REPORT

Town of Grande Cache

Source Water Protection Plan: Victor Lake and Grande Cache Lake

March 2015

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List of Abbreviations

AB	Alberta
AE	Associated Engineering Alberta Ltd.
ESRD	Alberta Environment and Sustainable Resource Development
DWSP	Drinking Water Safety Plan
EPEA	Environmental Protection and Enhancement Act
N	Nitrogen
P	Phosphorus
STMBA	Source to Tap, Multi-Barrier Approach
SWPP	Source Water Protection Plan

1 Introduction

1.1 BACKGROUND

The Town of Grande Cache (Town) is located in the Rocky Mountains of western Alberta, approximately160 km northwest of Jasper National Park on Highway 40 (Figure 1-1). The population of the Town, according to the last (2011) census, is 4,319 persons. In addition to the Town's population, the Grande Cache Institution includes a 243 inmate capacity. Municipal and Federal Census reports for the Town for years between 1975 and 2011 suggest an average historical annual growth rate of 0.6%. The Town has recently approved a 1.0% growth rate for their current infrastructure projects, and a 25 year projected population of 5,950 (2039). The most recent Municipal Development Plan provides for an increase of up to 9,000 people for the ultimate build-out (Town of Grande Cache 2012).

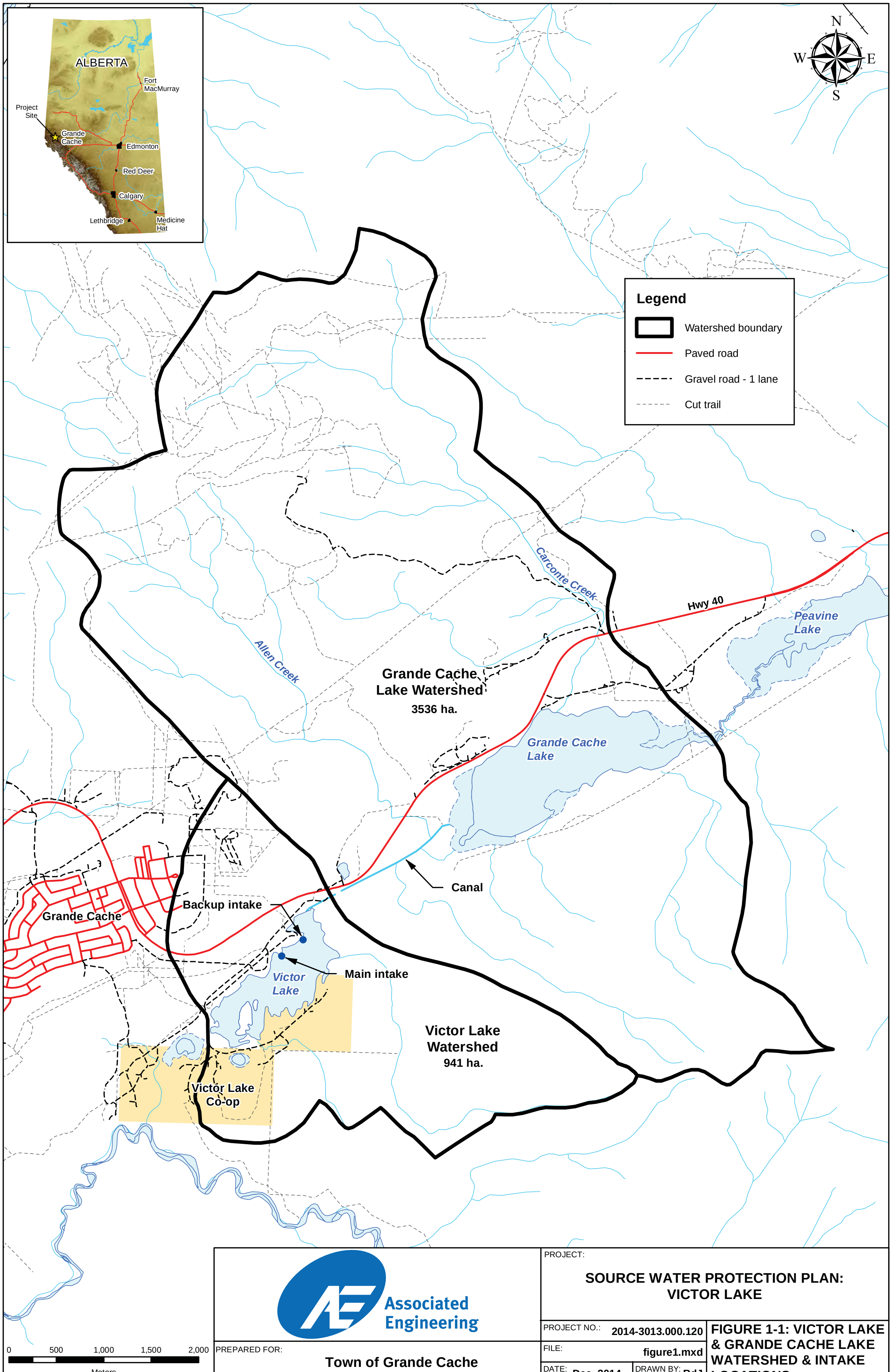
The Town's source of domestic water is Victor Lake, which is located about 1.9 km southeast of the Town centre. The water is pumped in through an intake off the north shore of the lake (Figure 1-1), and pumped up hill for treatment and storage in a reservoir. Victor Lake is connected by a channel to Grande Cache Lake that was reportedly constructed in 1975-1976 to manage water levels in Victor Lake, although the reason for the works (termed a "diversion ditch") is not stated in the provincial authorization (Licence of Occupation 5793). The Town's raw water diversion license includes both Victor Lake and Grande Cache Lake. It is understood that the flow in the diversion ditch is predominantly from Victor Lake to Grande Cache Lake, but the lake levels are very similar and flow in the opposite direction reportedly happens on occasion. As a result, it is likely that the diversion ditch enables the raw water diversion to withdrawn from the combined volume of both lakes.

In 2013, the Town completed a Drinking Water Safety Plan (DWSP) following the procedures described in <u>A Guidance Framework for the Production of Drinking Water Safety Plan</u> (Government of Alberta 2012) and using the standard DWSP MS-Excel template. The DWSP (Approval no. 720-02-04) assessed the full "Source to Tap" spectrum of the Town's water supply system – Source Risks, Treatment Risks, Network Risks, and Customer Information. The risk summary for the Grande Cache DWSP is provided in Appendix A. The Source Protection component considered approximately 36 potential risks, assigned each a likelihood score and a consequence score, and screened out the risks that were judged not to be a "key risk" (i.e. those with a Risk Score of <32). Twelve (12) source risks were judged to be "key risks" (Risk Score ≥32), warranting further action and intervention (Appendix A).

Following review of the DWSP results, the Town decided to proceed with a Source Water Protection Plan (SWPP) for the Victor Lake water source. The goal of the SWPP is to supplement the DWSP by determining steps that should be taken to reduce the key risks to the Victor Lake source and to set priorities for implementation. In 2014, the Town retained Associated Engineering Alberta Ltd. (AE) to develop the SWPP.

A draft version of this SWPP report was submitted to the Town for review in December 2014. On February 17, 2015, AE presented the report's finding and recommendations to the Town's Mayor and Council and at two public meetings (held at 1:00 pm and 7:00 pm). Feedback from the public meeting was considered in preparation of this final report.

The area addressed by the SWPP is the watersheds draining to Victor and Grande Cache Lakes (Figure 1-1 and Map 1 (attached in Appendix B; henceforth "the plan area"). As noted above, the predominant flow direction between the lakes is from Victor Lake to Grande Cache Lake. Therefore risks in the Victor Lake watershed are considered a higher priority for action (refer to Section 1.4).



Associated Engineering

PREPARED FOR:
Town of Grande Cache

PROJECT:
SOURCE WATER PROTECTION PLAN: VICTOR LAKE

PROJECT NO.: 2014-3013.000.120

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DRAWN BY: BdJ

FIGURE 1-1: VICTOR LAKE & GRANDE CACHE LAKE WATERSHED & INTAKE LOCATIONS

1.2 REGULATORY AND "MULTIPLE BARRIER" FRAMEWORKS

The goals of the Alberta Water for Life Action Plan include Goal #1 - *Albertans are assured their drinking water is safe* (Government of Alberta 2009). The requirement for development and implementation of DWSPs and, if needed, SWPPs, emerged as one of the tools to achieve that goal. The framework for source protection planning is based on the idea that drinking water safety requires steps to be taken "from source to tap" (i.e. in all aspects of the drinking water system) and that multiple barriers should be in place to minimize the risk of contamination reaching the water consumer.

The Multiple Barrier approach is "an integrated system of **procedures, processes and tools** that collectively prevent or reduce the contamination of drinking water from source to tap in order to reduce risks to public health" (CCME 2004). In the case of source protection, the options available as barriers include:

- Policies, rules, and procedures to avoid the generation of contamination;
- Physical works to prevent contamination from moving through the source to surface intakes or water supply wells;
- Land use planning and guidelines to minimize risks to drinking water;
- Monitoring of water quality and activities; and
- Education around land use activities in watersheds or aquifer capture zones used for drinking water supply.

The barriers introduced through source protection augment the natural barriers (or filters) that are already in place in watersheds or aquifers. Figure 1-2 illustrates this concept.

1.3 SWPP DEVELOPMENT METHODS

The Grande Cache SWPP was based on the Source to Tap Guidelines published by the Canadian Council of Ministers of the Environment (CCME 2004), adapted to reflect the Alberta DWSP process and the specific needs of the Grande Cache waterworks system. The steps that were taken to develop the SWPP were:

1. Review of the DWSP results, key risks, and recommended interventions.
2. Delineation of the watershed area, as described in Section 1.1.
3. Assembly and review of relevant background information including topographic maps, geology and soils maps and reports, land disposition information, land use maps including transportation corridors, and water quality data. Development of a watershed "working map" showing land use and known locations of the key risks.
4. Telephone discussions with watershed stakeholders and persons familiar with the lakes and their watersheds in order to gather information on land and water use activities and issues of concern.
5. A site visit completed on August 13 and 14, 2014, by Hugh Hamilton and Fiona Mulvenna of the study team. The site visit was used to undertake an inventory of the "key risk" contaminant sources and refine the map of their locations, assess the condition of the risk sites that were accessible, and to speak with a number of stakeholders. Those stakeholders were:

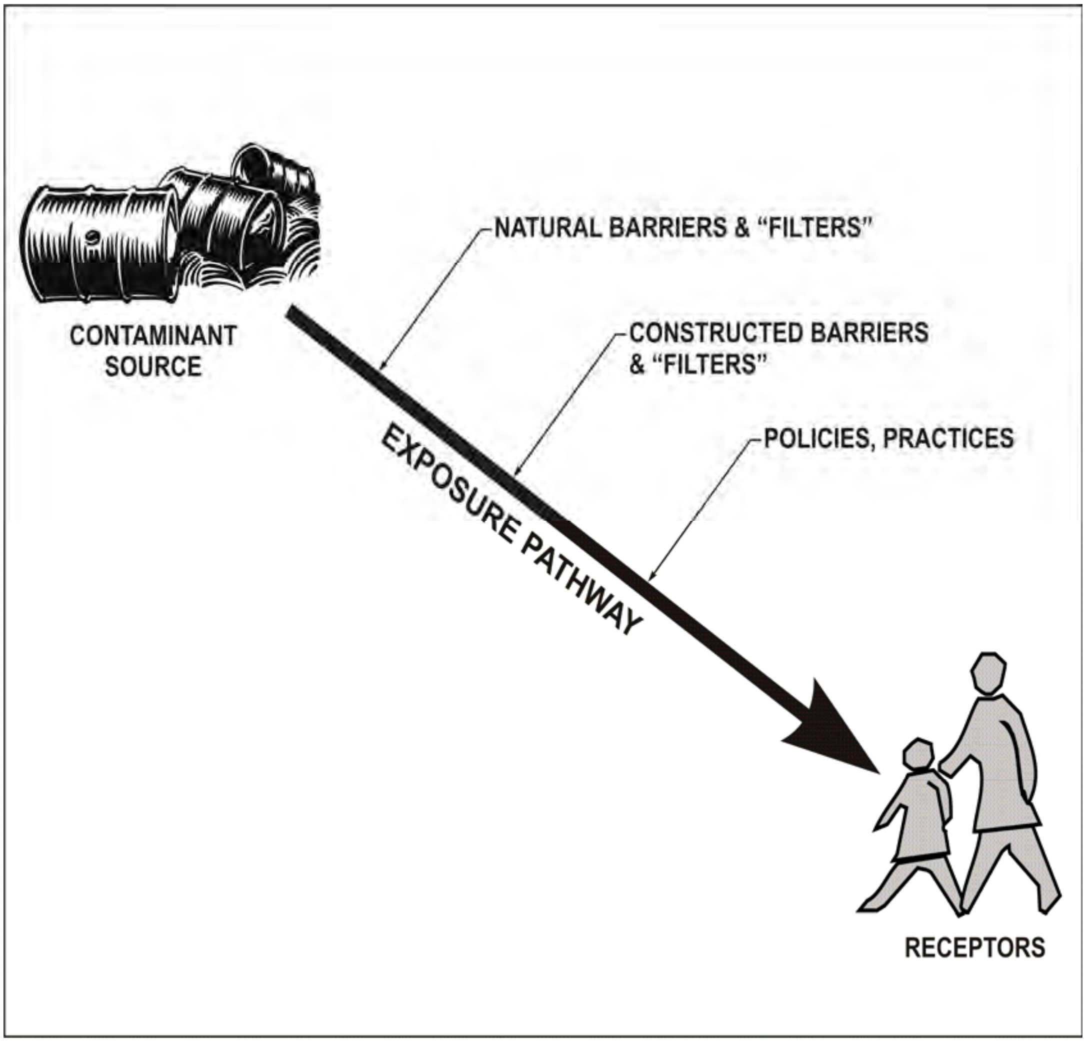
   a. Shauna Cooney (Forest Officer, ESRD),
   b. Billy McDonald (President of Susa Creek Co-op),
   c. Tom McDonald (President of Grande Cache Lake Co-op),
   d. Landon Delorme (President of Victor Lake Co-op) and
   e. Jason Delorme (Secretary/Treasurer for Muskeg Seepee Co-op and Town Employee who works at the water treatment plant). Following the meeting at the Aseniwuche Winewak Nation office, Landon Delorme and Jason Delorme accompanied the study team on a tour of the Victor Lake Co-op.
6. Evaluation of source water quality data (i.e. raw water from Victor Lake) including comparisons to Canadian and Alberta Drinking Water Guidelines and determination of the frequency of guideline exceedances.
7. Refining the DWSP Risk Scores, where warranted, based on the information review, site visit, and initial stakeholder discussions.
8. Development of a draft list of risk mitigation management options for each of the 12 source risks (i.e. key risks).
9. For each management option, assessment of its likely effectiveness to protect source water quality and the technical, jurisdictional, and financial feasibility of the option.
10. Preliminary ranking of management options.
11. Preparation of this draft report.

