health risks associated with exposure to potentially harmful algae species. Additional information on blue green algae is found in the following:

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

Increased sediment/nutrient delivery to the reservoirs 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.

Chemical Hazards

Chemical hazards to drinking water (TOC and hydrocarbons) present 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, that 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 suppressant 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 and are rated as having a level 2 consequence.

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). The risk is assessed at the WID intake on Powers Creek, prior to treatment. The assessed 'source' risk at the intake will be different from the risk 'at the tap' following treatment. This 'source' or 'unabated' risk to the drinking water is the worst-case scenario, i.e., in the event of a failure of the treatment system that resulted in the delivery of untreated drinking water to the community.

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	D
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)	E
	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[9]. The turbidity levels at the intake averaged ~1.7 NTU in 2007 with a maximum of 25 NTU during the spring freshet. 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 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.

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

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 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 from fire fighting activities as well as post fire effects. The risk of increased turbidity related to wildfire is rated as 'D'.

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[10] 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 since 2002 confirm that fecal coliform and E. coli are present at the intake and at each sampling site in the watershed. Based on the WID 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 Lambly 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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[10] 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 (TOC)

Sample results by WID confirm that the TOC levels in the raw water collected at the intake during 2007 ranged from 11 – 13 mg/L. With the recently completed water treatment plant, the risks to treated drinking water from TOCs have been basically eliminated. The likelihood that there will be elevated TOC levels in the treated drinking water is rated as 'E'.

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, WID 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 WID drinking water quality at the intake. For the physical hazards, the risk from natural sediment is rated as moderate to very high. There are limited natural sources that are a concern other than channel instability related to natural causes such as the pine beetle. However sediment from industrial activity, including roads, is 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 of concern 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 from biological contaminants are all rated as high to very high due to the known levels of occurrence at the intake and the limited barriers currently in place prior to the water treatment system. The construction of the new water treatment plant provides an additional barrier that delivers water that meets all IHA requirements for drinking water quality.

The risks from chemical hazards are rated as low to moderate. These risks could results from a fuel spill, a rupture of a hydraulic hose on an excavator or from a vehicle accident. The likelihood of hydrocarbons entering a stream and affecting the water quality at the intake is considered to be low. Herbicides are not licensed for use in the watershed, therefore the likelihood of contamination is low but the consequence should a spill occur is rated as moderate. Although the likelihood of a wildfire is increasing, the impacts from retardant chemicals are at worst moderate due to the composition of the new retardants.

4.5 SUMMARY

The risks to water quality and quantity are 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 the requirements established in the legislation that governs licensed activities in the watershed. These include the *Forest and Range Practices Act*, the *Water Act* and the *Drinking Water Protection Act.* The barriers are the application of the legislation 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 summarized in Table 4-6 indicate that the risks are low for hydrocarbons, moderate for herbicides and fire retardants, moderate to very high for increased sedimentation from wildfire, high for sediment from industrial roads, cattle impacts, algae, and organic carbon, and high to very high for sediment from natural causes, sediment from recreational activities, bacteria, protozoa, and viruses.

Table 4-6. Powers 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	2-5	Moderate to Very 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. Catastrophic peak flows or loss of supply from drought 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	D	3-5	Moderate to Very High	There will be an increasing risk of a wildfire over the next several years when the attacked pine is in the "red attack" stage. An intense wildfire 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)	E	2	Low	Organic material in streams will increase as the mature pine stands die but is removed during the treatment process.
	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 trees dying due to the pine beetle, there is increased potential for wildfires.

5. MODULE 8 – RECOMMENDATIONS TO IMPROVE DRINKING WATER

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 Powers Creek Source Assessment and Source Protection Plan are supported by SIRDWT. A copy of the MOU and the list of members of the SIRDWT is 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 Protection Plan is to recommend a process to address the hazards that are a threat to drinking water safety and sustainability of the Powers 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.

In March 2007 the Westbank Irrigation District (WID) completed construction and began operation of an advanced water treatment plant at the Powers Creek intake. The 54 ML per day In-Filter Dissolved Air Flotation (DAF) Water Treatment Plant utilizes a poly aluminum chloride coagulant to assist with flocculation and the removal of suspended matter (turbidity and organics) through the DAF clarification process. Filtration of the clarified water through anthracite and sand further polishes the treated water and chlorine is utilized for disinfection of the treated water. Treated water will meet or exceed all regulatory safety and quality objectives. Water treatment barriers do not, however, replace the need for diligent protection of the source water quality.

Section 5.1 provides a SWOT analysis for protection of the Powers Creek source water quality. Section 5.2 provides a Source Protection Plan with actions to improve the raw water quality in Powers 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 Powers Creek 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.* - WID 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. - Campsites at Lambly and Jackpine Reservoirs are managed by the BCFS - WID has an advanced water treatment plant designed to remove suspended solids and dissolved organics from the source water. Dual disinfection using both UV radiation and chlorination should be operational by the spring of 2009.	- 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. - Increased costs of treatment if source water quality declines.
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. - WID may have the opportunity to increase its storage in the Lambly Reservoir to capture additional runoff. - There is a significant opportunity for WID 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 a water license sharing 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 WID. - Increasing population in the Okanagan Valley will increase recreation pressures in the watershed, increasing the risks to water quality. - Demand for water in the WID service area may increase due to increased population and warmer summer temperatures. - Ongoing unregulated access for off-road vehicles will result in increased dispersed sources of sediment to streams. - Increased treatment costs if water quality deteriorates.

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 Powers Creek source water supply.

5.2.1 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 Q_{100} 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.

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

Recommendations for source protection related to sediment and turbidity from industrial activities are summarized below. Suggested responsible parties are indicated in the brackets following the recommendation.

- **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. (Forest Licensees)**

- **Address the 15 failing wood culverts identified including Site 81, which is located over the mainstem channel downstream from the Paynter reservoir. (Forest Licensees)**

- **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)**

- **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. (Forest Licensees)**

- **High use roads adjacent to streams and reservoirs should be considered for surface treatments to control dust during dry periods. (Tolko)**

- **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. (Forest Licensees)**

- **Review the sites in Appendix B with moderate hazard ratings and take actions to reduce sediment delivery to streams so that the hazard rating is reduced to low. (Forest Licensees)**

- **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 Powers 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. Planning should also consider best management practices where these are available. (WID, MoFR, MoTCA, Forest and Grazing Licensees)**

- **All stakeholders should consider including recognition of the Powers Creek Source Protection Plan in their forest stewardship plan. (All Stakeholders)**

- **The MoFR should consider providing an annual report to the Drinking Water Officer describing compliance of activities undertaken in the Powers Creek watershed under its jurisdiction. (IHA, MoFR)**

There is also the matter of sediment delivery in the diversion works from the Tadpole Reservoir through the Alocin Creek sub-basin related to erosion in the diversion ditch.

- **It is recommended that the WID assess the water quality impacts from bank erosion along the diversion ditch and take appropriate steps to protect the banks from future erosion. (WID)**

5.2.2 Range Use

There are currently 5 grazing licences issued over the Powers and Lambly watersheds with a total of 3,086 AUM's (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 59 (60%) of the 99 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 Powers Creek and the adjacent Lambly 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 may be useful to the Westbank Irrigation District as well, as the data may also reveal cattle travel routes and watering locations in the Powers Creek watershed.

Recommendations

Recommendations for source protection related to sediment and turbidity from range use are:

- **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. (Range Licensees, MoFR)**

- **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. (Range Licensees, WID, MoFR)**

- **Review and remediate areas around diversion ditches/pipelines to reduce soil disturbance and fecal material loading from cattle use. (Range Licensees, WID, MoFR)**

- **Identify riparian areas that may be affected by the pine beetle epidemic and subsequent loss of forest cover that may require increased range management to prevent increased livestock access. (Range Licensees, MoFR)**

- **Consider tracking cattle movement to improve knowledge of cattle travel patterns in the watershed to improve locations of cattle control structures and off channel watering sites to improve source water protection. (WID, MoFR, Grazing Licensees)**

5.2.3 RECREATION USE

The Okanagan Shuswap Land and Resource Management Plan defined a recreational management zone (RMZ) for off road motor vehicle recreation. The defined RMZ area includes land in both the Lambly Creek and Powers Creek watersheds. For Powers Creek, the affected area is primarily land around the Lambly Reservoir.

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 Jackpine Reservoir. These site disturbances contribute to the overall sediment load to the source water supply.

There is a small privately managed resort at Jackpine Reservoir that offers camping, boats, motors, equipment and seasonal RV sites. Water hook-ups and grey water disposal facilities are available on RV sites. At the time this report is produced, it is not known if site inspections of this facility are conducted to ensure compliance with any special use permit regulations that the resort is managed under. There is also a serviced recreation site at the north end of the reservoir with 6 campsites, pit toilets and a boat launch. At the time of inspection, the recreation site was clean and tidy with no obvious indicators of neglect or disrepair that may affect drinking water quality.

There is a small cabin downstream from the outlet of the Dobbin Reservoir; use of this facility does not pose a significant threat to drinking water quality.

There are also camping facilities at the Lambly Reservoir. Bear Lake Resort is a small private resort along the west side of Lambly Reservoir and there is a maintained recreation site with 18 campsites, boat launch and pit toilets along the west shoreline near the north end of the reservoir. As with the private facility at Jackpine Reservoir, it is not known if there are routine inspections by any authority to ensure the resort in compliance with operating permits. The BCFS sites at Lambly Reservoir were also tidy and had no obvious signs of activity that would significantly affect drinking water quality.

Lambly Reservoir is stocked annually with 10,000 rainbow trout and has also been illegally stocked with yellow perch. This area is a popular destination and increased recreational activity on the reservoir increases the risk to the drinking water supply. This increased risk has not been well defined and research to date has been unable to fully quantify risks to water quality from recreational activity on/near reservoirs.