Refinement of the DWSP risk ratings (Task #7) was based on the likelihood that the contaminants associated with each of the 12 source risks will reach the intake in sufficient quantities or concentrations to pose a risk to human health. The assessment of likelihood in the DWSP was largely based on the potential for the hazard to occur. The potential for the hazard to be significant at the water intake was characterized based on the presence or absence of existing barriers using the following <u>contaminant transport potential</u> (CTP) criteria:

- **Very high** – direct entry to Victor Lake or within 5 m of the lake shore (e.g. a spill of gas from a motorized vehicle or an outfall pipe in the lake);
- **High** – direct surface connection to either Victor or Grande Cache Lakes (e.g. runoff from Hwy. 40 in spring snowmelt; spill into Grande Cache Lake or a permanent tributary) <u>and/or</u> an activity taking place within 5 m to 30 m of high water mark (e.g. spills at boat launch or people going to the toilet at day use camp sites);
- **Moderate** – travel in groundwater from >30 m and ≤1,000 m of the lake <u>and/or</u> in an ephemeral tributary;
- **Low** – travel in groundwater from >1,000 m distance.

To refine the DWSP risk levels, these CTP ratings were scored as: Very High – 1.0; High – 0.75; Moderate – 0.5, and Low – 0.25. These scores were then multiplied by the Risk scores from the DWSP (refer to Section 2.0) to determine the revised risk rating (Section 5.1).

Figure 1-2
Role of Multiple Barriers in Source Protection



2 Drinking Water Safety Plan Summary

Table 2-1 provides the likelihood, consequence, and risk[1] scores for the key risks from the DWSP, presented in order from highest risk to lowest risk. The complete risk result table from the DWSP is provided in Appendix A. The further assessment of the key risks in this report consolidates the risk categories related to operation of the intake and other infrastructure into a single category (Source Infrastructure and Systems - Section 4.9) because they are managed directly by the Town, whereas the other key risks are outside the Town's control or there is shared responsibility.

Table 2-1
Grande Cache Source Risk Categories and Scores from DWSP

Hazard	Type of Contamination/Risk	Likelihood	Consequence	Risk
Transportation corridors	Chemical (e.g. road salt, spills)	16	8	128
Flooding, heavy rain	Sediment (turbidity)	8	8	64
In-ground septic systems	Microbial	8	8	64
Wildlife in watershed	Microbial	8	8	64
Mining activity	Metals, hydrocarbons, sediment	4	8	32
Forestry activity[2]	Sediment, colour, metals, nutrients, hydrocarbons	8	4	32
Pump failure	Loss of supply from pump failure	8	4	32
Recreational activity	Microbial, hydrocarbons	8	4	32
Water availability	Loss of supply from water main breaks or leaks	8	4	32
Wildfire	Chemical, sediment	8	4	32
Power loss	Loss of supply from loss of power	16	2	32

Note: The possible likelihood scores range from 1 (most unlikely) to 16 (almost certain). The possible consequence scores range from 1 (insignificant) to 16 (catastrophic).

[1] The terms likelihood, consequence, and risk are defined along with the scoring system in the Alberta DWSP template at http://environment.alberta.ca/apps/regulateddwq/DWSP.aspx
[2] The DWSP includes two risk categories for forestry. They have been combined here into one because they are related and received the same risk score of 32.

3 Watershed Delineation and Description

3.1 WATER INTAKE LOCATION AND DESCRIPTION

The main drinking water intake for the Towns drinking water system is located approximately 10 m out from the north shore of Victor Lake (Figure 1-1 and Map 1), at a depth of about 3 m below the average annual ice level. The pump house is located on the lake shore, less than 10 m back from the high water mark. This is the second intake that has been built on the lake. The original intake is located about 260 m east and now serves as the back-up intake. Its pump house is also situated close to the shoreline and the intake is at a depth of about 2 m below ice level.

The water is pumped from the intake upslope to the main Town site to a reservoir on the east side of town.

3.2 WATERSHED DELINEATION AND SOURCE PROTECTION AREA

As described in Section 1.1, construction of the diversion ditch between Victor Lake and Grande Cache Lake in 1975-1976 changed the nature of the connection between the two lakes. In addition, a weir at the outflow of Grande Cache Lake influences the water levels in both lakes. As a result, the watershed contributing to the Victor Lake source is the catchment areas of both Victor Lake and Grande Cache Lake (Figure 1-1 and Map 1). This area is referred to as the plan area in this report.

The Victor Lake catchment has an area of 941 ha, while the Grande Cache Lake catchment area is 3,536 ha, giving a total plan area of 4,477 ha (or 44.8 km^2).

3.3 GENERAL WATERSHED DESCRIPTION

3.3.1 Biophysical Characteristics

The plan area is located in the Rocky Mountain Natural Area, Montane Sub-Region. The elevations of Victor Lake and Grande Cache Lake are about 1,110 m (3,650 feet) above sea level, while the maximum elevations are 1,840 m (6,050' – Mount Louie) and 1,980 m (6,520' – Grande Mountain) respectively, giving a maximum relative relief of 870 m. Most of the plan area is forested with the exception of relatively small settled areas within Victor Lake watershed (see Section 3.3.2). Common tree species include lodgepole pine, white spruce, and trembling aspen. There is an extensive wetland area in the flats between the two lakes where black spruce is present.

The daily average temperatures at Grande Cache in January (coldest month on average) and July (warmest month) are -7.1 ºC and 13.3 ºC, respectively (based on 1971-2010 climate normals; Environment Canada 2014). Conditions are generally cool, with the minimum daily temperature falling below zero 209 days per year. Normal annual precipitation is 539.7 mm, with 355.5 mm falling as rain. Snowfall averages 192 cm.

3.3.2 Land Use

Figure 3-1 depicts the public land use dispositions within the Grande Cache Lake and Victor Lake watersheds. More than 90% of the land within both watersheds is Crown land, although the Town's northeastern boundary extends into the Victor Lake watershed.

Residential development is generally restricted to the Town limits, as the province has a general policy of not allowing residential development within the "Green Zone" (Infrastructure Systems, 2002). The Town and the Municipal District (MD) of Greenview are in agreement with this policy, although there has been a demand in recent years for 3-5 acre country residential lots (Infrastructure Systems, 2002). The Town and MD of Greenview are therefore working with the Provincial authorities to establish a country residential development node within the proximity of the Town's limits in order to satisfy these requests (Infrastructure Systems, 2002). The current Municipal Land Use Plan allows for a doubling of the Town's population (i.e., from approximately 4000 to 9000 residents), therefore new houses could potentially be built within the Victor Lake watershed (Town of Grande Cache, 2012).

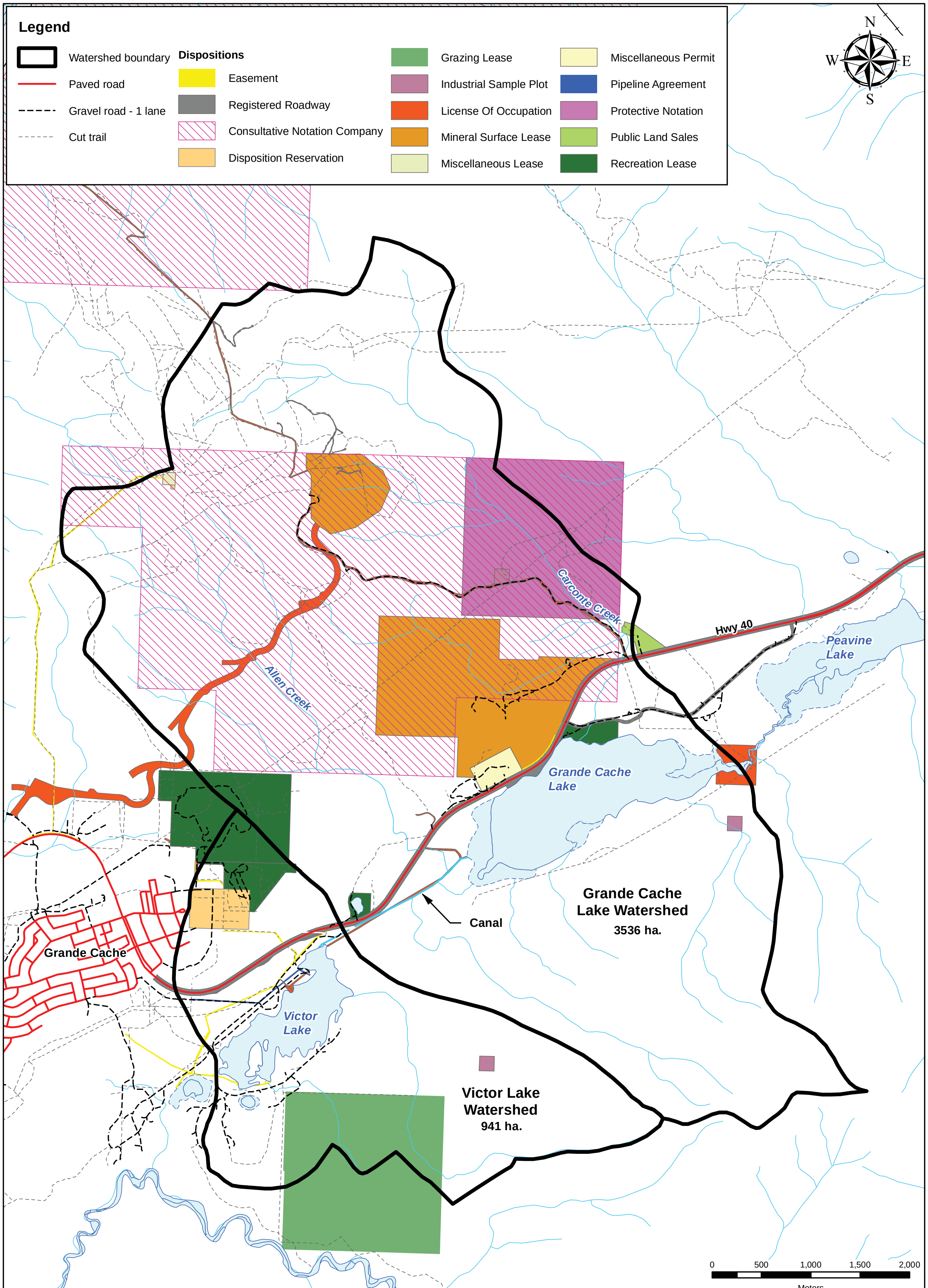
The Town was initially established as a community to support the extraction of coal by McIntyre Mines (Municipal Development Plan, 2012). Summit Coal (owned by Milner Power) has a disposition for an area located within the Grande Cache Lake watershed (located approximately 4.5 km to the northwest of Grande Cache Lake), which is currently in development as they have drilled a number of test wells. Grande Cache Coal also holds dispositions within the area, although their operations are outside of the Victor Lake and Grande Cache Lake watersheds.

Forestry is another significant industry that accounts for land use within the area. Foothills Forestry holds a disposition within the Grande Cache Lake watershed. This disposition forms part of Foothill Forestry's Forestry Management Unit (FMU) called E8.

Recreation is an important land use within the Grande Cache Lake and Victor Lake watersheds. There are many trails for motorized activities including all-terrain vehicles and snowmobiles (Town of Grande Cache, 2012). Fishing, canoeing, kayaking, camping and wildlife viewing are popular pastimes within the Grande Cache Lake and Victor Lake watersheds (Town of Grande Cache, 2012). The shores of Victor Lake and Grande Cache Lake are popular recreational areas. All-terrain vehicle (ATV) use is currently permitted in both watersheds, although the Town plans on reviewing ATV use in the community and surrounding area in order to balance access, sustainability and safety (Town of Grande Cache, 2012).

Highway 40 (Hwy 40), which is maintained by Alberta Transportation, is a major paved highway located in the Grande Cache Lake and Victor Lake watersheds. As can be seen from Figure 3-1, there are a number of secondary resource roads in the plan area that have been built and are maintained by the mining and forestry companies operating within both watersheds.

Land use planning within the Victor Lake and Grande Cache Lake Co-ops is undertaken by each community, although the Aseniwuche Winewak Nation of Canada helps to coordinate land use planning within each co-op and between the two co-ops.



Associated Engineering

PREPARED FOR:

Town of Grande Cache

PROJECT:

SOURCE WATER PROTECTION PLAN: VICTOR LAKE

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DATE: Dec. 2014	DRAWN BY: BdJ

FIGURE 3-1: LAND USE IN THE VICTOR LAKE & GRANDE CACHE LAKE WATERSHEDS

There is negligible agricultural activity within the Grande Cache area due to climatic and topographic constraints.

3.4 SOURCE WATER QUALITY SUMMARY

3.4.1 Victor Lake and Grand Cache Lake Water Quality Data

A search of the provincial water quality monitoring database for Victor and Grande Cache Lakes was completed on our behalf by ESRD. There is relatively limited data for these lakes. However, measurements of dissolved oxygen, water temperature, and specific conductance along a surface to bottom profile have been obtained on occasion, but most of the data are from 2011-2012 when it appears that ESRD undertook an investigation of water quality in the two lakes. Sampling for that study took place in June, August, and October 2011 and March 2012. Temperature and conductivity profiles were obtained at several locations and a composite sample from the length of the water column was obtained and analyzed for a range of variables. A similar survey took place in 1993 in Grande Cache Lake, but there was only a single composite sample[3].

Table 3-1 provides a summary of the water quality results from the 2011 composite samples in Victor Lake. Table 3-2 shows the same data for Grande Cache Lake, as well as the single composite sample obtained in 1993.

The 2011-2012 Victor Lake survey indicated an alkaline pH (average 8.34) with a relatively high level of dissolved minerals, as reflected by high alkalinity and total dissolved solids values. The average hardness was 165 mg/L, which is considered “hard” (McCutcheon et al. 1993). Total suspended solids (TSS) concentrations (called non-filterable residue in the AESRD database) were low at less than 2 mg/L. It is likely that some portion of the TSS was organic material (e.g. phytoplankton).

The total phosphorus concentrations (0.019 to 0.035 mg/L), Secchi depth, and chlorophyll *a* concentrations indicate that Victor Lake is meso-eutrophic[4] (CCME 2004). Ammonia-N was detectable but within the Alberta guideline for aquatic health protection (at pH 8.3 and all temperatures) (Government of Alberta 2014). Nitrate and nitrite were non-detectable. Fecal coliforms and *E. coli* were also non-detectable. All of the metals in Table 3-1 met the applicable Canadian drinking water quality guideline (Health Canada 2014).

The 2011 water quality monitoring results for Grande Cache Lake (Table 3-2) are very similar to those from Victor Lake, reflecting the hydraulic connection between them and the similar watershed geology and vegetation cover. Neither *E. coli* nor fecal coliforms were detectable in any sample, and the dissolved metals met the Canadian drinking water guidelines.

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[3] ESRD’s site numbers for the sampling locations are: Victor Lake - #AB07GA0046 and Grande Cache Lake - #AB07GA0040.

[4] Meso-eutrophic lakes have moderate levels of dissolved nutrient and an intermediate level of biological productivity. They fall between oligotrophic lakes (low productivity) and eutrophic lakes (high productivity).

Table 3-1
Victor Lake Water Quality Summary: June – October 2011

Variable	Jun	Aug	Oct	Mean
Routine, Anions & Cations				
pH (Lab)	8.28	8.45	8.28	**8.34**
Specific Conductance (Lab) µS/cm	355	335	331	**340**
Total Dissolved Solids (TDS) mg/L	185	170	185	**180**
Non-filterable Residue[5] (NFR) mg/L	2.0	1.6	1.6	**1.7**
Total Alkalinity (CaCO3) mg/L	175	164	172	**170**
Total Hardness (CaCO3) mg/L	172	149	174	**165**
Bicarbonate (HCO3) mg/L	213	193	210	**205**
Carbonate (CO3) mg/L	<1	4	<1	**1.7**
Chloride Dissolved (Cl) mg/L	10	10	10.4	**10.1**
Sulphate Dissolved (SO_4) mg/L	<3	<3	<3	**<3**
Magnesium Dissolved (Mg) mg/L	20.5	20.8	21.2	**20.8**
Sodium Dissolved (Na) mg/L	14.6	14.2	15.3	**14.7**
Potassium Dissolved (K) mg/L	1.4	1.1	1.2	**1.2**
Fluoride Dissolved (F) mg/L	0.15	0.14	0.15	**0.15**
Secchi Disk Transparency m	3.6	3.8	3.0	**3.5**
Nutrients				
Phosphorus Total (TP) mg/L	0.019	0.019	0.035	**0.024**
Phosphorus Total Dissolved (TDP) mg/L	0.011	0.008	0.004	**0.008**
Chlorophyll-a µg/L	5.6	2.1	5.3	**4.3**
Ammonia (NH_3-N) mg/L	0.006	0.011	0.031	**0.016**
Nitrate + Nitrite as N (NO_3+NO_2 -N) mg/L	<0.005	<0.005	<0.005	**<0.005**
Nitrite (NO_2-N) mg/L	<0.002	<0.002	<0.002	**<0.002**

[5] Also called Total Suspended Solids (TSS).

Variable	Jun	Aug	Oct	Mean
Total Kjeldahl Nitrogen (TKN) mg/L	0.55	0.57	0.64	**0.59**
Total Nitrogen (TN) mg/L	0.55	0.57	0.64	**0.59**
TN:TP Ratio	29	30	18	**26**
Dissolved Organic Carbon (DOC) mg/L	7.5	8.1	8.0	**7.9**
Biological				
Total coliforms (no./100 mL)	18	-	-	18
Fecal coliforms (no./100 mL)	<10	<10	<10	<10
E. coli (no./100 mL)	<10	<10	<10	<10
Microcystin, total ug/L	0.06	0.09	<0.05	0.06
Selected Metals				
Aluminum dissolved ug/L	0.336	2.18	0.772	**1.10**
Arsenic dissolved ug/L	0.231	0.228	0.0708	**0.18**
Boron dissolved ug/L	19.7	15.2	18.8	**17.90**
Cadmium dissolved ug/L	<0.002	<0.002	0.0026	**<0.002**
Calcium dissolved mg/L	26.3	22	26.1	**24.80**
Chromium dissolved ug/L	0.103	0.161	0.131	**0.13**
Copper dissolved ug/L	0.234	0.133	0.591	**0.32**
Iron dissolved ug/L	<2	13.3	15.7	**14.50**
Lead dissolved ug/L	0.0067	0.0109	0.0109	**0.01**
Manganese dissolved ug/L	0.264	0.59	0.43	**0.43**
Mercury dissolved ug/L	<0.01	<0.01	<0.01	**<0.01**
Molybdenum dissolved ug/L	0.294	0.282	0.272	**0.283**
Selenium dissolved ug/L	<0.01	0.101	0.566	**0.224**
Zinc dissolved ug/L	0.491	1.19	1.12	**0.93**

< Less than detection limit as shown.

Table 3-2
Grande Cache Lake Water Quality Data Summary

Variables	Date				Average of 2011 Study
ROUTINE	25-Aug-93	14-Jun-11	16-Aug-11	20-Oct-11	
pH (lab) pH units	8.46	8.40	8.44	8.33	8.39
Specific conductance (lab) us/cm	302	355	336	316	336
Total dissolved solids (calc.) mg/L	156	184	170	182	179
Residue non-filterable[6] mg/L	2	2.0	3.6	0.5	2.0
Chloride dissolved mg/l	2.4	7.6	7.1	7.7	7.5
Sulphate dissolved mg/l	7	1.5	1.5	5	2.7
Hardness total (calc.) $CaCO_3$ mg/L	-	174	154	173	167
Colour true TCU	-	10	20	10	13.3
Euphotic depth m	-	6.2	7	8.5	7.2
Secchi disk transparency m	2.4	2.5	2.75	3.6	2.95
Nutrients					
Phosphorus total (P) mg/L	0.018	0.019	0.023	0.015	0.019
Phosphorus total dissolved mg/L	0.006	0.011	0.012	0.003	0.009
Chlorophyll a mg/m^3	6.4	1.83	2.13	2.89	2.28
Ammonia dissolved mg/l	0.006	0.009	0.009	0.007	0.008
Nitrogen dissolved NO_3 & NO_2 mg/L	0.002	<0.005	<0.005	<0.005	<0.005
Nitrogen total (calc.) mg/L		0.502	0.492	0.552	0.515
Nitrogen total Kjeldahl mg/L	0.45	0.50	0.49	0.55	0.513
Carbon dissolved organic mg/L	7.1	8.4	8.8	8.2	8.5
Carbon particulate total mg/L	0.74	0.49	0.28	0.32	0.36
BIOLOGIC					
Coliforms fecal no/100 ml	-	<10	<10	<10	<10
Escherichia coli no/100 ml	-	<10	<10	<10	<10
Microcystin, total ug/l	-	0.07	0.08	0.05	0.07

[6] Also called Total Suspended Solids (TSS).

Variables	Date				Average of 2011 Study
SELECTED METALS					
Aluminum dissolved µg/L	-	0.797	0.786	0.700	0.761
Arsenic dissolved µg/L	-	0.296	0.334	0.0634	0.231
Boron dissolved µg/L	-	14.5	13.9	15.4	14.6
Cadmium dissolved µg/L	-	<0.002	<0.002	<0.002	<0.002
Calcium dissolved mg/l	-	30.9	29.6	28.8	29.8
Chromium dissolved µg/L	-	0.0915	0.156	0.154	0.134
Copper dissolved µg/L	-	0.445	0.36	0.578	0.461
Iron dissolved µg/L	-	2.29	23.7	21.2	15.73
Lead dissolved µg/L	-	0.0035	0.0238	0.0079	0.0117
Manganese dissolved µg/L	-	0.111	0.719	0.237	0.356
Mercury dissolved µg/L	-	<0.01	<0.01	<0.01	<0.01
Molybdenum dissolved µg/L	-	0.185	0.203	0.214	0.201
Selenium dissolved µg/L		<0.1	0.17	0.682	0.426
Sodium dissolved mg/l	10	12.8	11.7	12.5	12.3
Zinc dissolved µg/L		0.562	1.08	0.765	0.802

- Not sampled

< Less than detection limit as shown

3.4.2 Raw Water Quality Monitoring at Victor Lake Intake

The Town conducts regular grab sampling and analysis of raw water quality at the intake as part of the normal operations of the water treatment facility. In 2010, ISL Engineering (2010) reviewed the available data and concluded that:

- Turbidity was generally low with a small amount of variability.
- pH ranged from near neutral to alkaline.
- The water had high alkalinity and high dissolved minerals, and was rated as hard.
- True colour varied substantially, ranging from 5 to 88 TCU.
- Total iron concentrations ranged from 0.02 to 0.24 mg/L [the current Canadian Drinking Water guideline Aesthetic Objective (AO) is ≤0.3 mg/L]; while the total manganese concentrations ranged from 0.02 to 0.27 mg/L (the AO is 0.05 mg/L), indicating some exceedances of the AO.
- Total aluminum levels were considered low.
- Total organic carbon concentrations were sufficiently high to suggest the presence of disinfection by-products (DBPs) in the water.

In 2013, Stantec (2013) reviewed the raw water quality data that were available from 2010-2013 as part of a membrane filtration pilot study. The results indicated that:

- Turbidity ranged from 0.3 to 4.7 NTU.
- pH averaged 7.9, but was occasionally above the Canadian Drinking Water guideline of 8.5.
- True colour ranged from 1 to 53 colour units, with the highest values in spring and summer. Most of the colour appeared to be associated with organic carbon compounds like humic and fulvic acids, as reflected by somewhat elevated total organic carbon concentrations (range 7.8-9.7 mg/L).
- All iron samples met the AO, while manganese exceeded the AO a few times.
- *E. coli* was not detectable (<4 counts/100 mL) in any of the four samples obtained in 2013. Fecal coliforms were detected in one of the four samples, but just at the detection limit of 4 counts/100 mL.

4 Source Risks and Mitigative Actions

4.1 TRANSPORTATION CORRIDORS (RISK SCORE 128)

4.1.1 Hazard Inventory and Description

Potential contamination from Hwy 40 was assessed in the DWSP as having one of the highest risk scores. The highway parallels Victor Lake for 1.5 km, and is located approximately 160 m southeast of the shore at its closest point. A steep embankment exists to the southeast of the highway. There is only one cross drain, consisting of a set of two 1200 mm culverts along this stretch of Hwy 40. Significant, high velocity runoff flows through the twin culverts, as evidenced by the deeply incised channels (approximately 3 m deep) at the culvert outlet. Runoff travelling from the twin culverts, as well as runoff from the steep embankment slopes adjacent to the highway, reportedly floods the dirt access road towards Victor Lake and pools within a low lying area to the southeast of the access road. Overflow from the low area reportedly flows across the old airstrip on occasion and enters the lake.

Sedimentation concerns exist from the runoff, as does the potential for contamination caused by spills from trucks losing their loads along the highway or fuel spills from trucks or other industrial equipment travelling along the highway. Spills would tend to infiltrate to ground either along the ditch line or at the base of slopes, but could reach both lakes directly if the spill happens when soils are saturated or during wet weather.

4.1.2 Vulnerability and Risk Evaluation

Runoff from the twin culverts and from the steep embankment slopes adjacent to the highway reaches the lake on an almost annual basis in the spring and also during heavy rainfall events. The contaminant transfer potential for runoff from Hwy 40 to reach Victor Lake when flow conditions is rated as **high** during spring freshet and heaving rainfall events, and **moderate** for the rest of the year.

Sediment reaching the lake could increase turbidity levels in water at the intake, which has implications for treatment as high turbidity makes filtration and disinfection more difficult. Spills from the highway that reach the lake directly could result in detectable levels of hydrocarbons and other substances at the intake.

4.1.3 Recommended Management Actions to Minimize Risk

TC-1	***Highway 40 Drainage Assessment***: Given the high velocity flows characteristic at the twin culverts during freshet and subsequent flooding at the foot of the embankment slope, installing additional culverts beneath the highway may be necessary to improve drainage, reduce runoff velocities, and help reduce the potential for sediment and other contaminants to flow along the access road and area directly to the southeast of the road toward Victor Lake. The Town should ask Alberta Transportation to complete an assessment of the drainage along the highway during the spring in order to determine whether the existing 1200 mm twin culverts are sufficient to manage the runoff from the road.

TC-2	***Erosion Control in Road Prism***: Check dams should be installed along the drainage ditch that parallels Highway 40 to dissipate the velocity of the runoff and reduce erosion along the drainage ditches and embankment slope adjacent to Victor Lake. Slowing the velocity of the runoff will minimize the risk of contaminants from the road entering Victor Lake as the distance of the runoff will be reduced. It is suggested the Town approach Alberta Transportation to develop the design of the check dams. This could be included as part of the scope for the drainage assessment as described in the previous paragraph. For guidance, refer to Alberta Transportation's Design Guidelines for Erosion and Sediment Control for Highways, as well as the Stormwater Management Guidelines for the Province of Alberta.
TC-3	***Stormwater/Sediment Retention Pond***: The low-lying area at the bottom of the embankment slope on the upslope side of the old airstrip should be upgraded to serve as a stormwater pond to retain flow from the twin culverts and reduce the potential for sediment-laden runoff entering Victor Lake. The Town should consult Alberta Transportation to include this in the scope of the drainage assessment along the highway.
TC-4	***Monitoring***: In the spring (beginning in 2015), the Town should monitor the flow of surface runoff from Hwy 40 to where it pools at the bottom of the embankment slope to determine if the runoff is reaching the lake and moving toward the intakes. This is needed to confirm the potential need for a stormwater retention facility (TC-3) and inform its design. This would be part of an overall monitoring program that is suggested for 2015-2016 to augment the assessment of several of the identified hazards (refer to Section 5.2.3).