Recommendations

Recommendations for source protection related to sediment and turbidity from recreational use are:

- **Ensure that recreation use in the watershed is consistent with the objectives in the Okanagan-Shuswap LRMP. (MTCA)**
- **It is recommended that a 'recreation brochure' be prepared 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, WID, MoE, MoFR)

- **The WID should be informed of any monitoring or enforcement regarding the operation of private facilities on the Lambly and Jackpine reservoirs; Bear Lake Lodge and Jackpine Lake Wilderness Camp.**

- **The WID, 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 WID 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.* (WID, MoFR, MoE)**

- **The WID should work with other water suppliers in the Okanagan to lobby the government to pass Off Highway Vehicle legislation requiring the licensing of all off highway motorized vehicles and regulations to control the use of these vehicles on Crown land. (WID)**

- **It is recommended that WID 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. (WID, MoFR, MTCA)**

- **Consider developing an education program for local schools regarding appropriate use of the backcountry for recreation. (MTCA)**

5.2.4 OTHER ISSUES

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

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

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

- ***Crystal Mountain Resort* –** Crystal Mountain Resort has expansion plans for a four seasons resort including a golf course. Although the resort is located only partially within the watershed. An agreement in principle is in place between WID and the resort to cooperate in the development of a water supply from the Powers Creek watershed. Depending on the final stormwater management system design, a release of stormwater could affect the raw water quality upstream of the WID intake.

- ***Reservoirs*** – 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. WID should apply to the Integrated Land Management Bureau for control of the lands within the reservoir perimeter areas so that it can prohibit access for vehicles except at designated boat launches.

The WID has future plans to raise the dams at Lambly Reservoir by approximately 7.2 m that would provide approximately 5,000 acre feet of additional storage. The Bear Lake Resort and a portion of Bear Main FSR would be flooded, however the WID has an agreement in principle with the resort owners for WID to purchase and remove the camp when the dams are raised. It is understood that there may have been an agreement with the MoFR regarding relocating affected portions of the Bear Main FSR. The future of the MoTCA recreation area on the reservoir is not known.

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

- ***Monitoring*** – Monitoring is an essential component of the Source Protection Plan and the WID has a raw water-monitoring program. The program has established baseline monitoring and problem identification.

  - 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. The sampling results should be reported to the Drinking Water Officer, SIRDWT members and stakeholders annually.

- ***Watershed Hydrology and Flow Monitoring***
  - It is recommended that the WID discontinue the two hydrometric stations on Powers Creek that were installed to determine if there was a relationship between stream flows and water levels in the groundwater well near the junction of Bear Main and Jackpine Main.
  - It is recommended that a new permanent hydrometric station be established at the diversion works from Powers Creek to the Lambly Reservoir that can be calibrated to monitor the flows into lower Powers Creek as well as the flows to the Lambly Reservoir. This station should be linked to the WID SCADA system through the radio link at the Lambly Reservoir outlet control works.

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

- ***Education*** – WID, MTCA should 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.

  WID/MTCA/MoFR should 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. WID/DWK/RDCO/MoFR should consider 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. It is recommended that WID 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. A field tour would assist the inspector to appreciate the concerns. All development proposed by MEMPR in the watershed should be referred to the WID for review.

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 WID. The Advisory Committee (AC) 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 AC, 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 WID 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 timely. 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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Appendix A

Watershed Map

Westbank Irrigation District
Westbank Iirrigation District
Powers Creek
WATERSHED MAP
Legend
Boundaries
Watershed
H40
LID Area
Mineral Tenure
Recreation Reserve
Recreation Site
Range Tenure (ID RAN012345)
Private Land
Water
Reservoir
Lake
Wetland
Stream
Diversion
Dam
WID Works
Logging
Existing Harvest
Proposed Harvest
Roads
Public
Main Line
Logging
Stream Crossing (ID)
Contours
Index (100m)
Intermediate (20m)
Projection: UTM Zone 11
Datum: NAD83
1:30,000
600 300 0 600 1,200 1,800
metre
DOBSON Engineering Ltd.
Map Prepared for:
Dobson Engineering Ltd.
2580 Dunsmuir Road, Kelowna, BC, V1W 2V3
FPS Drafting & Geomatics Ltd.
Map Prepared by:
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Alocin
Dobbin Horseshoe Buffered Zone
Dobbin Reservoir
Horseshoe Reservoir
Paynter Buffered Zone
Lambly Buffered Zone
Unbuffered Sensitive Zone
Paynter Reservoir
Bear Lake Resort
Lambly Reservoir
North Powers
West Powers
Unbuffered Sensitive Zone
Jackpine Resort
Jackpine Buffered Zone
Jackpine Reservoir
Residual Above Intake
Unbuffered Sensitive Zone
Intake

Appendix B

Field Assessment Results and Photographs

Photo 1 – View of Jackpine Reservoir

Photo 2 – Downstream view of it Creek diversion works, Site 37

Photo 3 – Diversion channel from Tadpole Reservoir to Dobbin Reservoir

Photo 4 – Alocin Creek diversion works

Photo 5 – Tadpole diversion ditch to Dobbin Reservoir, Site 142

Photo 6 – Cattle and recreational impacts below the full-pool on Tadpole Reservoir

Photo 7 – Diversion ditch to Tadpole Reservoir

Photo 8 – Recreational activities at Dobbin Reservoir, north access

Photo 9 – Recreational use at Horseshoe Reservoir

Photo 10 – Failing log culvert at Site 81 on mainstem of Paynter Creek

Photo 11 – Recreational vehicles impacts within full-pool in Paynter Reservoir

Photo 12 – Diversion works on Powers Creek to Lambly Reservoir (Site 59)

Photo 13 – Lambly Reservoir - Bear Lake Campground near north dam

Photo 14 – Sediment delivery at Site 96

Photo 15 – Failing wooden culvert at Site 53

Photo 16 – Failing wood culvert at Site 52

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Photo 17 – Failing wood culvert at Site 51

Photo 18 – Sediment source at Site 34

Photo 19 – Ditch erosion at Site 72

Photo 20 – Fine textured soils at Site 37 on active haul road near Bit Creek

Stream Crossing Hazard Rating (SCHR) Summaries for the Powers Creek Watershed

					Running Surface					Ditch															
Sites Surveyed					Left Side		Right Side			Right Front Ditch		Right Back Ditch		Left Front Ditch		Left Back Ditch						**Anthropogenic Source Presence (1) / Not Observed (0)			
Xing ID	Structure Type	Structure Size	Erodibility	Road Use	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Ditch Substrate	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Erosion Potential	Delivery	Road Score	Ditch Score	Combined Score	* Risk	*Industrial*	*Cattle*	*Recreation*	Photos
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
7	5	800	0.85	0.92	0.6	0.9	0.6	0.9	0.85	0	0.9	0	0.9	0	0.9	0	0.9	0.96	0.00	**0.16**	**Very Low**	1	0	0	P9110206 - P9110217
8	5	900	0.85	0.92	0.6	0.85	0	0.85	0.85	0	0.85	0	0.85	0	0.85	0	0.85	0.51	0.00	**0.09**	**Very Low**	1	0	0	P9110228 - P9110232
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	1	0	0	
10	5	900	0.9	0.95	0.6	0.9	0.6	0.9	0.9	0	0.85	0	0.9	0	0.85	0	0.9	1.00	0.00	**0.17**	**Very Low**	1	1	0	P9170055 - P9170068
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
13	5	600	0.95	1	0.6	0.85	0.6	0.9	0.9	0	0.9	0.6	0.9	0	0.9	0.6	0.9	1.02	1.08	**0.35**	**Low**	1	1	0	P9150131 - P9150142
14	5	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	1	0	0	P9150143 - P9150151
15	5	600	0.95	1	0.6	0.9	0.6	0.9	0.9	0	0.9	0.6	0.9	0	0.9	0.6	0.9	1.05	1.08	**0.36**	**Very Low**	1	1	0	P9150080 - P9150093
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	-
17	7	-	0.9	0.92	0.7	1	0.7	1	0.9	0	0.9	0	0.9	0	0.9	0	0.9	1.28	0.00	**0.21**	**Very Low**	1	1	1	P9150063 - P9150067
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
27	5	600	0.9	0.92	0.6	0.9	0.6	0.9	0.9	0	0.9	0	0.9	0	0.9	0	0.9	0.99	0.00	**0.16**	**Very Low**	1	1	0	P9160190 - P9160197
28	5	600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	0	1	0	
29	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	0	1	1	P9160198 - P9160200
30	5	600	0.9	0.9	0.6	0.85	0.6	0.85	0.9	0	0.85	0	0.9	0	0.85	0	0.9	0.92	0.00	**0.15**	**Very Low**	1	0	0	P9160201 - P9160204

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Powers Creek SCHR Summaries cont'd.																									
					Running Surface					Ditch															
Sites Surveyed					Left Side		Right Side			Right Front Ditch		Right Back Ditch		Left Front Ditch		Left Back Ditch						**Anthropogenic Source Presence (1) / Not Observed (0)			
Xing ID	Structure		Erodibility	Road Use	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Ditch Substrate	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Erosion Potential	Delivery	Road Score	Ditch Score	Combined Score	* Risk	*Industrial*	*Cattle*	*Recreation*	Photos
31	5	600	0.9	0.92	0.6	0.9	0.6	0.9	0.9	0.6	0.85	0	0.9	0.6	0.85	0	0.9	0.99	0.97	**0.33**	**Low**	1	0	0	P9160183 - P9160189
32	5	1400	0.9	0.95	0.6	0.9	0.6	0.9	0.95	0.6	0.9	0.6	0.9	0.6	0.9	0.6	0.9	1.00	2.13	**0.52**	**Low to Moderate**	1	1	0	P9160139 - P9160154
33	5	1200	0.9	0.93	0.6	0.9	0.6	0.9	0.9	0	0.85	0	0.85	0	0.85	0	0.9	0.99	0.00	**0.17**	**Very Low**	1	0	0	P9160173 - P9160182
34	5	800	0.9	0.95	0.8	1	0.7	1	0.9	0.6	0.9	0.7	0.9	0.6	0.9	0.7	0.9	1.40	2.29	**0.61**	**Moderate**	1	1	0	P9160155 - P9160172
35	5	1600	1	0.95	0.6	0.9	0.6	0.9	0.85	0	0.9	0	0.9	0	0.9	0	0.9	1.05	0.00	**0.18**	**Very Low**	1	0	0	P9170025 - P9170042
36	7		0.9	0.85	0.6	1	0.6	1	0.9	0	0.85	0	0.85	0	0.85	0	0.9	1.06	0.00	**0.18**	**Very Low**	1	1	1	P9170043 - P9170054
37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	**-**	-	-	-	-
41	5	500	0.85	0.95	0.6	1	0.6	1	0.9	0	1	0.6	0.9	0	1	0.6	0.9	1.08	1.08	**0.36**	**Low**	1	0	0	P9160205 - P9160208
42	5	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	-
43	5	800	0.9	0.98	0.6	0.9	0.6	0.9	0.9	0	0.9	0	1	0	0.9	0.6	1	1.02	0.60	**0.27**	**Low**	1	0	0	P9160130 - P9160138
44	5	600 (x2)	0.95		0.7	0.9	0.7	0.9	0.95	0	0.85	0.7	0.9	0	0.85	0.7	0.9	0.63	1.26	**0.32**	**Low**	1	1	0	P9160077 - P9160096
45	4	-	0.9	0.9	0.8	1	0.8	1	0.9	0.7	0.9	0	0.85	0.6	0.9	0	0.85	1.45	1.11	**0.43**	**Low to Moderate**	1	1	0	P9160041 - P9160060
46	4	-	0.95	0.9	0.8	1	0.8	1	0.9	0.6	0.85	0.6	0.85	0	0.9	0	0.85	1.48	0.97	**0.41**	**Low to Moderate**	1	1	0	P9160061 - P9160076
47	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	1	1	1	P9160009 -P9160016
48	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	1	1	1	P9160017 -P9160030
49	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	1	1	1	P9160001 -P9160008
50	4	-	0.9	0.9	0.7	1	0.7	1	0.9	0.7	1	0	1	0.7	0.85	0	0.85	1.27	1.23	**0.42**	**Low to Moderate**	1	1	0	P9160218 - P9160221
51	4	-	0.9	0.9	0.7	1	0.7	1	0.9	0.7	1	0	1	0.7	0.85	0	0.85	1.27	1.23	**0.42**	**Low to Moderate**	1	1	0	P9160218 - P9160221
52	4	-	0.95	0.9	0.8	1	0.8	1	0.9	0.6	0.9	0	0.85	0.6	0.9	0	0.85	1.48	1.03	**0.42**	**Low to Moderate**	1	1	0	P9160098 - P9160115
53	4	-	0.9	0.9	0.7	0.9	0.7	0.9	0.9	0.6	0.85	0.6	0.9	0.6	0.85	0	1	1.14	1.51	**0.44**	**Low to Moderate**	1	1	0	P9160116 - P9160129

Powers Creek SCHR Summaries cont'd.																									
					Running Surface					Ditch															
Sites Surveyed					Left Side		Right Side			Right Front Ditch		Right Back Ditch		Left Front Ditch		Left Back Ditch						**Anthropogenic Source Presence (1) / Not Observed (0)			
Xing ID	Structure		Erodibility	Road Use	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Ditch Substrate	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Erosion Potential	Delivery	Road Score	Ditch Score	Combined Score	* Risk	*Industrial*	*Cattle*	*Recreation*	Photos
54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
55	5	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	0	1	0	P9160209 - P9160210
56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
57	5	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	1	1	0	
58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	1	1	0	
59	5	900	0.95	1	0.7	0.9	0.7	0.9	0.95	0	0.9	0.6	0.9	0	0.9	0.6	0.9	1.23	1.08	**0.38**	**Low**	1	1	0	P9150094 - P9150127
60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
61	5	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	1	0	0	-
62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
63	5	1200	0.85	0.95	0.6	0.9	0.6	0.9	0.9	0	0.85	0	0.9	0	0.85	0	0.9	0.98	0.00	**0.16**	**Very Low**	1	1	0	P9160212 - P9160217
64	5	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	1	1	0	-
65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
66	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
67	5	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	1	1	1	P9170143 - P9170149
68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-		-	-
69	5	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	1	0	0	P9150204 - P9150207
70	5	700	0.9	0.9	0.6	0.9	0.6	0.9	0.95	0	0.85	0	0.9	0	0.85	0	0.9	0.98	0.00	**0.16**	**Very Low**	1	1	0	P9150191 - P9150203
71	5	600	0.9	0.92	0.6	0.9	0.6	0.9	0.9	0	0.85	0.6	0.9	0	0.85	0.6	0.9	0.99	1.08	**0.34**	**Low**	1	1	0	P9150184 - P9150190
72	5	600	0.9	0.92	0.6	1	0.6	1	0.9	0	0.85	0.7	1	0	0.85	0.8	1	1.10	1.50	**0.43**	**Low to Moderate**	1	1	0	P9150217 - P9150230
73	5	700	0.9	0.92	0.6	0.9	0.6	0.9	0.9	0	0.9	0	0.9	0	0.9	0	0.9	0.99	0.00	**0.16**	**Very Low**	1	1	0	P9150170 - P9150183
74	4	-	0.85	0.9	0.6	0.85	0.6	0.85	0.85	0	0.85	0	0.9	0	0.85	0	0.85	0.90	0.00	**0.15**	**Very Low**	1	1	0	P9150040 - P9150048
75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
76	5	400	0.95	1	0.6	0.9	0.6	0.9	0.95	0	0.85	0.6	0.9	0	0.85	0.6	0.9	1.05	1.08	**0.36**	**Low**	1	1	0	P9150152 - P9150169
77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	-
78	5	1100	0.9	1	0.6	1	0.6	1	0.9	0	0.85	0.6	0.9	0	0.85	0.6	0.9	1.14	1.08	**0.37**	**Low**	1	1	0	P9170129 - P9170142
79	5	600 (x2)	0.9	0.9	0.6	0.9	0.6	0.9	0.85	0	0.85	0	0.9	0	0.85	0	0.9	0.98	0.00	**0.16**	**Very Low**	1	1	0	P9150207 - P9150216
80	5	0.6	0.9	0.95	0.7	0.8	0.7	0.8	0.85	0	0.8	0	0.8	0	0.8	0	0.8	1.04	0.00	**0.17**	**Very Low**	1	1	0	IMGP2458P29- IMGP2459P30

Powers Creek SCHR Summaries cont'd.																										
					Running Surface					Ditch																
Sites Surveyed					Left Side		Right Side			Right Front Ditch		Right Back Ditch		Left Front Ditch		Left Back Ditch						**Anthropogenic Source Presence (1) / Not Observed (0)			
Xing ID	Structure		Erodibility	Road Use	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Ditch Substrate	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Erosion Potential	Delivery	Road Score	Ditch Score	Combined Score	* Risk	*Industrial*	*Cattle*	*Recreation*	Photos
81	4	-	0.9	0.95	0.7	1	0.7	1	0.9	0.6	0.9	0.6	0.9	0.6	0.85	0.6	0.85	1.30	2.05	**0.56**	**Low to Moderate**	1	0	0	P9150029 - P9150039
82	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	1	1	0	IMGP2456P27-IMGP2457P28
83	4	-	0.9	0.95	0.6	0.9	0.6	0.9	0.9	0	0.85	0	0.9	0	0.85	0	0	1.00	0.00	**0.17**	**Very Low**	1	0	0	P9170001 - P9170013
84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	1	1	1	-
86	5	600	0.9	0.92	0.6	0.85	0.6	0	0.9	0	0.9	0	0	0	0.9	0.6	0.9	0.51	0.54	**0.18**	**Very Low**	1	1	1	P9150012 - P9150028
87	5	600/400	0.95	1	0.6	0.95	0.6	0.95	0.9	0	0.85	0	0.9	0	0.85	0	0.9	1.11	0.00	**0.19**	**Very Low**	1	0	0	P9170092 - P9170103
88	5	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	1	1	0	P9170085 - P9170091
89	5	500/700	0.9	1	0.6	0.9	0.6	0.9	0.9	0	0.85	0	0.9	0	85	0	0.9	1.03	0.00	**0.17**	**Very Low**	1	1	1	P9170104 - P9170128
90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
91	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	-
92	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	-
93	5	800	0.9	0.93	0.6	0.8	0.6	0.8	0.9	0	0.8	0.6	0.8	0	0.8	0.7	0.9	0.88	1.11	**0.33**	**Low**	1	0	0	IMGP2464P35-IMGP2465P36
94	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	1	1	0	P9170016 - P9170024
95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	1	1	0	-
96	5	800	0.9	0.95	0.6	0.9	0.6	0.9	0.9	0.6	0.8	0.7	1	0.6	0.8	0.6	0.8	1.00	2.09	**0.52**	**Low to Moderate**	1	1	0	IMGP2460P31-IMGP2462P33
97	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	-
98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
99	NCD																	0.00	0.00	**0.00**	**Very Low**	-	-	-	-
100	5	0.5	0.85	0.93	0.6	0.8	0.6	0.8	0.85	0	0.8	0	0.8	0	0.8	0	0.8	0.86	0.00	**0.14**	**Very Low**	1	1	0	IMGP2454P25-IMGP2455P26
101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
102	4	1m x .3 m	0.9	0.93	0.7	0.8	0.7	0.8	0.9	0	0.8	0	0.8	0	0.8	0	0.8	1.03	0.00	**0.17**	**Very Low**	1	1	0	IMGP2430P1-IMGP2438P8
103	5	1.2m x 2 m	0.9	1	0.6	0.9	0.6	0.9	0.9	0.6	0.85	0.6	0.8	0.6	0.8	0.6	0.8	1.03	1.90	**0.49**	**Low to Moderate**	1	1	0	IMGP2346P16-IMGP2347P18
104	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	-
105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	-
106	5	0.9	0.9	0.95	0.7	0.8	0.7	0.8	0.9	0.6	0.8	0.6	0.8	0.6	0.8	0.6	0.8	1.04	1.87	**0.49**	**Low to Moderate**	1	1	0	IMGP2444P14-IMGP2455P15