4.2 WASTEWATER TREATMENT SYSTEMS (RISK SCORE 64)

4.2.1 Hazard Inventory and Description

The DWSP identified this hazard as the microbial contamination of raw water supplies from the private septic systems or sewer outfalls. In the Victor Lake watershed, the private septic systems are located in the Victor Lake Co-op, on the south and southwest sides of the lake. Based on aerial photography and a reconnaissance visit to the community on August 14, 2014, there appears to be approximately 20-25 homes in the Victor Lake watershed, and another 5-8 homes just outside the topographic watershed boundary, but within the area where groundwater flow may be directed toward the lake. The set-backs to the lake range from 40 to over 400 m, and the distance from the closest lakefront property to the intake is approximately 550 m.

In the Grande Cache Lake watershed, there are about 10-12 homes or private businesses with septic systems, mostly located along Hwy 40 and the road that connects Highway 40 to the Grande Cache Lake Co-op. In addition, there are pit toilets in the public park at Grande Cache Lake, but it is understood that these toilets have holding tanks that are pumped out and the sewage treated at the Town's wastewater treatment facility.

The setbacks to the lake from the homes and business in the Grande Cache Lake watershed range from about 120 to 500 m. Any contaminants reaching the lake would have to travel about 3,300 m to reach the intake, and that would only be feasible when the flow direction is from Grande Cache Lake to Victor Lake.

The private wastewater systems in the two watersheds are a mixture of systems, including holding tanks that are periodically pumped out, septic tank plus treatment field systems, and septic tank plus treatment mound systems. Some homes reportedly collect grey water separately and discharge it to treatment mounds. A detailed inventory of systems was not undertaken for this project. The Victor Lake Co-op representatives that were contacted indicated that the majority of systems were properly designed and installed, but that operation and maintenance does not always conform to best management practices. Grey water is reportedly occasionally pumped from holding tanks to forested areas and allowed to infiltrate to ground.

All of the domestic wastewater systems are either single household “hold and pump” systems or are discharged to ground. There are no multi-household systems, and no direct discharges of domestic wastewater to the lakes.

4.2.2 Vulnerability and Risk Evaluation

Based on the set-backs from the lakes, the contaminant transport potential is rated **moderate** for the private systems that discharge to ground. For properties with holding tanks, there is negligible potential for contaminant transfer to the intake from normal operations. As noted above, maintenance procedures are not always to standard (similar to other rural communities), but the set-backs are sufficient to indicate that the direct introduction of coliform bacteria or other pathogens to Victor Lake are unlikely. Travel through groundwater to the lake is, however, possible.

If fecal contamination reaches Victor Lake, the shortest travel distance from a lakeside home to the intake is about 550 m. Whether or not *E. coli* and other human-related pathogens survive in lakes depends on a number of factors including exposure to sunlight, water temperature, predation by other microorganisms, nutrients, and the amount of suspended matter in the water column (Neger 2002; Health Canada 2012). Generally, coliform bacteria tend to survive for relatively short periods in clear waters like Victor Lake where light (i.e., UV radiation) penetrates the water column, nutrient concentrations are low, and there are few suspended particles for bacteria to adsorb to. During the winter, there is less die off from UV radiation under ice cover, but cold temperatures generally limit bacteria growth. Overall, these factors suggest that septic systems more than 500 m from the intakes pose limited risk to raw water quality, if the in-ground septic systems have been properly designed, installed, and maintained. A monitoring program would be of value (e.g., quarterly samples for two years) to measure coliform bacteria counts in the lake in the stretch of water between the Victor Lake Co-op and the intake, including winter samples through the ice.

4.2.3 Recommended Actions to Minimize Risk

Inspection and maintenance of the private wastewater systems at the Victor Lake Co-op is the primary mitigative strategy for reducing this source hazard. Monitoring is also recommended to better characterize the level of risk, because of the number of factors that influence the survival of coliform bacteria in lakes.

WW-1	Undertake an inspection program by a qualified person to assess conformance of private systems in the Victor Lake watershed with Alberta private sewage systems practice standards.
WW-2	Identify funding options for upgrades/maintenance, as needed. The Town should investigate opportunities to work with the Victor Lake Co-op and provincial agencies (i.e., Alberta Municipal Affairs, etc.) to secure funding for such upgrades.
WW-3	Continue to include *E. coli* in the raw water quality monitoring program. Consider a “State of the Lake” monitoring program including *E. coli* to further characterize lake water quality (refer to Section 5.2.3).

4.3 WILDLIFE IN WATERSHED: MICROBIAL HAZARDS (RISK SCORE 64)

4.3.1 Hazard Inventory and Description

The Victor and Grande Cache Lake watersheds have a suitable natural habitat to support a number of wildlife species including but not limited to caribou, elk, moose, deer, bighorn sheep, mountain goats, wolf, coyotes, bears, and foxes. The microbial hazard associated with wildlife in the watersheds is based on the potential for contamination of the Town’s raw water supply through wildlife defecating in or near water bodies, with subsequent transport via overland flow into the lake. The microbial hazard is also related to decaying wildlife carcasses within the lake and along the shores of lakes and tributary streams.

According to local residents, wildlife carcasses have reportedly been seen floating in Victor Lake during ice free periods on occasion. Wildlife dies of natural causes such as falling through the ice in the winter, disease, and predation. Hunting in the Victor Lake watershed is a popular pastime for local residents. Although the remains of harvested game are usually left behind, scavengers will typically consume the remains quickly; therefore, the hazard from this practice is likely negligible.

4.3.2 Vulnerability and Risk Evaluation

Based on the available water quality data (Section 3.4), specifically the generally low coliform bacteria counts, there is little to suggest that wildlife poses a significant hazard at the intakes. Riparian vegetation likely filters fecal matter in runoff before it reaches a stream or lake, and the travel time in the lakes is likely sufficiently long to minimize pathogen survival (as discussed in Section 4.2.2). As such, the contaminant transport potential is rated as **low**.

4.3.3 Recommended Actions to Minimize Risk

Functioning riparian buffers along streams and lakes in the plan area are important for maintaining the risk from wildlife low. Riparian setbacks are specified in the ground rules for forestry (refer to Section 4.7).

WL-1	***Hunter Education Initiatives:*** As part of an overall source protection public education strategy, include information for hunters on best practices for dealing the remains of harvested game (e.g. disposal at least 30 m from a watercourse).

4.4 HEAVY RAINFALL, RUNOFF AND FLOODS (RISK SCORE 64)

4.4.1 Hazard Inventory and Description

As identified in the DWSP, the hazard is associated with an increase in turbidity within Victor Lake following heavy rainfall and flooding events causing deterioration in raw water quality. A significant portion of the runoff and sediment originates from the Hwy 40 corridor, as described above in Section 4.1. From the DWSP, it is understood that there is presently no way to close the main intake when the quality of raw water has been compromised by high turbidity. The Town has no raw water storage "upstream" of the treatment system and therefore the system is susceptible to fluctuations in raw water quality.

Historical weather information from Grande Cache illustrates that the area receives the highest rates of precipitation in June, July, and August, with about half of the average annual precipitation falling in these months and high-intensity storms are not uncommon. Runoff and sedimentation is also generated by spring snowmelt.

Runoff also reportedly accumulates during heavy rainfall and freshet within the old gravel pit area that is located on the Victor Lake Metis Co-op (Figure 3-1 and Map 1). The gravel pit was formerly operated by the railway company and it not known whether industrial activities other than gravel extraction occurred there. Water readily infiltrates to the ground given the gravelly soil and has the potential to reach Victor Lake via subsurface flow. However, the gravel pit is located approximately 650 m from the shores of Victor Lake so the infiltration of runoff to ground in the pit is unlikely to have a measureable effect on water quality at the Victor Lake intake.

In contrast, heavy rainfall and flooding events apparently does cause overland flow along the abandoned airstrip with the potential to transfer sediment into Victor Lake as there is only limited riparian cover in some places, and several access points where runoff may flow directly to the lake.

4.4.2 Vulnerability and Risk Evaluation

Runoff from the Town's stormwater drains reportedly has the potential to reach Victor Lake on an annual basis. Runoff from the twin culverts and from the steep embankment slopes adjacent to Hwy 40 reaches the lake on an almost annual basis in the spring and also during heavy rainfall events. Subsurface flow from the abandoned airstrip will likely reach Victor Lake on a seasonal basis, although it is unlikely that contaminants or sediment will enter the lake as they will be filtered out before reaching Victor Lake. Runoff from the abandoned airstrip will reach the lake following heavy rainfall events given the number of access points along the shores thereby transferring a potentially large amount of sediment and potential contaminants into the lake. The contaminant transfer potential for runoff to enter Victor Lake during heavy rainfall and spring freshet is **high**, while it is **moderate** for the rest of the year during less intense precipitation events.

4.4.3 Recommended Actions to Minimize Risk

Recommendation TC-2 in Section 4.1.3 addresses stormwater retention for runoff from the Hwy 40 corridor. The following are additional recommendations for managing risks from surface runoff, erosion, and sedimentation.

HR-1	***Reclaim Abandoned Airstrip within 30 m of high water mark:*** The section of the old air strip that is within 30 m of the lakeshore should be reclaimed by the Town to create a functioning riparian buffer that will filter out sediment. Reclamation of the riparian buffer would include site preparation, planting of a ground cover, planting of native shrubs and trees, and temporary fencing until the ground cover is established. This action would also help to concentrate recreation to fewer sites (refer to Section 4.6).
HR-2	***Monitoring:*** Similar to recommendation TC-3, runoff from the developed part of the Town that flows to the old gravel pit area west of Victor Lake should be documented during spring 2015 to determine if any of the flow reaches the lake or if it infiltrates to ground. This would be part of the overall monitoring program suggested for 2015 (Section 5.2.3).

4.5 MINING EXPLORATION & DEVELOPMENT (RISK SCORE 32)

4.5.1 Hazard Inventory and Description

As identified in the DWSP, the hazard relates to deterioration in raw water quality as a result of mining water drainage or site runoff reaching Victor Lake. Contaminants associated with mining activity include but are not limited to heavy metals, sediment, polycyclic aromatic hydrocarbons (PAHs), and compounds used in processing. Mining activity has been the most important economic driver in the community since it was founded, and a number of companies currently have Mineral Surface Leases (MSL) within the Grande Cache Lake Watershed (Figure 2). There are no MSLs or mining activities in the Victor Lake Watershed, nor has there been any in the past.

Mine Development/Future Operations

There are currently two mining companies operating in the area; Grande Cache Coal Corporation and Summit Coal (owned by Milner Power). Smoky River Coal Ltd. was also operating in the area, although their License of Occupation (LOC 840240) was cancelled. An outstanding obligation remains on the LOC, as the site hasn't been decommissioned and reclaimed. Summit Coal's Mine 14 site is currently in the development stage and is located approximately 4.5 km to the northwest of Grande Cache Lake. They have drilled a number of test wells, but the mine is not being developed at this time and there are no immediate plans to do so. Summit Coal also operates an access road to Mine 14 which is located to the northwest of Grande Cache Lake from Hwy 40. They also hold a LOC for a second access road to Mine 14 that will be located to the northeast of the development from the Town. Milner Power's other mining operations are at least 20 km northwest from the Town and have no potential to affect Victor Lake and Grande Cache Lake watersheds.

The potential for future mining operations to present a drinking water hazard depends on the sizes of any operation and whether surface or underground mining techniques are used. Authorizations for mining in Alberta typically include conditions preventing the release of untreated water and for avoiding accidental spills and releases of contaminants. To manage the water quality hazards associated with coal mining (e.g., metals, erosion and sedimentation), the operating conditions for any new mine should reflect the fact that the Town's drinking water source is in the watershed (refer to Recommendations – Section 4.5.3).

Closed Mine Operation

An old mine reportedly operated by Smoky River Coal Ltd.is located approximately 500 m to the northwest of the shore from Grande Cache Lake (Figure 3-1). Although road access to the mine from Hwy 40 has been blocked off at the entry by large boulders, some residents are using the area to dispose of garbage. Old oil drums, mattresses, and other types of waste were observed at the base of the slope below the pit during the field reconnaissance visit on August 13, 2014. The garbage has been thrown over the waste rock slope in the direction of Grande Cache Lake. The mine has not been reclaimed, and the pit remains open with exposed slopes. However, there was no evidence of drainage leading away from the pit towards the lake, and there was no standing water in the pit. Some potential for sedimentation also exists from the exposed waste rock slopes that are located within 500 m of Grande Cache Lake.

4.5.2 Vulnerability and Risk Evaluation

There is a tributary to Carconte Creek that runs through the closed mine and drains into Grande Cache Lake from the southeast (Figure 1-1); therefore potential exists for the transfer of contaminants from the garbage that is being disposed of at the site. Contaminants from that mine site could potentially travel into Grande Cache Lake via groundwater infiltration.

Three tributaries to Carconte Creek flow from Summit Coal's Mine 14 site (Figure 2); therefore, any drainage water generated on-site could be transported from the site and into Grande Cache Lake, once the mine is in operation. The mine is located approximately 4.5 km from the shore at its closest point.

The new access road to Summit Coal's Mine 14 will cross three tributaries to Allen Creek which drains into Grande Cache Lake and the canal that connects Grande Cache Lake to Victor Lake. The new access road will also cross a tributary to Carconte Creek. Sediment and contaminants from construction of the new access road has the potential to enter Grande Cache Lake, although this would only occur during rainfall and snowmelt events as the new access road is located approximately 2.5 km from the canal that connects the two lakes. Contaminants from any spills along the new road once it is in operation also have the potential to reach Grande Cache Lake via Allen Creek, especially during heavy rain and snowmelt events.

To summarize, water released from the future mind developments could travel via ephemeral tributary into Grande Cache Lake. No mining activity is likely in the Victor Lake watershed. Any mining company operating in the area will have water quality monitoring programs in place that form part of their *Environmental Protection and Enhancement Act* (EPEA) regulatory approval, with monthly and annual reporting requirements. They will also have emergency response procedures in place to contain and treat water before it can be released.