Powers Creek SCHR Summaries cont'd.																										
					Running Surface					Ditch																
Sites Surveyed					Left Side		Right Side			Right Front Ditch		Right Back Ditch		Left Front Ditch		Left Back Ditch						**Anthropogenic Source Presence (1) / Not Observed (0)			
Xing ID	Structure		Erodibility	Road Use	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Ditch Substrate	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Erosion Potential	Delivery	Road Score	Ditch Score	Combined Score	* Risk	*Industrial*	*Cattle*	*Recreation*	Photos
107	5	1m x .3 m	0.9	0.95	0.7	0.8	0.7	0.8	0.9	0.7	0.8	0	0.8	0.7	0.8	0	0.8	1.04	1.06	**0.35**	**Low**	1	1	0	IMGP2441P11-IMGP2443P13
108	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	
109	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	
110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	
111	5	400	0.9	1	0.6	0.8	0.6	0.8	0.9	0.6	0.9	0.6	0.8	0.6	0.9	0.6	0.8	0.91	1.99	**0.48**	**Low to Moderate**	1	1	0	IMGP2449P19-IMGP2451P21
112	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	IMGP2466P37
113	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	-
114	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	-
115	5	0.6	0.9	1	0.6	0.8	0.6	0.8	0.9	0.6	0.8	0.6	0.8	0.6	0.8	0.6	0.8	0.91	1.87	**0.46**	**Low to Moderate**	1	1	0	IMGP2452P22-IMGP2454P24
116	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
117	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
118	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
119	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
121	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
122	5	400	0.9	0.93	0.6	0	0.6	0.9	0.85	0.6	0.85	0.6	0	0.6	0.85	0.6	0.9	0.45	1.48	**0.32**	**Low**	1	1	1	P9110040 - P9110048
123	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
124	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
125	8	0	0.85	0.92	0	0.85	0	0.85	0.9	0	0.85	0	0.85	0	0.85	0	0.85	0.00	0.00	**0.00**	**Very Low**	0	1	0	P9110027 - P9110039
126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	-
127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	-
128	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	**0.00**	**Very Low**	-	-	-	-
129	5	400	0.9	0.95	0.6	0.9	0.6	0.9	0.85	0	0.9	0.6	1	0	0.85	0.7	1	1.00	1.30	**0.38**	**Low**	1	1	0	P91410152 - P9110160
130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
131	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
132	7	0	0.9	0.9	0.6	1	0.6	1	0.85	0	0.85	0.6	0.9	0	0.85	0.6	0.9	1.09	1.08	**0.36**	**Low**	1	1	1	P9110064 - P9110080
133	4	-	0.85	0.9	0	0.85	0	0.85	0.9	0	0.85	0	0.85	0	0.85	0	0.9	0.00	0.00	**0.00**	**Very Low**	1	1	1	P9110090 - P9110103
134	7	0	0.9	0.9	0.6	1	0.6	1	0.85	0	0.85	0.6	0.9	0	0.85	0.6	0.9	1.09	1.08	**0.36**	**Low**	0	1	1	P9110081 - P9110089
135	5	500	0.9	0.93	0.6	0.9	0.6	0	0.9	0.6	0.9	0	1	0.6	0.9	0.6	1	0.54	1.63	**0.36**	**Low**	1	1	0	P9110049 - P9110062

Powers Creek SCHR Summaries cont'd.																										
					Running Surface					Ditch																
Sites Surveyed					Left Side		Right Side			Right Front Ditch		Right Back Ditch		Left Front Ditch		Left Back Ditch						**Anthropogenic Source Presence (1) / Not Observed (0)				
Xing ID	Structure		Erodibility	Road Use	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Ditch Substrate	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Erosion Potential	Delivery Potential	Erosion Potential	Delivery	Road Score	Ditch Score	Combined Score	* Risk	*Industrial*	*Cattle*	*Recreation*	Photos
136	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
137	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
138	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
139	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
141	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-
142 (B1)	5	800	0.85	0.93	0.6	0.9	0	0	0.85	0	0	0	0	0	0.85	0.6	0.85	0.54	0.51	**0.18**	**Very Low**	1	1	1	P9110006 - P9110026
143 (B2)	5	800	0.85	0.95	0.6	0.9	0.6	0.9	0.85	0	0.9	0	0.9	0	0.9	0	0.9	0.98	0.00	**0.16**	**Very Low**	1	1	1	P9110162 - P9110178
144 (B3)	5	1000 (x3)	0.9	0.95	0.6	0.9	0.6	0.9	0.85	0	0.9	0	0.9	0	0.9	0	0.9	1.00	0.00	**0.17**	**Very Low**	1	1	0	P9110265 - P9110269

Appendix C

Stream Crossing Assessment Procedure

The Stream Crossing Quality Index:
A Water Quality Indicator for Sustainable Forest Management

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Abstract
One of the goals of sustainable forest management is the maintenance of water quality. One of the biggest forestry related impacts to water quality is accelerated sediment delivery to streams at road crossings. Good road building and maintenance practices will minimize the erosion hazard and related negative impacts to water quality. Based on this, several divisions of Canadian Forest Products Ltd. have recognized that a good water quality indicator should be based on a field-survey that evaluates effectiveness of controlling accelerated erosion and sediment delivery at stream crossings. This has led to the development of a sediment source hazard assessment procedure called the Stream Crossing Quality Index (SCQI). The procedure evaluates and scores the size and characteristics of road-related sediment sources at crossings and the potential for the eroded sediment to reach the stream environment. A high score infers that there is a significant erosion problem which may in turn cause sediment-related water quality problems. The SCQI is a good management tool because it identifies specific problems in the landscape and provides future direction to minimize them.

Introduction

One of the goals of sustainable forest management (SFM) is to implement best management practices so that water quality is maintained within natural ranges of variability (CCFM 2000). Within an SFM framework there is a requirement for a set of clearly defined performance criteria and indicators to gauge progress towards the goal of maintaining water quality. Designing a meaningful indicator to address this goal is not an insignificant challenge. Forestry activities are an extensive type of disturbance that generally cover many hundreds of square kilometers and numerous watersheds. Forest harvesting activities can affect many water quality characteristics, but increased sediment loading has been identified as one of the most detrimental (MacDonald *et al.* 1991). Several forest harvesting activities can cause increased erosion rates and sediment delivery to aquatic environments. However, road building and maintenance, particularly at stream crossings, is the dominant point source for forestry-generated sediment in landscapes where landslides are not a dominant process (Beaudry 2001, Beschta 1978, Bilby *et al. 1989,* Cafferata and Spittler 1998) (Figure 1).

Figure 1. Ditches, road surfaces and cut/fill slopes can be significant sources of sediment at stream crossings.

Within any given watershed, there may be dozens or even hundreds of stream crossings, each being a potential source of sediment. Although the impacts of forestry disturbances on water quality can be relatively small and subtle at any given point within a watershed, the sum of the impacts may add up to significant downstream cumulative effects. If good road building and maintenance practices can minimize (or eliminate) accelerated erosion and sediment delivery to streams, then negative impacts to water quality will be minimized. Based on this assumption, several B.C. and Alberta Divisions of Canadian Forest Products Ltd. (Canfor) have decided that a good water quality indicator should be based on a field survey that evaluates how well accelerated erosion and sediment delivery are being controlled in the vicinity of stream crossings. The stream crossing quality index (SCQI) was developed as an SFM indicator to provide a meaningful measure of the potential hazard that a stream crossing may present for water quality.

Development and Refinement of the SCQI

In 2000, the Prince George Division of Canfor considered a variety of SFM indicators for use in its forestry certification program. As an indicator of protection of water quality, Canfor was considering the concept of the stream crossing density used in the BC Watershed Assessment Procedure (WAP), i.e. # of stream crossings counted on a map divided by the watershed area (BC Government 1995). We suggested that although the stream crossing density is very simple and inexpensive to measure, a better alternative would be to complete a field assessment of the crossing and score its real potential for accelerated erosion and sediment delivery to the stream. Such a procedure would provide accurate field-based information and would be a large improvement on the stream crossing density concept that assumes that all crossings produce the same amount of sediment to the stream environment. Thus was born the concept of the SCQI, a field-based hazard assessment of the potential for accelerated erosion and sediment delivery at stream crossings.

The origins of the SCQI methodology were based on the concepts of the sediment source survey (SSS) presented in version 2.01 of the WAP (B.C. Government 1999). In the WAP, the road-related SSS is used as an indicator of the level of hazard that forestry roads have for delivering sediment to the aquatic ecosystem and thus potentially reducing water quality. One of the major refinements provided by the SCQI methodology is the systematic description and evaluation of all individual sediment sources at a crossing that have the potential to deliver sediment to the stream network.

As an SFM indicator, the basic assumption that underlies the SCQI is that if erosion and sediment delivery in the vicinity of stream crossings is minimized, through proper road building and maintenance practices, then the potential impact to water quality from increased sediment delivery is also minimized (Figure 2). The SCQI is a useful management tool because it provides a clear incentive to improve erosion and sediment control (ESC) practices in the vicinity of stream crossings since it documents practices that create a water quality hazard and those that minimize it. Improvement of forest management practices over time is a clearly explicit goal of all forest certification schemes. The Canadian Council of Forest Ministers (CCFM 2000) clearly recognizes the potential negative impacts to water quality associated with road crossings. In their sustained forest management program they have defined one of the aquatic indicators as being: “percentage of forest area having road construction and stream crossing guidelines in place” (Indicator 3.2.2).

Figure 2. Hay mulch used effectively for both erosion and sediment control.

Method

The execution of an SCQI survey begins with the mapping of current access within the watershed and planning an effective way of completing a 100% sampling of stream crossings with that watershed. In many situations 100% sampling is not possible but at least 90 to 95% sampling is usually achieved. Stream crossings are accessed using trucks, quads or by walking.

Once the surveyor has arrived at the stream crossing, the procedure begins by evaluating the size and characteristics of all sediment sources that can potentially contribute sediment to the aquatic environment. Each stream crossing is divided into eight distinct and independent “elements”. These include four road ditches that run into the stream, two road fill slopes and two road running surfaces, each of these potential sediment sources being assessed independently. The sediment source hazard score for each individual element is a product of the *erosion potential* and the *delivery potential* of that source. The *erosion potential* is calculated as a function of several factors which are:

1. the size of the sediment source
2. the soil texture of the source
3. the slope gradient of the source
4. the percentage of non-erodible cover
5. the level of road use (for road surface) and
6. the shape of the ditch (for ditch elements)

The cornerstone of the SCQI procedure is the measurement of the size of the sediment source (m^2). The other variables act as modifiers to increase or decrease the hazard associated with the size of the sediment source (Appendix 1). Each of the modifiers is scaled from 0 to 1, where zero (0) represents a condition that would eliminate the hazard (e.g. coarse gravel, no slope or an abandoned fully revegetated road) and one (1) represents a condition that would maximize the hazard (e.g. silt, slope greater than 15% or active mainline). The size of the sediment source (m^2) is multiplied by the value of each modifier to generate an *erosion potential* score for the particular element being assessed. This is then multiplied by the *delivery potential* (scaled from 0 to 1) to obtain the element score. The *delivery potential* represents a qualitative assessment of the percentage of the eroded material that will likely reach the stream. A series of definitions are provided to assist in the determination of the delivery potential, e.g. 0 means that there is no connection between the erosion source and the stream and no delivery is possible, 0.5 means that the delivery is indirect and filtered through trees grasses and/or sediment control structures, 0.8 is used when sediment is weakly filtered through a sparse grass cover and most of the material reaches the stream and 1.0 means that delivery is evident, direct and uninterrupted with no obvious depositional zones before reaching the stream. The total score for the crossing is simply the sum of the eight scores for each of the individual elements. The final SCQI crossing score generates five hazard classes as defined in Table 1.

Table 1. Correspondence between SCQI score and hazard class.

Score	Sediment Source Hazard Class
0	None
0< score <0.4	Low
0.4 ≤ score ≤ 0.7	Moderate
0.7 < score ≤ 1.6	High
Greater than 1.6	Very High

The values for each of the modifiers are based on the concepts and values developed for the Revised Universal Soil Loss Equation (RUSLE) presented by Wall *et. al*. (2002). The universal soil loss equation was initially developed by Wischmeier and Smith (1965). The objective of the RUSLE was to provide a quantitative tool to assess the potential for soil erosion at a given site.

The SCQI procedure is a useful management tool because it identifies the specific location and magnitude of erosion problems. If scores are high, the crossing can be improved through remedial actions and current practices can be altered to avoid high scores in the future. If scores are low, then it shows that good erosion and sediment control practices are being implemented and by extension water quality is being protected. The procedure has been presented to numerous field practitioners in a series of field workshops and received a favourable response because it clearly identifies the specific location of the problem and the practice that generates the problem.

It is important to note that the SCQI method was designed to be quick (about 15 minutes per crossing) so that a maximum number of crossings can be assessed, thus providing a better landscape level perspective. The SCQI has evolved over the last three years from its initial structure based mostly on subjective assessments. The procedure is now more objective, repeatable and transparent, using values based on the RUSLE.

It must be noted that the whole SCQI approach is largely a conceptual model, based on the general concepts of the RUSLE, and was not developed based on an experimentally acquired set of empirical relationships. It provides a score in a consistent way that can be compared with other crossings in a given watershed and evaluated for how "good" or "bad" the crossings are. The SCQI does not provide a quantitative evaluation (e.g. kg/ha/yr) of exactly how much sediment is entering the stream or what the impact of that sediment has on the stream environment. The SCQI approach tells you where there are erosion and sediment control problems, how frequent in the landscape those types of problems appear and provides a basis of information to judge the magnitude of the problem and how to fix it so that impacts to water quality will be minimized. It is important to emphasize that the SCQI focuses exclusively on the evaluation of the sediment source and the potential of that sediment to reach a stream (i.e. the “hazard”). It does not in any way attempt to measure, evaluate or score the sensitivity of the stream or the impact of increased sediment delivery to the aquatic environment (i.e. it does not evaluate “consequence”). Work is currently underway to develop a methodology to evaluate the sensitivity of a stream to increased sediment loads. If this effort is successful, it could be combined with the SCQI approach to produce a true risk assessment procedure.

Evaluation of the SCQI Procedure

In 2001 an evaluation program was initiated by Canfor, Prince George Division, to test the validity of the SCQI procedure by monitoring stream turbidity levels at selected stream crossings. Several hundred stream crossings ranging over a variety of topographic and climatic conditions across the Prince George Timber Supply Area (TSA) were surveyed in the spring of 2002 to generate a population of possible sampling sites. From this database, we eliminated all large streams (relatively rare occurrence in the landscape) and streams that were too small to be instrumented. Our objective was to focus the measurements on "small" streams with an average bankfull width of 1 to 3 metres (Figure 3) since about 90% of stream crossings in the Prince George region occur on small streams (P. Beaudry and Associates Ltd. 2002). The crossing scores were then grouped into one of three hazard levels, i.e. low, moderate or high (see Table 1). A random selection of seven stream crossings, per hazard level, was selected to serve as our experimental sample (i.e. total of 21 crossings).

Figure 3. Example of size of stream monitored and instrument set-up for measurement of turbidity. Note water is turbid as a result of rainstorm.

Each crossing was instrumented with electronic continuous turbidity sensors in an "upstream-downstream" experimental design. The assumption behind this approach is that the difference between the upstream and downstream measurements can be attributed to the erosion and sediment delivery at the stream crossing (i.e. induced turbidity). An example of the induced turbidity results, obtained from one of the monitored crossings, is provided in Figure 4. The objective was then to compare the measured induced turbidity with the hazard score generated by the SCQI procedure to see if there was an acceptable correlation.

Both the provincial (Government of BC 2001) and federal (DFO 2000) governments have produced some guidelines that relate increases in turbidity to the risk to the aquatic environment. We used an adaptation of these guidelines to define five hazard classes for our SCQI scores. The classes range from no hazard to very high hazard (Table 2). As an example, a hazard level of "high" is defined as a site that generates enough sediment to the stream that it will consistently cause an increase in turbidity between 70 NTU and 130 NTU, when significant rainfall occurs. The maximum induced turbidity for every rainfall-turbidity event measured during the field season was tabulated and crossing averages were calculated. The event-frequency distributions for each crossing were analyzed and the right tail 10% of the distributions were removed to account for extreme events occurring at very low frequencies (i.e. one large event over the entire field season) that might skew the average. It is also our opinion that most of these extreme events do not actually represent increases in turbidity, but rather an anomaly caused by debris passing over the turbidity sensor, and thus should be removed from the database.

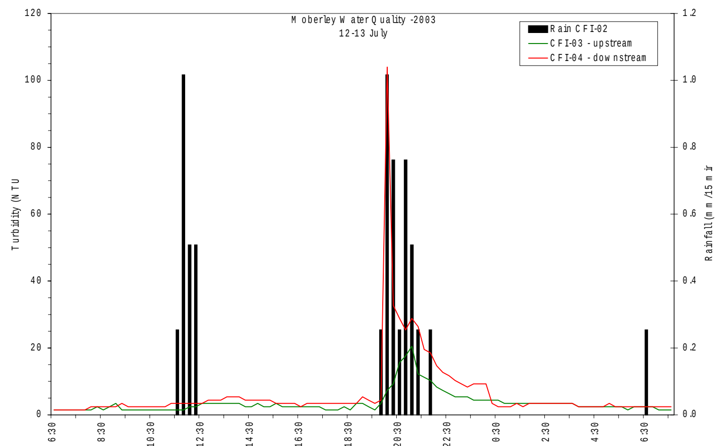

Figure 4. Example of measurement of induced (red) turbidity, where the downstream turbidity peak is about 80 NTU greater than the upstream peak (green).

Results from the 2002 turbidity measurements generally showed a good correspondence between the assessed hazard level and induced turbidity measurements. The validation process also identified some specific problems with the procedure and improvements were made accordingly during the 2003 field season. One of the major refinements was the introduction of an objective measurement of the actual size of each of the sediment sources, rather than the previously used subjective assessment of the "level of erosion". This refinement provided an opportunity to generate a more quantitatively-based score with no pre-defined upper limit. The individual crossing scores for each of the 21 sites were related to the average induced turbidity of the entire monitoring site to determine if the SCQI score was a reasonable predictor of induced turbidity.

Table 2. Levels of risk associated with increases in turbidity (adapted from Fisheries and Oceans, 2000)

Induced Turbidity (NTU)	Risk to Fish Habitat	Sediment Source Hazard Class
0	None	None
1 to 8	Low	Low
8 to 70	Moderate	Medium
70 to 130	High	High
>130	Unacceptable	Very High

The regression analysis has shown that indeed the relationship is quite good, at least for SCQI score less than 3.5 (Figure 5). Two of the monitored crossings had scores greater than 8, and yet did not generate turbidity levels as high as the scores suggest they should have. These two points were not included in the dataset as they render the linear relationship insignificant. Based on these two "outliers", it appears that the SCQI procedure needs to be further refined for situations where the sediment source is very large. Currently, we think that as a sediment source increases in size (e.g. > 150 m^2) and the complexity and variability of the characteristics of the sediment source also increase, it becomes increasingly difficult to predict how much of the eroded material will actually reach the stream.