Given the regulatory requirements for new mine operations, the distances of the mine sites from Grande Cache Lake, and the lack of MSLs in the Victor Lake watershed; the Contaminant Transfer Potential is rated as **Moderate**.

4.5.3 Recommended Actions to Minimize Risk

MED-1	***Clean-up Garbage at Closed Mine:*** The waste that has been thrown over the embankment slope along the southeast edge of the property should be removed, and a 'No Dumping' sign installed. The Town should formally request that ESRD issue a clean-up order to the land owner.
MED-2	***Decommission the Closed Mine***: The Town should approach ESRD to determine the status of the property and confirm whether there is a plan to fully decommission and reclaim the site to provincial standards, or whether enforcement action can be initiated.
MED-3	***Restrict Access to Closed Mine:*** If the mine cannot be decommissioned and reclaimed, stronger measures (e.g. a gate placed further down the road) should be put in place to prevent public access and dumping of waste.
MED-4	***Strengthen Communication with Mining Companies Operating in Area:*** The Town should engage with ESRD and the mining firms during the authorization process for new operations to ensure that environmental controls and monitoring reflect the status of the watershed as a drinking water source. On-going dialogue is encouraged to discuss any watershed issues that have the potential to impact the Town's raw water supply.
MED-5	***Town of Grande Cache should be included in Emergency Response System:*** If the planned new mining operations go forward, the Town should be a participant in the emergency planning and response system, and be notified immediately if a release of waste occurs so the water intake can be closed.

4.6 RECREATIONAL ACTIVITY (RISK SCORE 32)

4.6.1 Hazard Inventory and Description

The Victor Lake and Grande Cache Lake watersheds are popular recreational areas for residents of Grande Cache and surrounding communities. Fishing (in all seasons), swimming, picnicking, camping, hiking, water skiing, and hunting and are some of the activities that occur in the watershed. Recreational activity was identified in the DWSP as having the potential to contaminate the raw water supply via microbial contamination or the introduction of hydrocarbons into Victor Lake. With the exception of the toilets at Grande Cache Lake Park, the recreational areas lack sanitary facilities. The hazard is related to people defecating close to the shores of Victor Lake, and is also related to the use of motorized vehicles in the lakes, on the ice in winter, or along the shores. Off-road vehicle use on public land can also contribute to erosion and sedimentation.

During the site reconnaissance on August 14, 2014, more than a dozen access points were identified along the shores of Victor Lake, about half of which are large enough to launch a motorized boat (Figure 3-1). Only electric-powered motorized boats are permitted on Victor Lake, but gas-powered motors are allowed on Grande Cache Lake. The most popular boat launch is located approximately 15 m from the main intake – a 'no gas motorized boat' sign is located beside the boat launch. There is a no trespassing sign at the intake, but no signage to indicate that the lake is the Town's water supply. It is possible that non-compliant boaters are using gas powered boats on Victor Lake, with the potential for fuel to spill into the water during refueling activities or malfunctioning boats. Fuel spills are also possible in Grande Cache Lake as gas fueled motorized boats are permitted there. The gas contamination could then enter Victor Lake via the canal that connects to Grande Cache Lake, although the dominant direction is away from Victor Lake. Potential also exists for fuel spills when cars or trucks are launching their boats from one of the access points along Victor Lake or Grande Cache Lake, especially at the boat launch located 15 m from the Town's drinking water intake.

Victor Lake has become a popular destination for an annual ice fishing derby. Some participants reportedly drive their trucks and snowmobiles on the lake during the event, with the potential for these motorized vehicles to spill fuel or fall through the ice. A one-ton truck holding a tank full of diesel fuel did break through the lake in February 2015. The refueling of ice augers could also cause fuel to enter Victor Lake. There are also reports of huts being left on the ice until the ice melts, and of garbage being left behind.

As noted earlier, no public washrooms (either permanent or portable) are located at Victor Lake, so there is potential for human waste to be deposited either on close to the lake (photographs taken by a local resident in February 2015 confirmed that a number of people had gone to the toilet on the ice close to their huts). During the August 2014 field assessment, fire rings were found at most of the access points to the lake, indicating that people spend extended periods near the lake. Furthermore, garbage and dog feces were observed at multiple locations. There are no garbage containers in the area, so recreational users and responsible pet owners who clean up after their dogs are expected to pack out their garbage.

A beach is located on the shore of Grande Cache Lake. A washroom is located adjacent to the beach, and there are a number of garbage containers and fire pits available at the site. However, some potential still exists at other locations along Grande Cache Lake for human or pet waste to be deposited near the lake.

An old airstrip is located adjacent to Victor Lake, and a dirt road provides access to the area. It is a popular spot for ATV's and other off-road vehicular use during the summer months. This creates an abundance of dust with the potential for sediment to enter Victor Lake. The vehicle use also prevents the natural re-vegetation of the old airstrip.

4.6.2 Vulnerability and Risk Evaluation

As identified in the DWSP, the campgrounds, washrooms and garbage containers located at the Grande Cache Lake beach are well used, and therefore lower the risk of microbial and contamination of Grande Cache Lake. Victor Lake is more vulnerable to microbial contamination as these facilities are unavailable. The existing riparian buffer surrounding the shore of Victor Lake (generally measuring a minimum of about 10 m from the lake except at the access points) helps to reduce the risk of bacterial contamination and sediment from entering the lake during ice free periods.

Hydrocarbon contamination directly entering the lake is possible during summer as the potential for fuel spills from non-compliant boat owners using fuel powered boats in Victor Lake exists. Fuel spills are also possible in Grande Cache Lake as fuel powered motorized boats are permitted, although the risk is lower given the distance to the Town's intake. Hydrocarbon contamination directly into the lake is also possible in the winter, most notably during the annual ice fishing derby.

The Victor Lake boat launch is located less than 40 m from the main pump house. In addition of the potential for fuel spills, soil erosion from the launch and access road can cause sediment to directly enter the lake.

Given the potential for direct entry of contaminants into Victor Lake and Grande Cache Lake, the contaminant transfer potential related to recreational use is rated as being **very high**.

4.6.3 Recommended Actions to Minimize Risk

Victor Lake has been a popular recreation area since the Town was founded because of its close proximity and because it is managed as a recreational fishery. Therefore restricting recreational access as a way to reduce drinking water hazards is likely unrealistic. The following are recommendations to reduce the hazards while still allowing recreation to occur.

RA-1	***Re-locate the Victor Lake Main Boat Launch:*** A new boat launch should be constructed at least 200 m from the intake. The new boat launch should be designed to encourage its use in order to minimize use of the informal launch sites, and prevent soil erosion.
RA-2	***Signage Indicating Source Water Supply:*** The Town should post signs indicating that Victor Lake is the source of the Town's drinking water. The signage would include a major sign at the main access point from Hwy 40 plus several smaller signs at the main boat launch and other high-use access points.
RA-3	***Additional Signage:*** The Town should replace the current symbol-based sign to more clearly communicate that gas-fueled motorized boats are not permitted on Victor Lake. Signage indicating that 1) camping is not allowed, 2) refueling activities for all machinery should occur at least 100 m from the shore of both lakes, and 3) to remind pet owners to clean up after their dogs should be placed at the high-use areas of both lakes.

RA-4	***Decommission Boat Launches:*** The current main boat launch near the intake should be removed and the riparian area re-vegetated (refer to RA-1 for replacement) and fenced off to prevent future access. Any other informal boat launches within 200 m of the intake should also be decommissioned (such as by placing boulders).
RA-5	***Install Washroom Facilities:*** Washroom facilities similar to those in Grande Cache Lake Park should be considered for Victor Lake, located at least 60 m back from the lake shore.
RA-6	***Bear Proof Garbage Bins:*** Garbage bins should be installed at Victor Lake, to be emptied on the same schedule as the park.
RA-7	***Development of Ministerial Order:*** It is possible to have the provincial government issue a Ministerial Order to restrict recreational activities that pose a threat to drinking water (e.g., motorized vehicle use on the lake when ice is present). This would give any Peace Officer (i.e., Police, ESRD staff, and Town bylaw officers) the ability to ticket/fine offenders. The Town should work with ESRD to explore this option and move towards implementation.

Recommendation HR-2 in Section 4.4.3 (partial reclamation of the old air strip) is also a tool to reduce the recreation hazard.

4.7 FORESTRY ACTIVITY (RISK SCORE 32)

4.7.1 Hazard Inventory and Description

The hazard relates to the potential for effects on raw water quality from forestry activities in the area. As can be seen from Figure 3-1, there are currently no forestry dispositions within the Victor Lake watershed. There is, however, a Consultative Notation (Company) for forestry activities located within the Grande Cache Lake watershed. The disposition is held by Foothills Forestry and occupies about 30% of the Grande Cache Lake watershed. At its closest point, the Foothill's disposition is about 500 m to the shores of Grande Cache Lake.

The disposition in the Grande Cache Lake watershed forms part of Foothill Forestry's Forestry Management Unit (FMU) called E8. The total FMU covers 219,648 ha, and is one of the few forest management units in Alberta where timber hasn't been allocated through a Forest Management Agreement (FMA) (ESRD, 2008). As such, a Forestry Management Plan (FMP) for the area was developed by ESRD in partnership with Foothills Forestry and other stakeholders in the Grande Cache area including the Town and members of the Metis Co-ops (ESRD 2008). The FMP provides guidance for the sustainable management of forest resources in the E8 FMU, and was developed in accordance to CAN/CSA-Z809-02 Sustainable Forest Management Requirements and Guidance Document, the Alberta Forest Management Planning Standard, the Mountain Pine Beetle Interpretive Bulletin, and the Mountain Pine Beetle Action Plan (ESRD, 2008). It was approved in 2008 and is valid for 10 years.

The main water quality hazards associated with logging in the Grande Cache Lake watersheds are 1) erosion and sedimentation from roads and landings, and 2) potential increases in peak flows of Allen Creek and Carconte Creek within any future harvested areas that eventually drain into Grande Cache Lake.

An increase in the peak flows has the potential to increase channel and bank erosion and the subsequent deposition of sediment into the lakes which can negatively impact the raw water quality by elevating turbidity levels. However, detectable changes in peak flow are typically associated with equivalent clear cut areas (ECA) exceeding 15-20% of the watershed area.

Although unlikely, hydrocarbons and other chemicals used for forest management could also be transported to the lakes and affect the raw water quality. Leachate from decomposing wood in cutblocks can cause an increase in the nitrate and a decrease in pH to the water in the ephemeral tributaries that eventually drain into Grande Cache Lake and the canal that joins Victor Lake to Grande Cache Lake.

4.7.2 Vulnerability and Risk Evaluation

Foothills Forestry has said they have no immediate plans to conduct logging in the Victor Lake and Grande Cache Lake watersheds (pers. comm. 2014). Contaminants from future harvesting activities could travel into the lakes due to an increase in the amount of overland flow as a result of the reduction in forest cover and understory vegetation. The amount of overland flow will increase during heavy rainfall and snowmelt events, therefore posing a greater risk to the raw water quality in Victor Lake.

The boundary of the disposition held by Foothills Forestry is 500 m to the shore of Grande Cache Lake at its closest point, and the company will be required to work with ESRD in order to establish appropriate setback limits and management practices so that negative impacts to the Town's raw water quality are avoided during harvesting activities in accordance with the FMP for the area. The 'Foothills Forest Monitoring Program' forms part of the FMP, which includes ground rules for forestry activities that are carried out within watersheds. The ground rules define operating practices to manage the implications of timber operations on water quality, quantity and flow regimes (ESRD, 2014). Of particular note is ground rule 6.0.12, which states that: "Harvesting is not permitted within water source areas during non-frozen periods." (ESRD, 2014). The ground rules also specify that temporary and permanent erosion and sediment control measures must be implemented during harvesting in order to minimize erosion and sedimentation entering surrounding watercourses (ESRD, 2014).

A hydrologic assessment of Foothill Forestry's Spatial Harvesting Plan was conducted in order to determine potential impacts to the flow regime of watercourses within the FMU. The assessment concluded that any increases in peak flows from forestry activities would fall within the range natural variability that is characteristic of the watersheds within the Grande Cache area (Watertight Solutions, 2008). The level of watershed disturbance as ECA was also evaluated. The report recommended ECA values of 15-20% be used as management objectives as these values were considered to be indicative of a low disturbance to the watersheds within the FMU (Watertight Solutions, 2008). Finally, the report concluded that no long lasting changes to streamflow, stream channel morphology, aquatic habitats, or water quality were expected to occur from the implementation of the Spatial Harvesting Plan (Watertight Solutions, 2008).

The Town's water plant also has a SCADA system so that operators are alerted when there is an increase of more than 3 NTU at the intake, therefore potential increases in suspended sediment entering Victor Lake from land use activities (including forestry) can be responded to accordingly.

Given the current forestry management practices as specified in Foothill Forestry's FMP, the contaminant transfer potential is **low**.

4.7.3 Recommended Actions to Minimize Risk

FA-1	***Strengthen Communication with Forestry Companies Operating in Area:*** The Town should engage with ESRD and the forestry companies during the authorization process to ensure that environmental controls and monitoring reflect the status of the watershed as a drinking water source. On-going dialogue is encouraged to discuss any watershed issues that have the potential to impact the Town's raw water supply.
FA-3	***Town of Grande Cache should be included in Emergency Response Plan:*** In addition to the recommendations listed above, the Town should be a participant in the emergency planning and response system (recommendation MED-5) as this will also be beneficial to confirm the risk level from Forestry Activity.
FA-4	***Hydrologic Assessment if ECA projected to exceed 15%:*** The previous hydrologic assessment recommended a maximum ECA of 15%. If future forestry proposal exceed this threshold in the watershed of either lake, an updated hydrologic risk assessment should be undertaken to guide forest development and source water protection.