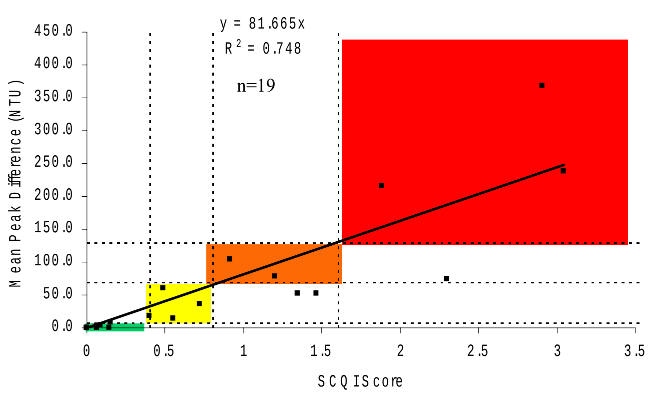

Figure 5. Relationship between SCQI score and induced turbidity (mean peak difference NTU).

Further improvements to the SCQI procedure are necessary to accommodate the complexities of larger sediment sources. Another related issue is that the upper limit of the induced turbidity scale is dependent on the sediment saturation potential of the volume of water transported in the stream and when the water is very dirty the relationship between delivery of sediment and increases in turbidity may no longer be linear.

In Figure 5, we added coloured rectangles to illustrate the areas on the graph that represent the different hazard rating classes used in the SCQI procedure and how these relate to the expected range of induced turbidity. These results clearly suggest that the procedure is very good at predicting induced turbidity (within the expected range) for the low and moderate hazard levels, and although somewhat less accurate, also good for the high and very high classes (up to scores of about 3). The three points that are outside of the coloured areas all represent the same situation, i.e. the SCQI score is predicting a situation that is a little bit worse than the actual problem, but only for situations where a significant problem already exists. Thus, for a proportion of crossings surveyed, the SCQI procedure may be overstating the size of a problem where a significant problem exists, but it accurately predicts the size of the problem where the problems are small or non-existent. Consequently, we believe that the SCQI is a good tool to identify the proportion of problem and non-problem crossings across the landscape and is thus a good SFM indicator to address the goal of protection of water quality. Work is continuing on the development and refinement of this procedure.

Hazard rating = Low.
Turbidity < 8 NTU.
SCQI < 0.4.

Hazard rating = Moderate.
8 NTU < Turbidity < 70 NTU.
0.4 ≤ SCQI ≤ 0.7.

Hazard rating = High.
70 NTU < Turbidity < 130 NTU.
0.8 ≤ SCQI ≤ 1.6.

Hazard rating = Very High.
Turbidity > 130 NTU.
SCQI > 1.6.

Conclusions

Canfor has completed SCQI surveys over a wide range of their operating areas as part of their forest certification programs (well over 3,000 crossings). These include areas within central and northern B.C. and eastern Alberta. Several independent certification audits have identified this approach as a meaningful and well structured process to objectively document the extent of effective erosion control practices in the landscape. Road construction and maintenance supervisors find this a useful tool because it locates and identifies specific problems and provides direction for remedial action with the built-in incentive of obtaining a better SCQI score in the future. The SCQI tool is also useful to show improvements in erosion control practices over time, a requirement of many forestry certification schemes.

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Appendix 1. **Modifier score values** (subject to change with further validation work)

Table A1. Sediment Source Area Scores

Size (m^2)	Score	**Size (m^2)**	Score
0	0	**50-100**	2
0-1	0.1	**100-150**	3
1-2	0.2	**150-200**	4
2-4	0.3	**200-250**	5
4-8	0.4	**250-300**	6
8-14	0.5	**300-350**	7
14-20	0.6	**350-400**	8
20-26	0.7	**400-450**	9
26-32	0.8	**450-500**	10
32-40	0.9	**500-550**	11
40-50	1	**550-600 etc**	12, etc

Table A2. Soil texture class modifier scores.

Soil Textural Class	***Score/Compactness Level***		
	M	***L***	***H***
Very Fine Sand	1.0	0.90	0.80
Silt	0.97	0.86	0.77
Silt -Loam	0.88	0.80	0.70
Silty Clay Loam	0.74	0.70	0.60
Clay	0.51	0.46	0.41
Sandy Loam	0.3	0.27	0.24
Medium Sand	0.16	0.14	0.13
Coarse Sand	0.014	0.013	0.011
Stones and Gravel	.007	0.006	0.006

Table A3. Slope modifier scores.

Gradient	**Score**
>12%	1.0
9-12%	.97
7-9%	.85
5-7%	.75
3-5%	0.60
1-3%	0.25
<1%	0.15
away from stream	0.00

Table A4. Road use level modifier scores.

Road Use Level	***Score***
Active mainline	1.0
Active branch line	0.99
Moderate activity (occasional grading)	0.95
Low activity (no grading, x-ing structure still present)	0.96
De-activated (xing structures removed)	
-used extensively by 4 wheelers	0.98
-minor use by 4 wheelers	0.92
-no 4 wheeler use evident	0.85
Abandoned – no access (too much veg)	0.80

Table A5. Ditch shape modifier scores

Ditch shape	***Score***
"V"shape-V.steep&V.steep	1.55
"V"shape-Steep&V.steep	1.45
"V"shape-Gentle&V.steep	1.35
"V"shape-Flat&V.steep	1.10
"V"shape-Steep&Steep	1.35
"V"shape-Gentle&Steep	1.25
"V"shape-Flat&Steep	1.00
"V"shape-Gentle&Gentle	1.15
"V"shape-Flat&Gentle	0.90
"U"shape-V.steep&V.steep	1.40
"U"shape-Steep&V.steep	1.30
"U"shape-Gentle&V.steep	1.20
"U"shape-Flat&V.steep	1.10
"U"shape-Steep&Steep	1.20
"U"shape-Gentle&Steep	1.10
"U"shape-Flat&Steep	1.00
"U"shape-Flat&Gentle	0.90
"U"shape-Flat&Flat	0.85
"U"shape-Gentle&Gentle	1.00

Appendix D

Drinking Water Source Protection Memorandum of Understanding, Southern Interior Drinking Water Team Membership

MEMORANDUM OF UNDERSTANDING

BETWEEN

Ministry of Agriculture and Lands
Ministry of Energy, Mines and Petroleum Resources
Ministry of Environment
Ministry of Community Services
Ministry of Health
Ministry of Forests, Range and Housing
Ministry of Transportation
Office of the Provincial Health Officer
Fraser Health Authority
Interior Health Authority
Northern Health Authority
Vancouver Coastal Health Authority
Vancouver Island Health Authority

REGARDING

INTER-AGENCY ACCOUNTABILITY AND COORDINATION ON DRINKING WATER PROTECTION

VERSION 7: OCTOBER 16 · 2006

1 Background

1.1 In March, 2002 the Province adopted an *Action Plan for Safe Drinking Water in British Columbia* which sets out a multi-faceted and multi-agency approach to the protection of public health as it relates to drinking water quality.

1.2 The Action Plan sets out government's commitment to an integrated approach for drinking water protection. The ADMs' Committee on Water and the Directors' Inter-Ministry Committee on Drinking Water are the facilitating bodies for the Action Plan.

1.3 The Action Plan also states the accountability of different ministries for the coordination of source protection, land use planning and infrastructure:

(a) The Ministry of Environment will be responsible for source water quality standards, monitoring, compliance and enforcement, and resource ministries will continue to be responsible for protecting drinking water sources under their legislated mandates.

(b) The Ministry of Agriculture and Lands will work with communities to help make appropriate land use decisions that carefully consider drinking water protection.

(c) The Ministry of Community Services will work in partnership with federal and local governments to help ensure required infrastructure is in place.

1.4 The *Drinking Water Protection Act* (DWPA) is one element of the Action Plan. It is the principal statute concerning drinking water protection.

1.5 Many other statutes deal with matters of relevance to drinking water protection, and through which government seeks to achieve various legislative objectives related to matters such as resource extraction, land use and environmental practices. Many of these statutes contain their own provision for drinking water protection, most particularly source water protection.

1.6 The role of drinking water officers under the DWPA complements the roles of statutory officials under other statutes, and the DWPA contains numerous provisions to balance respect for other statutory mandates while at the same time ensuring that public health protection respecting drinking water is achieved.

1.7 The DWPA requires the Provincial health officer to perform an oversight and accountability function regarding the administration of the DWPA. This includes a duty to report to the Minister of Health and potentially to Cabinet any situation that

(a) in the opinion of the Provincial health officer, significantly impedes the protection of public health in relation to drinking water, and

(b) arises in relation to the actions or inaction of one or more ministries, government corporations or other agents of the government.

1.8 In light of all the above, the parties to this MOU have entered into this understanding with a view to ensuring each agency's accountability in respect of their actions concerning drinking water protection.

1.9 This MOU is not intended to address issues of consultation and/or coordination between the parties to this agreement and federal agencies.

2 Guiding principles

2.1 In fulfilling the terms of this MOU the parties[1] will be governed by the following guiding principles:

Constructive – The parties will foster constructive working relationships.

Proactive – The parties will work to ensure that any potential concerns regarding inter-agency cooperation are identified in a proactive manner and that steps are taken to avoid them, or to address them as soon as possible.

Information sharing – Each agency, through either the ADMs' or the Directors' Committees, will share with the other agencies information relevant to the matters covered by the MOU. This will include:

- sharing of information respecting the development or amendment of legislation, policy, practices, etc. that may affect drinking water protection (in advance where possible)
- sharing information from the ADMs' and Directors' Committees with officials[2] responsible for implementing the regional protocols (discussed below)
- clear communication regarding the goals and purposes of the various regulatory mandates, particularly those which are results based.

Respect for mandates – All of the parties will recognize and respect the mandates and statutory decision-making functions of the other parties.

Partnership – The parties will give effect to this MOU in manner that reflects a sense of partnership and shared responsibility for drinking water protection and risk management.

Efficiency and Practicability – The parties seek to ensure that the goals of the MOU are achieved in a manner that minimizes the need for the development of additional referrals systems and other activities that will impose significant resource requirements on staff. The parties will also support an appropriate degree of flexibility among regions in implementing the regional protocols (discussed below), so as to reflect the particular needs and circumstances of the various regions. Communication and referrals on resource activities that are part of the regional protocol will be based on best available information at the time of the application.

[1] "Parties" means the agencies as represented on the ADMs' Committee on Water.
[2] i.e., officials from any agency.

3 Establishment of regional drinking water teams

3.1 For each region, a regional drinking water team will be established, with representation from each agency that is party to this agreement, as well as representation from local governments that wish to participate.

3.2 The members of the regional drinking water teams will serve as the principal contact for discussion of regional inter-agency drinking water issues.

3.3 Each health authority will designate a drinking water officer to serve as a coordinator of the respective regional drinking water teams. The coordinator will maintain an up-to-date contact list for members of the regional drinking water team and make that available to all team members.

3.4 Regional drinking water teams may communicate by whatever means is considered the most efficient and effective and all may meet, in whole or in part, at times mutually agreeable to all the members. The coordinator for each team will schedule at least one meeting each year to which all members of the regional drinking water teams will be invited to attend. If a subset of the membership meets, the coordinator of the drinking water team will communicate the outcome of the meeting to all members within a week of the meeting.

4 Commitment to the establishment of regional protocols

4.1 Each of the Parties to this MOU will participate in the development of regional protocols to give operational effect to the purposes of this MOU.

4.2 For the purposes of the regional protocols, the regions will be defined by the geographic areas of each of the five health authorities, as set out in Appendix A. Due to the absence of coincident boundaries among the agencies, discussions may need to occur among multiple offices to identify appropriate committee membership for each regional protocol.

4.3 The regional protocols will be developed by the regional teams, and they will set out the types of decisions that should as a general rule be the subject of some form of coordination or consultation, recognizing however that the decision whether or not to undertake inter-agency coordination in any particular case is ultimately a matter for the discretion of officials[3] (unless some legal requirement to do so exists).

4.4 Regional drinking water teams may develop whatever form of protocol they determine appropriate to achieve the goals and meet the requirements of this MOU, but they are encouraged to consider using the form of protocol set out in Appendix B, and to consider coordination regarding those activities set out in Appendix C that are relevant to that

[3] i.e., officials from any agency.

region. Regional protocols may include strategies for engaging local stakeholders interested in community drinking water issues.

4.5 Regional protocols must be developed for each region no later than October, 2007. A copy of such protocols must be provided to the Directors' Inter-agency Committee on Drinking Water when it is completed, and at any time it is amended.

4.6 Nothing in this MOU or any regional protocol developed under it is intended to be legally binding, and neither creates any legal rights or duties. Moreover, nothing in this MOU or a regional protocol shall be taken to limit or constrain the exercise of discretion by a party in respect of a statutory power or decision.

5 Commitment to include drinking water coordination activities within each ministry and agency

5.1 Each agency that is party to this MOU will undertake the necessary internal steps to ensure its commitment to inter-agency coordination of drinking water issues and the implementation of this MOU.

6 Process for review and performance management

6.1 On or before June 30 of each year, beginning June 2008, each drinking water team will provide to the Directors' Inter-agency Committee on Drinking Water a summary report of its activities for the previous fiscal year.

6.2 The Directors' Inter-agency Committee on Drinking Water will review the reports of the regional drinking water teams and provide an annual overview report to the ADMs' Committee on Water.

6.3 The Directors' Inter-agency Committee may at any time provide recommendations to the regional drinking water teams, with a view to ensuring the effective and efficient implementation of this MOU.

7 Process for dealing with disagreements or unresolved issues

<u>Disagreements or unresolved issues in implementation of regional protocols</u>

7.1 Responsibility for addressing disagreements or unresolved issues concerning implementation of the regional protocols rests with the regional team members and their supervisors as appropriate. If however the regional teams draw to the attention of the Directors' Inter-agency Committee on Drinking Water any disagreements or unresolved issues arising in relation to the implementation of a regional protocol, the Directors' Committee may review and discuss the matter, with a view to recommending to the ADMs' Committee any amendments to this MOU that may prevent such occurrences from occurring in future.

Disagreements or unresolved issues in implementation of this MOU

7.2 If any disagreements or unresolved issues arise in the implementation of this MOU , the relevant members of the Directors' Inter-agency Committee on Drinking Water will discuss the matter and attempt to resolve it. If that does not prove successful, those parties will refer the matter to the relevant members of the ADMs' Committee. In the event that the Assistant Deputy Ministers of the agencies concerned are unable to resolve the disagreement in a mutually acceptable manner, they will refer to matter to the Deputy Provincial health officer, who may consult with the parties with a view to resolving the matter.

8 Costs

8.1 Each agency will bear its own costs of undertaking the activities associated with this MOU.

Grant Parnell, Assistant Deputy Minister, Crown Land Administration, Ministry of Agriculture and Lands	Dec 8/06. Date
Harvey Sasaki, Assistant Deputy Minister, Risk Management and Competitiveness, Ministry of Agriculture and Lands	06.12.08 Date
Eric Partridge, Assistant Deputy Minister, Mining and Minerals, Ministry of Energy, Mines and Petroleum Resources	06. 11. 07 Date
Jim Mattison, Assistant Deputy Minister, Water Stewardship, Ministry of Environment	2006.12.11 Date
Dale Wall, Assistant Deputy Minister, Ministry of Community Services	2006. 12. 14 Date

Andrew Hazlewood, Assistant Deputy Minister, Population Health and Wellness, Ministry of Health	Nov 03/06. Date
Jim Snetsinger, Chief Forester, Ministry of Forests, Range and Housing	Dec 12/06 Date
for Peter Milburn, Assistant Deputy Minister, Highways Department, Ministry of Transportation	06/12/4 Date
Dr. Perry Kendall, Provincial Health Officer, Office of the Provincial Health Officer	31/Oct/2006 Date
Dr. Roland Guasparini, Chief Medical Health Officer, Fraser Health Authority	24 January 2007 Date
Dr. Rob Parker, Chief Medical Health Officer, Interior Health Authority	Dec 28/2006 Date
Dr. David Bowering, Chief Medical Health Officer, Northern Health Authority	Jan 9/2007 Date
for Dr. John Blatherwick, Chief Medical Health Officer, Vancouver Coastal Health Authority	02/NOV/2006 Date
Dr. Richard Stanwick, Chief Medical Health Officer, Vancouver Island Health Authority	Jan/17/07 Date

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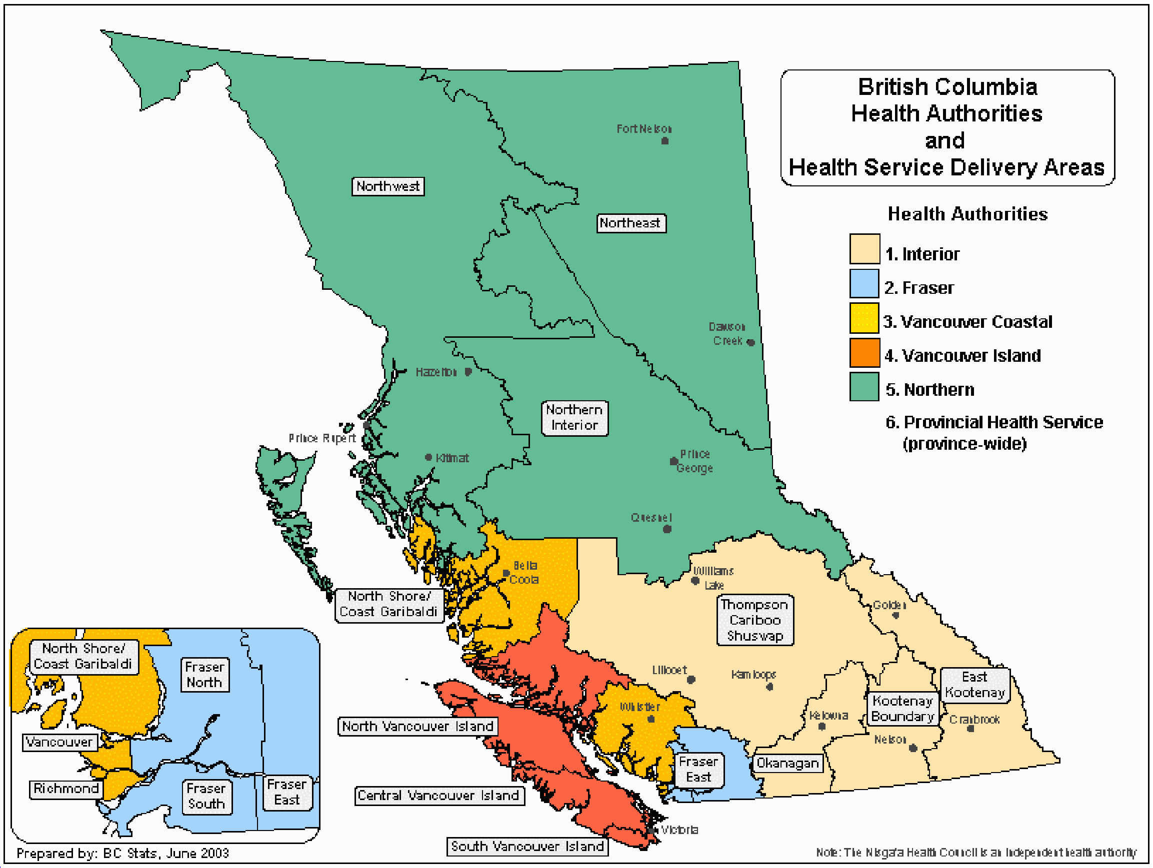
Appendix A

Map of Health Authorities



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Appendix B

Suggested template for Regional Protocols

REGIONAL DRINKING WATER TEAM
The members of the _____ Regional Drinking Water Team, including contact information and the names of alternate members, are set out in the attached table.

Each agency will bear the costs of its participation in the Regional Drinking Water Team and the meetings referred to below.

MEETING SCHEDULE
Regular meetings
The Regional Drinking Water Team will hold a regular meeting at least *[SPECIFY FREQUENCY]*. Such meetings will be arranged by *[SPECIFY DRINKING WATER OFFICER OR OTHER PERSON]* upon at least 3 weeks notice to all the other parties. All parties will send a representative to such meetings.

Parties will attempt to participate in regular meetings in person, but may arrange to participate by conference call if personal attendance is not practicable.