4.8 WILDFIRES (RISK SCORE 32)

4.8.1 Hazard Inventory and Description

The DWSP identifies wildfires as having the potential to contaminate the Town's raw water due to the changes in soil chemistry as a result of the intense heat. Other mechanisms potentially affecting water quality include the loss of ground cover, aerial delivery of fire-fighting chemicals, and road construction to enable fire-fighting. Potential contaminants that may be transferred towards Victor Lake and/or Grande Cache Lake as a result of forest fires include polycyclic aromatic hydrocarbons (PAH), fire-fighting chemicals (retardants and water-enhancers), sediment, and nutrients (phosphorous and nitrogen). The most likely pathways for contaminants to be delivered to the lakes are the forest road ditches and culverts and the ephemeral and permanent tributaries that drain the forested areas.

There have been five wildfires within the 100 km of the Grande Cache area over the past six years, which provides an indication of the level of risk although none of these fires occurred within the Grande Cache Lake or Victor Lake watersheds. Three fires took place in 2014, all of which were caused by lightning strikes during a summer storm. The closest fire occurred on Mt. Louis located approximately 6 km from the Town, which was quickly contained by ESRD to an area of 12 hectares. The other two wildfires were located 30 km to the northeast (covering an area of 20 hectares) and 60 km northeast (1500 hectares) from the Town. During the summer of 2009, a lightning-caused fire, covering 1500 hectares, occurred approximately 14 km to the northwest of the Town. Several human caused fires have also occurred, but affected smaller areas. The relatively high level of recreational and industrial activity in the watershed raises the risk of human-caused fires, but also means the response by the local fire department would be quick.

Wild fire management on Crown land is undertaken by ESRD, while fires on private land and the co-ops are the responsibility of the Town's fire department.

4.8.2 Vulnerability and Risk Evaluation

Contaminants generated from wildfires would tend to enter Victor Lake and Grande Cache Lake via the resource road drainage network and the tributaries that drain into the lakes. Some transfer to the lake in groundwater is also possible. The potential for the contaminants would be highest if significant rain events follow a fire when the ground surface is exposed. The contaminant transport potential from wildfires in the Grande Cache Lake and Victor Lake watersheds is rated as **moderate**.

4.8.3 Recommended Actions to Minimize Risk

The risks posed from wildfires within the area are minimized through wildfire prevention strategies employed by ESRD, the Town, and members of the Victor Lake and Grande Cache Lake Co-ops.

Wildfire prevention efforts are also coordinated with Foothills Forestry in areas where they are harvesting. ESRD conducts vegetation management in the form of pruning, thinning and mulching of understory vegetation and lower hanging branches around the Town on an annual basis. These prevention strategies work to reduce the intensity of future wildfires as the removal of understory vegetation limits the opportunity for fire to reach the crowns of the trees, which are more difficult fires to contain than ground fires.

WF-1	***Communication with ESRD:*** In addition to ensuring that ESRD fire management personnel and the forestry firms are aware that the watershed is a drinking water source, the Town should regularly communicate with ESRD's fire management department in Edson, AB during the fire season to evaluate the fire hazard and, if warranted, begin response planning (refer to WF-4).
WF-2	***Coordinate Wildfire Prevention Efforts with Affected Stakeholders:*** The Town should work in partnership with ESRD, Foothills Forestry and with members of the Victor Lake and Grande Cache Lake Co-ops to minimize the risk of forest fire within the Victor Lake and Grande Cache Lake watersheds. The Town should also discuss the possibility of implementing a permanent fire ban on Crown Land in the Victor Lake Watershed with ESRD. This will reduce the risk of contamination by forest fire in the Victor Lake watershed.
WF-3	***Develop Fire-Fighting and Post-Fire Protocols:*** The use of fire-fighting chemicals for any fires that occur in the watershed should consider potential drinking water hazards. A monitoring program capable of detecting contaminants related to wildfires should be implemented during and after a fire (if the source continues to be used). If any trails are cut to enable fire-fighting, those trails should be deactivated and reclaimed as soon as possible after the fire to minimize runoff, erosion, and sedimentation.

4.9 SOURCE INFRASTRUCTURE AND SYSTEMS (RISK SCORES 32)

4.9.1 Hazard Inventory and Description

The DWSP included three elements of the raw water intake and transmission system as Source Risks:

- Reduced water availability due to breaks or leaks in raw water mains (DWSP-S-035);
- Pump failure at pump station (DWSP-S-037); and
- Loss of pump station power at the pump station (DWSP-S-038).

All received a Risk Score of 32 from the combinations of likelihood and consequence. They are considered together here and in the rest of this report because the risks can all be managed through operational and maintenance procedures completely under the Town's control, unlike the other source protection issues that involve activities on private or Crown Land.

4.9.2 Vulnerability and Risk Evaluation

The three infrastructure risks are important for the supply of drinking water to Town residents, but less important for water quality. The recommendations for improved maintenance and the addition of automation and alarm systems in the DWSP will collectively result in reduced probability of a loss of supply from Victor Lake. As noted earlier, an automated turbidity sensor was added at the intake in 2014. It will work in combination with the flow alarms to minimize loss of supply events and improve raw water quality.

4.9.3 Recommended Actions to Minimize Risk

No additional recommendations are needed beyond those specified in the DWSP.

5 Risk Mitigation Action Summary and Priorities

5.1 CRITERIA FOR SETTING PRIORITIES FOR ACTION

Sections 4.1 to 4.9 each identify a number of source protection recommendations. Several of the recommendations pertain to more than one of the key risks. The general goals of the source protection plan are to identify and confirm the elements of the key risks and to separate the **serious and imminent risks** from those that pose less risk to drinking water safety. This was done by modifying the risk scores from the DWSP by multiplying them by the Contaminant Transport Potential (CTP) scores as described in Section 1.3. Table 5-1 shows the CTP score and the Revised Risk Rating for the key risks for activities in the watershed.

For the Recreation Activity hazard the original Likelihood score from the DWSP was changed from “probable” (score 8) to “almost certain” (score 16) based on discussions with ESRD and local residents, as well as field observations. For the other hazards, the likelihood and consequence scores were carried over from the DWSP.

After developing the Revised Risk Rating, the priority level ratings for action were defined as outlined in Table 5-2.

Table 5-1
Adjusted Risk Scores considering Contaminant Delivery Potential

Hazard	Type of Contamination/ Risk	Likelihood	Consequence	DWSP Risk Rating	Contaminant Transfer Potential*	Updated Risk Rating	Rank
Transportation corridors	Chemical (e.g. road salt, spills)	16	8	128	0.75	96	1
Flooding, heavy rain	Sediment (turbidity)	8	8	64	0.75	48	3
In-ground septic systems	Microbial	8	8	64	0.50	32	4
Wildlife in watershed	Microbial	8	8	64	0.25	16	5
Mining activity	Metals, hydrocarbons, sediment	4	8	32	0.50	16	5
Forestry activity	Sediment, colour, metals, nutrients, hydrocarbons	8	4	32	0.25	8	8
Recreational activity	Microbial, hydrocarbons	16**	4	64	1.00	64	2
Wildfire	Chemical, sediment	8	4	32	0.50	16	5

* Refer to Section 1.3 for scoring criteria.

** Changed from score of 8 in DWSP. Other likelihood and consequence scores remain the same as DWSP.

Table 5-2
Mitigation Action Priority Level Ratings

Priority Level	Criteria
1 – Short Term (implement within 2 years)	• Revised Risk Rating ≥48; and • Risk can be reduced with relatively cost-effective measures within control of local and provincial government agencies or by private sector following BMPs.
2 – Medium Term (implement within 5 years as resources allow)	• Revised Risk Rating ≥48; and risk reduction requires special techniques and/or potentially high expense; or • Revised Risk Rating between 16 and 47; and • Risk can be reduced with relatively cost-effective measures within control of local and provincial government agencies or by private sector following BMPs.
3 – Monitor and Re-assess (defer action unless monitoring indicates a need)	• Revised Risk Rating <16.

5.2 SOURCE WATER PROTECTION ACTIONS BY ORDER OF PRIORITY

5.2.1 Physical Works

Table 5-2 lists the recommendations from Sections 4.1 to 4.9 that would lead to the construction or installation of physical works to reduce source water risks, along with the action priority rating. The highest priority physical works are those that address the risks from Hwy 40 runoff, runoff from the old air strip and recreational areas at Victor Lake, and management of recreational activities at Victor Lake.

Table 5-3
Summary of Recommended Physical Works to Reduce Risks to Drinking Water

Recommendation Number	Description	Action Priority Level
TC-1	Highway 40 Drainage Assessment and Upgrades	1
TC-2	Erosion Control in the Highway 40 Road Prism	1
TC-3	Stormwater/Sediment Retention Pond in level area downslope from Highway 40	1
HR-1	Reclaim the abandoned airstrip in areas within 30 m of high water mark	2
MED-1	Clean-up garbage from the closed mine site	2
MED-2	Decommission the closed mine	2
MED-3	Restrict access to the closed mine (if it cannot be decommissioned)	2
RA-1	Re-locate the Victor Lake main boat launch and reclaim the site	1
RA-4	Decommission informal boat launches at Victor Lake	1
RA-5	Install washroom facilities at Victor Lake	2
RA-6	Install bear proof garbage bins at Victor Lake	1

5.2.2 Policies, Procedures, Education and Communication

Table 5-2 lists the recommendations from Sections 4.1 to 4.9 that would help reduce risks to drinking water through education, improved communication, or through policy and procedures. The highest priorities relate to managing recreation activities at Victor Lake. Note that many of the Priority Level 2 recommendations involve strengthening communications between stakeholders (MED-4, MED-5, FA-1, FA-3, and WF-1) or investigation the feasibility of mitigation options (WW-2). They are rated as Level 2 because of the overall risk scoring. However, given their relatively low cost, it is recommended that these be considered for the first two years of plan implementation.

Table 5-4
Summary of Recommended Policy, Procedure, Education and Communication Approaches to Reduce Risks to Drinking Water

Recommendation Number	Description	Action Priority Level
WW-1	Complete regular private sewage system inspections in the Victor Lake watershed.	2
WW-2	Identify funding options for private sewage system upgrades and maintenance, as needed.	2
WL-1	Hunter education initiatives or signage.	2
MED-4	Strengthen communication with mining companies operating in area.	2
MED-5	Town should be included in emergency response systems at operating mines.	2
RA-2	Install signage indicating that Victor lake and Grande Cache Lake are source water supplies.	1
RA-3	Replace the non-motorized boat only signs to improve communication to the public. Install additional signage at Victor Lake to address specific practices (re-fuelling, responsible pet ownership, and no camping).	1
RA-7	The provincial government can issue a Ministerial Order to restrict recreational activities that pose a threat to drinking water (e.g., motorized vehicle use on the lake when ice is present). This will give any Peace Officer the ability to ticket/fine offenders. The Town should work with ESRD to explore this option and move towards implementation.	1
FA-1	Strengthen communication with forestry companies operating in area.	3
FA-3	Town should be included in emergency response plans of forestry firms and their contractors.	2
FA-4	Complete Hydrologic Assessment if Equivalent Clear-cut Area (IECA) in either Victor or Grande Cache Lake watershed is projected to exceed 15%.	3

Recommendation Number	Description	Action Priority Level
WF-1	Town should be in regular communication with ESRD during wildlife season to assess risk and, if need, implement water quality protection measures.	2
WF-2	Coordinate Wildfire Prevention Efforts with other watershed stakeholders.	2
WF-3	Develop fire-fighting and post-fire protocols that reflect area's status as a drinking water source.	2

5.2.3 Monitoring

This initial Source Protection Plan for the Victor Lake drinking water source is based on a combination of reviews of existing information, discussions with stakeholders, a field reconnaissance, and a review of the raw water quality data. It depended to some degree on verbal reports of conditions during spring runoff or during rainfall, and on activities that happen only occasionally throughout the year. A one-year monitoring program is recommended to improve the understanding of: 1) some of the hazard processes that influence Victor Lake water quality; and 2) the current status of Victor Lake water quality. Although the Town collects sufficient raw water quality data to manage the treatment system, there is relatively little data on the ecological health of Victor Lake. The following are recommendations for these two categories of monitoring.

5.2.3.1 Assessment of Spring Runoff in 2015

Runoff from the Town to the western part of the Victor Lake watershed (old gravel pit area) and from Hwy 40 should be documented during spring runoff in 2015 and 2016 (if needed to complete documentation) to determine whether the runoff and associated sediment is reaching the lake, and to identify possible locations for a stormwater retention pond if such a pond is judged to be of value.

5.2.3.2 Victor Lake Water Quality Study

An assessment of water quality and limnological conditions in Victor Lake will provide an improved understanding on several of the hazards discussed in this plan, in particular private on-site sewage systems, wildlife, mining, and recreational activity. The components of the recommended study are:

1. Establish sites for water quality sampling. The four recommended sites are:
    a. Victor Lake site sampled previously by ESRD (No. AB07GA0046).
    b. Grande Cache Lake site sampled previously by ESRD (No. AB07GA0040).
    c. Victor Lake at the intake.
    d. Victor Lake at the outlet to the canal to Grande Cache Lake (note: document the direction of flow at time of sampling).

2. Collect water samples quarterly in 2015 – February (through the ice), May (after break-up), August (peak recreation season), and November (before freeze-up). Sampling should follow ESRD protocols and methods.
3. At sites a) and b), measure water temperature, specific conductance, pH, turbidity, redox potential, and dissolved oxygen at 0.5 m intervals to establish a profile from the surface to the lake bottom. Also measure Secchi depth.
4. Collect grab samples at each recommended site to be analyzed for:
   a. Bacteria – fecal coliforms and *E. coli*.
   b. Routine parameters, anions, and cations – alkalinity, hardness, pH, specific conductance, chloride, sulphate, and total dissolved solids.
   c. Nutrients – total and dissolved phosphorus; dissolved nitrate + nitrate-nitrogen (N), dissolved ammonia-N, total N; and chlorophyll *a*.
   d. Total suspended solids (also call non-filterable residue).
   e. True colour.
   f. Total metals.
5. When the lakes are observed from the profiles to be stratified at sites a) and b), samples should be obtained from both the epilimnion (upper layer) and the hypolimnion (lower layer).
6. For the recommended August sampling trip, obtain additional water samples at mid-depth from at least three locations (ideally 5) in Victor Lake in the area off-shore from the Co-op community and at least three locations away from the Co-op or recreational areas. This is to assess whether effects of private wastewater systems are detectable. These samples would be analyzed only for fecal coliforms, *E. coli*, nitrate-N, and chloride (i.e. indicators of domestic wastewater).
7. Compare the analytical results to Canadian Drinking Water Guidelines.
8. Compare the findings to previous monitoring conducted by ESRD to assess changes over time.

Prior to beginning the monitoring, ESRD should be contacted to see if they would undertake the sampling as part of their on-going lake or fisheries programs, or whether cost-sharing is feasible.

6 Follow-up Review and Adjustment of SWPP

6.1 RECOMMENDED SCHEDULE FOR PERIODIC REVIEW OF SWPP

The Source Water Protection Plan, as a component of the Grande Cache Drinking Water Safety Plan, is intended as a “living document” that is periodically reviewed and updated as actions are completed or to address emerging threats to drinking water safety (Government of Alberta 2013). The Level 1 Priority actions listed in Section 5.2 are recommended to be completed within two years, or the end of 2016. Therefore the SWPP should be reviewed and updated as necessary in the first quarter of 2017.

6.2 FRAMEWORK FOR PLAN UPDATES

The suggested framework for the recommended periodic SWPP review is as follows:

1. Convene a committee of stakeholders including but not necessarily limited to representatives of the Town of Grande Cache, the Victor Lake Co-op, the Grande Cache Lake Co-op, the Ministry of Health, and ESRD.
2. Review the source protection actions completed to date. Also review any changes to other components of the drinking water system that have been implemented as part of the overall DWSP.
3. Review the lake water quality and raw water quality monitoring data.
4. Based on the review, re-assess the hazard likelihood and consequence ratings.
5. Review and, if necessary, revise the list of recommended action items for source protection.
6. Document the process, recommendations, and schedule for action in a brief report. The report would also specify the timing for the next review of the SWPP.

7 Recommendations

Associated Engineering recommends that the Town implement the source water Priority Level 1 (within 2 years) and Level 2 (within 5 years) protection actions identified in Section 5.2. Furthermore, we recommend the Town periodically review and update this SWPP plan, with the first review scheduled for the first quarter of 2017.

Closure

This report was prepared for the Town of Grande Cache to develop the Source Water Protection Plan for the Victor Lake water source.

The services provided by Associated Engineering Alberta Ltd. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,
Associated Engineering Alberta Ltd.

April 14, 2015

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April 14, 2015

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ASSOCIATED ENGINEERING
QUALITY MANAGEMENT SIGN-OFF

Signature:

Date: April 14, 2015

APEGA Permit to Practice P 3979

Appendix A – Town of Grande Cache Drinking Water Safety Plan

Approval Holder Town of Grande Cache
Water Supply System Grande Cache Waterworks System
Approval Number 720-02-04
Location Town of Grande Cache

Last run: November-06-2013 19:07

	Risk Description	Risk I.D.	Hazard	Cause of Potential Failure	Comments	Current Monitoring	How Risk is Currently Controlled	Assess if Control is Adequate	Do any Standard Procedures cover this	Likelihood	Consequence	L'Hood Score	Cons. Score	Risk Score	Key Risk	Required Interventions to Prevent Failure	Responsible Party
Source Risks	Microbiological contamination of raw water resulting from wildlife activity in watershed.	DWSP-S-002	Microbiological contamination	Due to wildlife dying or defecating in watershed.	The area has a predominant wildlife population that access the watershed	Weekly e coli testing is done. Results are less than 10 normally less than 4	Monitoring is the only possible control	Yes	No	Probable	Severe	8	8	64	Yes	Review 2-year monitoring results to determine treatment process requirements for future.	Manager of Public Works & Utilities
Source Risks	Contamination of raw water with sewage	DWSP-S-004	Microbiological contamination	Resulting from sewage input to the source from private septic tanks or sewer outfalls.	The small communities located on the south side of Victor Lake have minimal control over their septic systems	None	No controls are in place	no	No	Probable	Severe	8	8	64	Yes	Review 2-year monitoring results to determine treatment process requirements for future. Inspect sewage diposal practices of the adjacent informal subdivision.	Manager of Public Works & Utilities
Source Risks	Chemical contamination of raw water as a result of proximity to transport corridor.	DWSP-S-005	Chemical contamination Hydrocarbons	Due to chemical contamination in the source due to spillage from transport corridor (e.g. road or rail tanker) adjacent to source and no containment.	The Town is located on vital and very busy transportation corridor. The lake is immdiately adjacent to Highway 40. The soils in the area are very porous	None	None in place	No	No	Almost Certain	Severe	16	8	128	Yes	Installation of hydrocarbon sensors and alarms in raw wet-well chamber that would shut-down raw water pumps. Confirmation with local RCMP and fire department to contact the Town of Grande Cache ASAP of any spills.	Manager of Public Works & Utilities
Source Risks	Chemical contamination of raw water as a result of mining activity drainage	DWSP-S-008	Heavy metals Hydrocarbons	Due to mine drainage discharge being contaminated or deoxygenated	There is heavy mining activity in the area however mine discharge and activity would appear to drain in to the () creek away from the town	None by the Town, the mine does monitoring	Provincial regulators and inspectors visit the mine on a regular basis	Yes	No	Medium	Severe	4	8	32	Yes	Communication with mining company about andy potential discharges or spills from the mine.	Manager of Public Works & Utilities
Source Risks	Chemical contamination of raw water as a result of recreational activity within watershed	DWSP-S-009	Microbiological contamination Hydrocarbons	Due to uncontrolled defecation or use of land or water vehicles within watershed	The area has camping, hiking, water skiing, hunting and fishing all in the area	None presently	Campgrounds with proper washroom facilities are in the area and well used. There is a component of bush camping but its less prevalent	The control is consistent with practices across the Province	No	Probable	Moderate	8	4	32	Yes	Ensure adjacent recreation areas have proper sealed washroom facilities and pump outs.	Manager of Public Works & Utilities
Source Risks	Deterioration of raw water as a result of flooding or heavy rain	DWSP-S-013	Turbidity	Due to inability to close intake when raw water has deteriorated.	There is no raw water storage and therefore the intake is susceptible to fluctuation in raw water quality from heavy rain or flooding	Turbidity monitoring is in place at the raw water pump house but no SCADA system to alarm operators is in place	Visual monitoring of the raw water turbidimeter	Alarming at a minimum should be provided	No	Probable	Severe	8	8	64	Yes	Have online turbidimeters alarm when water quality deteriorates to levels about 3 NTU	Manager of Public Works & Utilities
Source Risks	Deterioration of raw water from forestry activities	DWSP-S-014	Turbidity Colour Iron & manganese	Resulting from poor quality surface run-off from forestry activities due to forestry within watershed.	There is significant logging activity in the area which is controlled by AESRD.	None known at this time	None in place	No	No	Probable	Moderate	8	4	32	Yes	Discuss logging operation plans with AESRD. Ensure logging in general area of the lake is buffered to reduce erosion and run off impacting turbidity levels.	Manager of Public Works & Utilities
Source Risks	Contamination of raw water from forestry activities	DWSP-S-015	Fertilizers Hydrocarbons Microbiological contamination	As a result of forestry-related human activity within watershed.	Many forestry activities will result in chemicals being brought into watershed. Human waste may also produce pathogenic organisms.	Determine is there is a joint committee	None in place	No	No	Medium	Severe	4	8	32	Yes	Installation of hydrocarbon sensors and alarms in raw wet-well chamber that would shut-down raw water pumps. Discuss buffering and reporting of spills with AESRD.	Manager of Public Works & Utilities
Source Risks	Contamination of raw water as a result forestry fires	DWSP-S-016	Chemical contamination	Due to change in soil chemistry as a result of heat or run-off rate as a result of reduced vegetation	There is no raw water storage and there is close proximity to forestry activities. A fire is likely man or naturally caused	None	None in place	No	No	Probable	Moderate	8	4	32	Yes	Communicate with AESRD about the location of fires in particular in the Grande Cache lake area and Victor Lake.	Manager of Public Works & Utilities
Source Risks	Reduced resource availability due to break/leak on raw water mains	DWSP-S-035	Loss of supply	Resulting from raw water main breaks/leaks as a result of poor mains condition.	Lack of maintenance may lead to more frequent interruptions to supply.	Visual inspection and pressure readings	Monitoring and repair. There is two forcemains	Yes	No	Probable	Moderate	8	4	32	Yes	A pressure transmitter should be installed at the pump house so alarms can be sent if line pressure drops. Flowmeter should be installed at the pumphouse.	CAO & Council
Source Risks	Failure of pumps at Pump Station	DWSP-S-037	Loss of supply	Resulting from pumps failure due to insufficient/no standby generation if electricity supply fails.	A standby generator is located on the site.	Visual inspection and monitoring	There are two pumps that can be used if needed	Yes	No	Probable	Moderate	8	4	32	Yes	Automation and alarming is required to alert operator of a power failure.	CAO & Council
Source Risks	Loss of power to pumps as a result of electrical fault.	DWSP-S-038	Loss of capacity	Loss of power to pumps due to control panel fault resulting from insufficient maintenance.	Essential components need to be maintained regularly.	Inspection	Back up generator is provided	Yes	No	Almost Certain	Minor	16	2	32	Yes	Maintenance records need to be kept of pumps and regular maintenance completed.	Manager of Public Works & Utilities
Treatment Risks	Inadequate treatment due to poor contact chamber design	DWSP-T-003	Turbidity Microbiological contamination	Inefficient filtration due to incorrect contact time for coagulant.	The coagulant is injected at the raw water pump house and contact is in the pipeline. There is not way to measure the effectiveness	None	No Controls beyond sampling and coagulant dosage readings	A proper contact chamber should be installed	No	Probable	Severe	8	8	64	Yes	The effectiveness of mixing in the pipeline to the plant needs more study and sampling	Manager of Public Works & Utilities
Treatment Risks	Loss of supply caused by failure of heating at works inlet	DWSP-T-004	Loss of Supply	As a result of mechanical failure due to poor maintenance	No backup power is provided is provided at filter plant but there is at the pumphouse	Visual no temperature alarms	Visual monitoring only	Alarms are needed with the extreme climate in the region	No	Probable	Severe	8	8	64	Yes	Alarming is required when temperature drops to 5 C or lower.	CAO & Council
Treatment Risks	Breakthrough of contaminants as a result of poor floc formation caused by incorrect or no dosing	DWSP-T-007	Turbidity Aluminium Iron Microbiological contamination	due to poor floc formation due to incorrect coagulant dose due to flow meter out of calibration or signal failure due to inadequate maintenance	This plant does not have a contact tank or clarifier therefore it is very likely that this could occur. The plant has no SCADA system or automated controls to warn the operator of issues. Aluminum exceeds CDWQG	None beyond grab samples and visual observation	Samples are taken in the system weekly for microbiology and twice annually for chemical values	No this needs immediate correction	No	Almost Certain	Catastrophic	16	16	256	Yes	Improved monitoring and automation.	CAO & Council
Treatment Risks	Contamination caused by unauthorised human access	DWSP-T-008	Unknown contamination	Unauthorised human access may lead to contamination.	WTWs should be kept secure at all times when not attended.	Doors are locked. N	Locks only no alarm was evident	No alarms need to be installed	No	Probable	Severe	8	8	64	Yes	Alarms are not present at the pump house or plant to warn of unauthorized access.	

Approval Holder Town of Grande Cache
Water Supply System Grande Cache Waterworks System
Approval Number 720-02-04
Location Town of Grande Cache