The team members will rotate the responsibility for organizing and hosting regular meetings, and in preparing minutes that result from such meetings.

Additional meetings
Additional meetings may be held at any time that any of the team members wishes to propose and organize such a meeting. In providing notice of additional meetings, the person proposing the meeting should give as much notice as is reasonable in the circumstances, and must indicate the purpose of subject matters(s) to be addressed in the meeting. The other parties may attend such additional meetings at their discretion.

Parties may participate in additional meetings in person or by teleconference.

Matters for consideration at meetings
The Regional Drinking Water Team will establish its own agendas for regular and additional meetings. This may include, but is not limited to:

- Discussion of routine consultation and activities taken pursuant to the protocol (see next section)

- Proactive identification of drinking water protection issues that may warrant inter-agency consultation and coordination even before a specific statutory decision or function is contemplated

- Consultation with local stakeholders interested in community drinking water/watershed protection issues

- *[Others?]*

MATTERS FOR WHICH COORDINATION AND CONSULTATION WILL BE ROUTINELY CONSIDERED

Staff of the parties to the protocol will, as a general matter, apply the principles set out in the following chart concerning inter-agency consultation when exercising their statutory functions relevant to drinking water protection.

However, in any case where an official from an agency determines that some other approach is more appropriate on the facts of any particular case, he or she may adopt the principles that are considered appropriate.

[Insert chart based on proposal set out in Appendix C of MOU[4], but tailored to needs and circumstances of the region.]

DEALING WITH DISAGREEMENT OR UNRESOLVED ISSUES

In the event issues arise about which the team members disagree, or cannot be resolved, and which have potential impact on drinking water protection and related matters, the team members involved will refer the matter to their immediate supervisors for consideration and direction.

If as a result of the referrals discussed above a team members considers that a matter is not resolved to the mutual satisfaction of the agencies concerned, he or she must advise the person from that agency that is a member of the Directors' Inter-agency Committee on Drinking Water.

COMMUNICATION STRATEGIES

The parties will adopt the following communication techniques and strategies to ensure open and effective communication regarding drinking water protection issues:

- Copies of this protocol and the related MOU will be provided to [specify]
- The parties will share information in a timely way regarding developments within their respective agencies that are relevant to the matters covered in this protocol.
- *[Others?]*

[4] Appendix C is a table including agencies' decisions related to drinking water and the associated legislation.

PREPARATION OF AN ANNUAL REPORT

8.2 On or before June 30, beginning June 2008, of each year, each drinking water team will provide to the Directors' Inter-agency Committee on Drinking Water a summary report of its activities for the previous fiscal year. Responsibility for preparing the report will rotate annually among members of the Regional Drinking Water Team.

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Appendix C

Please note: THE FOLLOWING EXAMPLE IS FOR ILLUSTRATIVE PURPOSES ONLY. This chart is intended to be completed by the regional drinking water teams. The actual contents of the chart would need to be discussed and considered by relevant ministry staff.

Chart of key statutory decisions for which regional inter-agency coordination may be appropriate

ACT	DECISION OR ACTION BEING CONSIDERED OR TAKEN	AGENCIES WITH WHICH TO COORDINATE* "c" - consider consulting and pursue as appropriate "i" - share for information purposes "r" - request input before decision-making (*May be departed from where the official concerned views the type or degree of coordination set out below is not appropriate in the circumstances)									
		DWO	MAL	MCS	MEMPR	MOFR	Local Gov't	MOE	MOT	PHO	
Dike Maintenance Act											
Drinking Water Protection Act	Construction permits										
	Operating permits										
	Hazard Abatement Orders										
	Public reporting requirements (e.g., boil water notices)										
	Assessment (technical committee)										
	Assessment response plan										
	Emergency Plans										
	DWPP (request for)										

ACT	DECISION OR ACTION BEING CONSIDERED OR TAKEN	AGENCIES WITH WHICH TO COORDINATE* "c" - consider consulting and pursue as appropriate "i" - share for information purposes "r" - request input before decision-making (*May be departed from where the official concerned views the type or degree of coordination set out below is not appropriate in the circumstances)									
		DWO	**MAL**	**MCS**	**MEMPR**	**MOFR**	**Local Gov't**	**MOE**	**MOT**	**PHO**	
Environmental Assessment Act											
Environment Management Act	Pollution abatement order										
	Pollution prevention orders										
	Pollution information order										
	Waste discharge (Schedule 1)										
	Area-based planning										
	Substitution orders										
	Remediation orders (CS)										
	Animal Waste Control Regulation										
	Organic Matter										
	Recycling Regulation										
Farm Practices Protection Act	Farm bylaws through the local government act										
Fisheries Act											
Fish Protection Act	Riparian Area Regulation										
Forest Act	Tenure/licence award										

ACT	DECISION OR ACTION BEING CONSIDERED OR TAKEN	AGENCIES WITH WHICH TO COORDINATE* "c" - consider consulting and pursue as appropriate "i" - share for information purposes "r" - request input before decision-making (*May be departed from where the official concerned views the type or degree of coordination set out below is not appropriate in the circumstances)									
		DWO	MAL	MCS	MEMPR	MOFR	Local Gov't	MOE	MOT	PHO	
Forest Practices Code	Road construction permits										
	Watershed Assessments in community watersheds(until 2006)										
	Forest Development Plan Approval										
	Cutting permits										
	Setting water quality objectives (known)										
Forest and Range Practices Act	Forest Stewardship Plans										
	Range Stewardship Plans										
	Range Use Plan										
	Woodlot Regulation										
	Community Watershed designation (MSRM)										
	Community Watershed objectives (MWLAP)										
Geothermal Resources Act	Tenure (MEM)										
	Exploration and Development Approvals (MEM?)										

ACT	DECISION OR ACTION BEING CONSIDERED OR TAKEN	AGENCIES WITH WHICH TO COORDINATE* "c" - consider consulting and pursue as appropriate "i" - share for information purposes "r" - request input before decision-making (*May be departed from where the official concerned views the type or degree of coordination set out below is not appropriate in the circumstances)									
		DWO	MAL	MCS	MEMPR	MOFR	Local Gov't	MOE	MOT	PHO	
Integrated Pest Management Act	Service license approvals (including conditions)										
	Directives and orders										
	Selective permitting										
Land Act	Plan approvals and objectives										
	Fee simple										
Land Amendment Act	Water Objectives (MSRM)										
Lands, Parks and Housing Act	Same powers under both (Land Act LWBC) Land Act: application-based, proactively look for opportunities (e.g., sale of Crown land)										
	Crown Land Allocation Framework (CLAF)										
	Recreational Lot Sales Strategy										
Livestock Act	Fencing										
	Land clearing										
Local Government	Regional Growth Strategies										

ACT	DECISION OR ACTION BEING CONSIDERED OR TAKEN	AGENCIES WITH WHICH TO COORDINATE* "c" - consider consulting and pursue as appropriate "i" - share for information purposes "r" - request input before decision-making (*May be departed from where the official concerned views the type or degree of coordination set out below is not appropriate in the circumstances)									
		DWO	MAL	MCS	MEMPR	MOFR	Local Gov't	MOE	MOT	PHO	
Act/ Community Charter	OCPs										
	Subdivsion zoning bylaws										
	Variances										
	Borrowing powers regarding water DWO determines non-potable										
	Liquid Waste Management Plans										
	Amendments to municipal boundaries										
	Adoption of OCP										
	Adoption of Zoning Bylaws										
Local Government Grants Act	Infrastructure funding										
Local Services Act	Subdivision regulation (unserviced areas within RDs, approval by MOT)										
Mines Act	Sand and gravel, placer, and hardrock. mining										
	Approvals and permits										

ACT	DECISION OR ACTION BEING CONSIDERED OR TAKEN	AGENCIES WITH WHICH TO COORDINATE* "c" - consider consulting and pursue as appropriate "i" - share for information purposes "r" - request input before decision-making (*May be departed from where the official concerned views the type or degree of coordination set out below is not appropriate in the circumstances)									
		DWO	MAL	MCS	MEMPR	MOFR	Local Gov't	MOE	MOT	PHO	
	Remediation orders										
	Dumps										
	Dams										
	Remediation for acid rock drainage										
	Gravel pits										
Parks Act	Water supplier provisions										
	Park Use Permits										
Petroleum and Natural Gas Act	Tenure (MEM)										
	Exploration and Development Approvals										
Range Act											
Transportation Act	New highway development										
	Road maintenance standards and agreements for 10 years										
	Permit to construct works on Crown lands										
	Transportation of Dangerous Goods										
Water Act	Water licences										
	Dam building										

ACT	DECISION OR ACTION BEING CONSIDERED OR TAKEN	AGENCIES WITH WHICH TO COORDINATE* "c" - consider consulting and pursue as appropriate "i" - share for information purposes "r" - request input before decision-making (*May be departed from where the official concerned views the type or degree of coordination set out below is not appropriate in the circumstances)									
		DWO	MAL	MCS	MEMPR	MOFR	Local Gov't	MOE	MOT	PHO	
	Storage										
	Water Users' Communities										
	Section 9 approvals: "changes in and about a stream"										
	Issuance of permits over Crown land (pipes);										
	Dam and dyke approvals. (Potential for flooding of intake works for wells or surface intakes.)										
	Flood proofing of wells										
	Well construction										
	Water Management Plans (MSRM/MWLAP)										
Water Utilities Act	Excludes sections strictly for energy utilities										
	Certificate of public convenience and necessity										
Water Utilities Commission Act											

ACT	DECISION OR ACTION BEING CONSIDERED OR TAKEN	AGENCIES WITH WHICH TO COORDINATE* "c" - consider consulting and pursue as appropriate "i" - share for information purposes "r" - request input before decision-making (*May be departed from where the official concerned views the type or degree of coordination set out below is not appropriate in the circumstances)									
		DWO	MAL	MCS	MEMPR	MOFR	Local Gov't	MOE	MOT	PHO	
Weed Act	Spraying										
Wildfire Act											
Wildlife Act											

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