Last run: November-06-2013 19:07

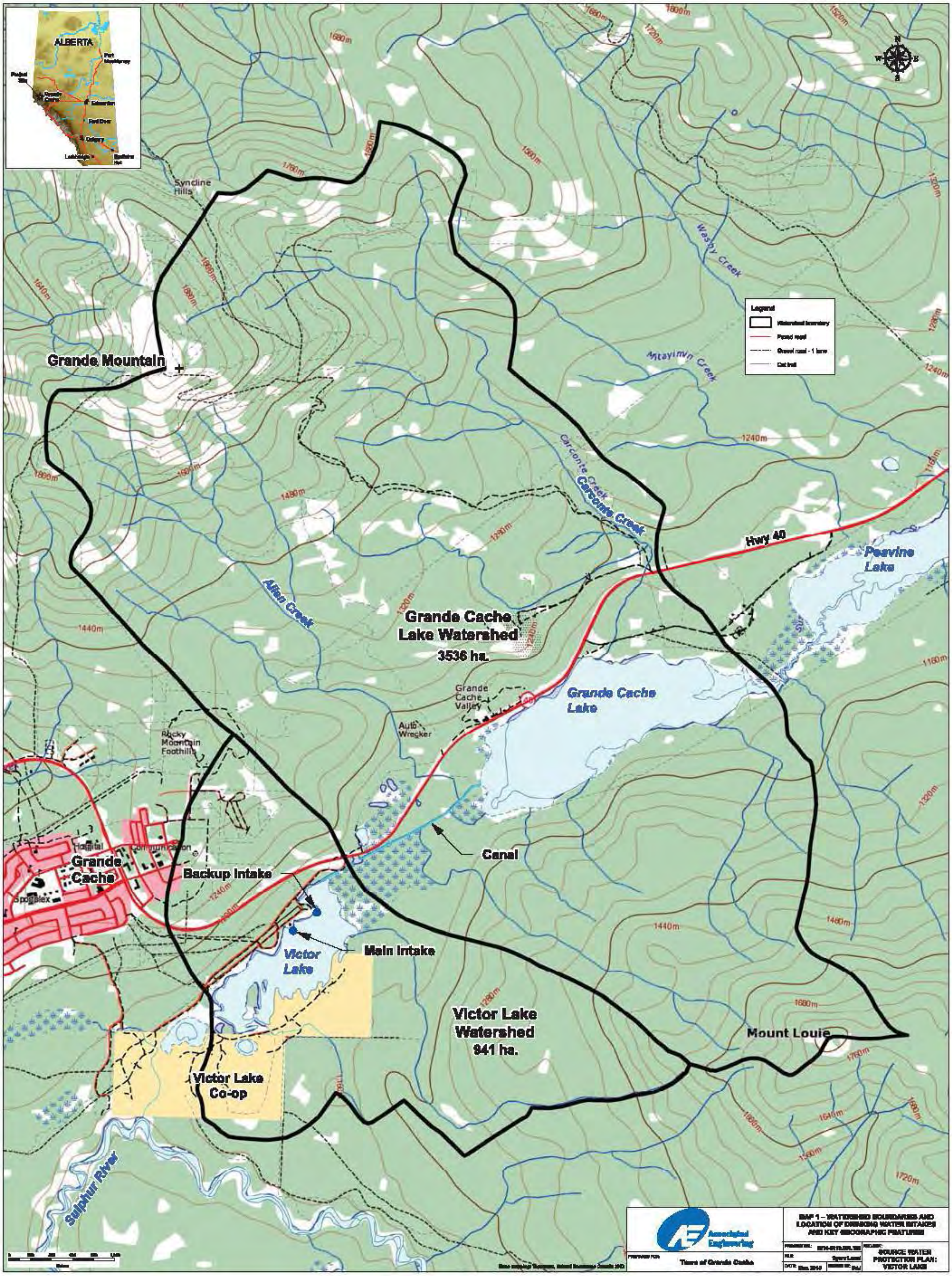
	Risk Description	Risk I.D.	Hazard	Cause of Potential Failure	Comments	Current Monitoring	How Risk is Currently Controlled	Assess if Control is Adequate	Do any Standard Procedures cover this	Likelihood	Consequence	L'Hood Score	Cons. Score	Risk Score	Key Risk	Required Interventions to Prevent Failure	Responsible Party
Treatment Risks	Deterioration of treated water quality as a result of failure of coagulant dosing	DWSP-T-010	Trace organics Turbidity Iron Manganese	As a result of failure to dose coagulant due to dosing line blocked.	There is no way to monitor the dosing pumps remotely	Visual monitoring only with daily records of weight utilized	The controls are minimal at best with daily visual monitoring	The controls in place are not adequate as SCADA and alarms are not in place	no	Almost Certain	Severe	16	8	128	Yes	The system can not be remotely monitored to determine if a pump failure has occurred. SCADA and alarming is required.	CAO & Council
Treatment Risks	Inability to meet demand as result of damage to single line interprocess pipework	DWSP-T-012	Loss of Supply	Structural failure due to failure of single line interprocess pipe work; i.e. Interruption to process.	The plant pressure systems are not alarmed or able to be viewed on SCADA	Visual monitoring and pressure observation	Observation only	The controls should include alarming rather than rely on visual monitoring	No	Medium	Severe	4	8	32	Yes	Install a pressure transmitter and alarm on the reservoir supply line. Install valve to isolate filter banks from each other.	CAO & Council
Treatment Risks	Inability to meet demand caused by power failure	DWSP-T-013	Loss of Supply		There is no generator on at the plant	Visual monitoring	Observation only	No back up power is provided at the plant however other facilities have power.	No	Probable	Moderate	8	4	32	Yes	Air valves and plant essential electrical should have backup power.	CAO & Council
Treatment Risks	Inadequate treatment caused by incorrect dosing of chemicals	DWSP-T-017	Chemical contamination	Due to incorrect dosing due to faulty equipment.	Possible with no controls	Daily testing and observation	None	No SCADA is needed so dosage pumps can be observed	No	Medium	Severe	4	8	32	Yes	Install SCADA to allow remote monitoring and alarming.	CAO & Council
Treatment Risks	Loss of supply resulting from failure of telemetry.	DWSP-T-018	Loss of supply	Due to plant shut down not being notified due to failure of telemetry	Further automation are needed. Lease from Telus provides communication and needs testing.	Alarm for communication failure	No controls in place	No	No	Probable	Severe	8	8	64	Yes	Plant has no automation that is functioning.	CAO & Council
Treatment Risks	Loss of supply resulting from failure of the control system	DWSP-T-019	Loss of supply	Due to inability to run the plant as a result of PLC software failure or to voltage variation and lack of power surge protection.	If control system fails the plant may not be able to run on manual.	None in place	None on failure only	No	No	Almost Certain	Severe	16	8	128	Yes	Plant has no automation that is functioning.	CAO & Council
Treatment Risks	Breakthrough of contaminants as a result of inadequate frequency for backwash.	DWSP-T-046	Suspended solids Trace organics Residual coagulant Microbiological contamination	Due to inadequate filtration due to overload of filter due to frequency of washing.	If allowed to operate in this way, the media may also become less efficient due to build up of dirt.	Backwashing operator initiated on turbidity readings	Observation of turbiditmeters	The control is not adequate as turbidity is taken from the cumulative total of all filters in series there is no other means to measure the results of backwash. For instance head loss is used.	No	Almost Certain	Moderate	16	4	64	Yes	Automation and additional turbidimeters are required. Pressure differential gauges should be replaced and connected to SCADA	CAO & Council
Treatment Risks	Breakthrough of contaminants as result of loss of media	DWSP-T-050	Suspended solids Trace organics Residual coagulant Microbiological contamination	Due to inadequate filtration due to inadequate media depth.	Media loss may be greater in dual media filters. Anthracite/ carbon has a lower density and is washed over more easily	2009 and 2013 inspections completed	Inspections are done every 4 years	Should be carried out every 1 year	No	Probable	Severe	8	8	64	Yes	Inspection of media quality and levels is needed.	Manager of Public Works & Utilities
Treatment Risks	Breakthrough of contaminants as result of failure to set correct coagulant or polyelectrolyte dose.	DWSP-T-051	Suspended solids Trace organics Residual coagulant Microbiological contamination	As a result of floc that is too soft or too small penetrating the bed more rapidly.	A rise in treated water turbidity may indicate a problem. Flocculation tests should then be done to check floc formation.	The system is sealed and therefore it is not possible to inspect.	No controls are in place presently	No samples should be taken on a regular (daily) basis from the supply line to the filters	No	Probable	Moderate	8	4	32	Yes	SCADA and further monitoring is needed of turbidity from each filter not cumulative totals.	CAO & Council
Treatment Risks	Contamination of treated water as a result of excessive formation of disinfection by-products	DWSP-T-066	Chemical contamination	As a result of excessive disinfectant dose and high levels of trace organics	Due to formation of disinfection by-products	THM testing is done quarterly	There are no organic reduction controls in place	No	No	Almost Certain	Catastrophic	16	16	256	Yes	DBP levels already exceed recommended levels. Organic control is needed in the treatment process.	CAO & Council
Treatment Risks	Failure of disinfection as a result of failure of chlorine gas flow	DWSP-T-068	Microbiological contamination	Due to failure of disinfection due to failure of delivery system.	A dual system is in place	Visual inspection only	Daily testing and visual inspection	Alarms are needed for low residuals	No	Almost Certain	Catastrophic	16	16	256	Yes	SCADA and alarming is required and residual monitors are needed.	CAO & Council
Treatment Risks	Failure of disinfection as a result of failure or lack of automatic shutdown following disinfection process failure	DWSP-T-071	Microbiological contamination	Due to WTW failing to shut down when disinfection fails.	No automated system is in place	Manual testing and visual inspection of online meters	No controls are in place	No SCADA is needed and alarming	No	Almost Certain	Catastrophic	16	16	256	Yes	There is no ability to shut down the system automatically.	CAO & Council
Treatment Risks	Inadequate treatment as a result of inability to meet disinfection requirements due to high chlorine demand	DWSP-T-073	Microbiological contamination	Due to inability to add sufficient chlorine due to high flow or high chlorine demand	No online monitoring or alarming	Manual testing and visual inspection of online meters	No controls	No automation and alarms are required	No	Probable	Catastrophic	8	16	128	Yes	Chlorine residual alarms are needed.	CAO & Council
Treatment Risks	Inadequate treatment as a result of insufficient contact time	DWSP-T-074	Microbiological contamination	Due to insufficient contact time to kill bacteria as a result of poor contact tank design or operating beyond design flow	CT results are not available	None in place	Baffles are in place but not inspected	No	No	Probable	Moderate	8	4	32	Yes	A CT and possible tracer study is needed to determine actual CT.	Manager of Public Works & Utilities
Treatment Risks	Inadequate treatment as a result of incorrect chlorine dose	DWSP-T-075	Microbiological contamination	Due to lack of residual controller and rapid change in chlorine demand, due to insufficient manual intervention.	There are residual analysers but not controlling the dosage	Visual and manual grab testing	Automation is not in place	No alarms need to be installed	No	Probable	Severe	8	8	64	Yes	Alarms need to be installed.	CAO & Council
Treatment Risks	Contamination of treated water as a result of vandalism	DWSP-T-081	Microbiological contamination Chemical contamination	As a results of actions by intruders	Lids and fences all need repair and inspection	Visual inspection	Inspection	Yes	No	Probable	Catastrophic	8	16	128	Yes	Install cameras and replace locks and screens	CAO & Council
Treatment Risks	Loss of potatable water supply from contamination	DWSP-T-201	Cotaminated water supply	Filter does not go automatically to waste on high turbidity	SCADA/Automation need to be updated	Visual Only	Visual monitoring only	No	No	Almost Certain	Catastrophic	16	16	256	Yes	Filters need to go to waste on high turbditiy levels	Manager of Public Works & Utilities
Network Risks	Loss of supply and/or deterioration of water quality as a result of broken main	DWSP-N-004	Loss of supply Chemical contamination Microbiological contamination	As a result of a broken main due to failure of pipe integrity.	May be as a result of many different circumstances	Visual inspections are completed but not documented	Inspection only	Alarms and meters would assist with early detection. Pressure is mostly gravity so pressure drops are hard to detect	No	Probable	Moderate	8	4	32	Yes	Flowmeters, pressure sensors, and SCADA is needed to better monitor the system.	
Network Risks	Contamination of water due to failure to follow proper hygiene practice when carrying out repairs.	DWSP-N-008	Chemical contamination Microbiological contamination	Due to ingress of material from excavation and/or poor disinfection procedures.	Operators should be fully trained in proper hygiene practice	Policy is not in place. No documentation regarding monitoring	No controls are in place	Documented procedures need and QA/QC process should be developed	No	Probable	Moderate	8	4	32	Yes	Establish standard operating procedures and documentation.	

Approval Holder	Town of Grande Cache
Water Supply System	Grande Cache Waterworks System
Approval Number	720-02-04
Location	Town of Grande Cache

Last run: November-06-2013 19:07

	Risk Description	Risk I.D.	Hazard	Cause of Potential Failure	Comments	Current Monitoring	How Risk is Currently Controlled	Assess if Control is Adequate	Do any Standard Procedures cover this	Likelihood	Consequence	L'Hood Score	Cons. Score	Risk Score	Key Risk	Required Interventions to Prevent Failure	Responsible Party
Network Risks	Failure to meet demand as a result of insufficient valves to isolate area affected by break	DWSP-N-015	Loss of supply	Due to high loss of water due lack of isolation of mains	Single crossing the highway is a risk for failure		No controls are in place	Inspections need to be documented	No	Probable	Moderate	8	4	32	Yes	Valve exercise and inspection program should be formalized and documentation kept. Consider installing an additional line across Highway 40.	
Network Risks	Failure to meet demand as a results of operating system above design pressure	DWSP-N-016	Loss of supply	Due to broken mains as a result of operating mains above design pressure.	The Town has a number of PRV stations to manage pressure	No formal maintenance or inspection program is in place	No controls are in place	No documentation and inspection is needed	No	Probable	Severe	8	8	64	Yes	An inspection program should be formalized and documentation kept.	
Network Risks	Pressure problems caused by PRV failure	DWSP-N-028	Loss of pressure High pressure	Pressure fluctuation due to the failure of PRV.	PRVs should be serviced as required.	PRV's are serviced but not on a predetermined schedule	Servicing and inspection	Program should be formalized and documented	No	Medium	Severe	4	8	32	Yes	Establish formal PRV maintenance schedule and documentation.	
Network Risks	Contamination of water due to ingress of water as a result of inadequate structure or maintenance.	DWSP-N-037	Chemical contamination Microbiological contamination.	Due to lack of structural integrity of reservoir as a result of poor design or maintenance	Common weaknesses are lids, ducting holes for cables, poorly sealed roof joints, air vents.	Visual inspections are completed but not documented	Inspection and maintenance	Documentation is needed and follow up on action list	No	Probable	Moderate	8	4	32	Yes		
Network Risks	Contamination of water due to reservoir running empty due to faulty or no telemetry.	DWSP-N-040	Chemical contamination	Due to disturbance of sediment on floor of reservoir due to low level as a result of lack of alarm.	Regular cleaning will help keep sediment build up to a minimum.	Visual only there is no alarms or telemetry on the e system	Inspection only	No , controls and alarms are needed	No	Probable	Moderate	8	4	32	Yes	Install a level sensor and alarm on the main reservoir.	
Network Risks	Contamination of water as a result of vandalism	DWSP-N-041	Chemical contamination Microbiological contamination.	Due to vandalism, due to lack of secure fencing and structure.	Degree of security required will depend on location.	The reservoir is adjacent to the public works yard but there is not an alarm in place for the evening	Visual inspection or reports from citizens	A camera and alarm would assist	No	Probable	Severe	8	8	64	Yes	Video and building alarms should be installed.	
Network Risks	Contamination of water due vermin accessing reservoir	DWSP-N-043	Microbiological contamination	Due to lack of mesh or flap valve on overflow from reservoir.		Screen on vent is damaged	Inspection only	Locks and screens need to be checked, and replaced as necessary	No	Almost Certain	Severe	16	8	128	Yes	All locks and screens should be inspected weekly and documented. Existing screen should be repaired	

Appendix B – Map 1: Watershed Boundaries and Location of Drinking Water Intakes and Key Geographic Features



ALBERTA
Syncline Hills
Grande Mountain
Wasby Creek
Legend
Mtayimn Creek
Carconte Creek
Hwy 40
Peavine Lake
Allen Creek
Grande Cache Lake Watershed
3536 ha.
Grande Cache Valley
Grande Cache Lake
Auto Wrecker
Rocky Mountain Foothills
Hospital
Grande Cache
Communication
Sportplex
Canal
Backup Intake
Main Intake
Victor Lake
Victor Lake Watershed
941 ha.
Mount Louie
Victor Lake Co-op
Sulphur River
SOURCE WATER PROTECTION PLAN: VICTOR LAKE

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