



AECOM



Greater Vernon Water (GVW)

Technical Memorandum No. 2 Evaluation of Water Supply Sources

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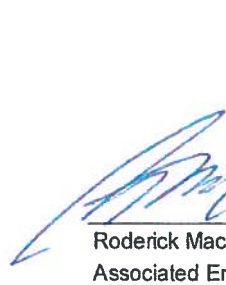


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Technical Memorandum No. 2: Evaluation of Water Supply Sources

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1. Introduction

Greater Vernon Water (GVW) relies on surface water sources for its raw water supply. The two major sources, Kalamalka / Wood Lake and the Duteau Creek watershed, are subject to limitations such as water licensing, available run-off and storage. Although both are surface water sources, each have very different water resource characteristics as it pertains to the water utility. Water from the Duteau Creek source is collected and drawn from an upland (plateau) watershed and associated lakes which serve as reservoirs. Kalamalka / Wood Lake is a valley-bottom lake and source water includes contributing surface water and groundwater (Clarke Geoscience, 2011)

The Duteau Creek watershed contains a group of reservoirs, diversions and control structures originally constructed by the past Vernon Irrigation District. The combined live storage capacity of Aberdeen, Haddo and Grizzly reservoirs is currently 18,340 ML (See TM No. 3 – Source Storage and Supply for further detail). In addition, the Gold-Paradise Diversion supplements flow to the Duteau system from the neighbouring Harris Creek Watershed.

The Kalamalka / Wood Lake levels are controlled by an outlet structure which releases flows to Vernon Creek. The Province is responsible for operation of this structure, and typically maintains water levels to satisfy license, fish habitat, recreation and minimum flow levels in Lower Vernon Creek. GVW holds 15 consumptive use water licenses (8,842 ML/yr) on Kalamalka / Wood Lake (see Table 2-1).

Other water sources licensed by GVW also include Deer Creek, B.X. Creek and Coldstream Creek. There are also existing groundwater sources for Antwerp Springs and Coldstream Ranch, as well as potential aquifers throughout the region capable of providing localized non-potable water supplies.

1.1 Report Objectives

The specific objectives of this report include:

- A review and update of the watershed hydrology in the Duteau Watershed to confirm runoff estimates, and long term supply expectations; and
- Evaluating other sources to determine yield based on a 50 year drought return frequency.

The following specific objectives also form part of this study; however, will be addressed in other memoranda.

- Reviewing watershed improvement possibilities that improve yield or water quality. Assess based on existing water quality data and to recommend monitoring programs where data is insufficient;
- Analyzing expected future trends in raw water quality and the level of treatment required to meet the anticipated water use under the current and expected future regulatory criteria; and
- Prioritizing supply sources using an index based on available quantity, raw water quality, proximity to the user, suitability for potable or agricultural use and cost to develop as a regional supply.

Note that water quality issues will be addressed in TM No. 7 – Water Treatment.

2. Background

2.1 GVW Water Supply Characteristics

Duteau Creek and Kalamalka / Wood Lake are the primary drinking water sources for GVW. Although both are surface water sources, each have very different water resource characteristics as it pertains to the water utility. Water from the Duteau Creek source is collected and drawn from an upland (plateau) watershed and associated lakes, which serve as reservoirs. Kalamalka / Wood Lake is a valley-bottom lake and source water includes contributing surface water and groundwater (Clarke GeoScience 2011).

The hydrologic regime of the Duteau Creek watershed is dominated by snowmelt and therefore, snow pack depth and timing of snowmelt dictate the supply status of upland reservoirs. Snow pack depth reaches the maximum in late March, early April, while snowmelt starts to fill the reservoirs after this date. Historical data indicates that by the middle of May, the seasonal snow pack is generally gone. This date represents the tail end of the snowmelt season. In normal years; the reservoirs would be nearing capacity by June. After this time, water supply is dependent on precipitation inputs. The summer period also corresponds to the period of peak irrigation demand, with maximum consumption between mid-July and mid-August. In the summer, because stored water is being consumed at a rate that far exceeds inflow, reservoir levels start dropping.

Kalamalka / Wood Lake, due to its large storage capacity and long turnover rate is much less susceptible to the annual variations in snow pack depth. Besides Upper Vernon Creek, Oyama Creek, and Coldstream Creek, abundant groundwater springs provide source inflows to Kalamalka / Wood Lake.

2.2 Okanagan Basin Water Supply and Demand Project

In 2004, the B.C. Ministry of Environment initiated the Okanagan Water Supply and Demand Project (OWSDP). The OWSDP is a multi-phase work program focused on improving the state of knowledge of the water resources of the Okanagan Basin (Summit 2010). The OWSDP is currently in Phase 3, with Phases 1 and 2 completed in 2005 and 2010, respectively. Phase 1 identified and evaluated the information available for a comprehensive basin-wide analysis of water supply and demand in the Okanagan Basin and identified data gaps, while Phase 2 was a series of scientific investigations and hydrologic modeling to determine the current supply and demand of water, as well as potential future changes. Phase 3 is focused on updating and improving the Phase 2 data and models and turning the results into policy.

Included in Phase 2 of the OWSDP, a "Surface Water Hydrology and Hydrologic Modeling Study" was completed. This study documented and summarized the current state of knowledge of surface water flows in the Okanagan Basin and developed naturalized flow data for inclusion within a hydrologic model using the MIKE SHE modeling platform (referred to as the Okanagan Water Accounting Model). Naturalized stream flow estimates were developed at 72 points-of-interest (including Vernon Creek at the mouth) for a 1996-2006 calibration period. In addition to the surface water study, groundwater investigations were also completed that identified aquifers (bedrock and alluvial) and their recharge and supply characteristics across the Okanagan Basin. Accordingly, using GVW's previous water supply information and the information summarized and developed from the OWSDP, GVW's water supply estimates and long term supply expectations were updated.

2.3 Water Licences

Water license information for the Greater Vernon Area, including Duteau Creek and Kalamalka / Wood Lake watersheds was extracted from the province's Web License database in January 2012. The licenses were then grouped and reviewed for duplication and adjusted depending on storage location. The results of the search are found in **Table 2-1**.

GVW holds 58,115 ML of licenses within watersheds or sub-watersheds. Of this quantity, 38,379 ML is considered irrigation licenses, and the remaining are for domestic use by a purveyor (called "waterworks"). The largest quantity of water is out of Duteau Creek, where 34,582 ML is allocated to GVW. There is currently 33,051 ML of storage licenses allocated to the Duteau system; however, only 28,369 ML are allocated within the Aberdeen, Haddo, and Grizzly Reservoirs. The remaining Duteau storage is contained in Goose Lake and a minor quantity in Kalamalka / Wood Lake.

3. Water Source Review

The following sections provide a summary and review of each of GVW's water sources.

3.1 Duteau Creek Watershed

The GVW water supply intake is located on Duteau Creek at the Headgates Diversion (**Figure 1-2**), and is supplemented by flows from Aberdeen, Haddo, and Grizzly Reservoirs. In addition, water is diverted from the Harris Creek watershed into the Duteau Creek watershed by the Gold-Paradise Diversion.

The Duteau Creek watershed upstream of the Headgates Diversion consists of five sub-watersheds (**Figure 1-2**):

- Aberdeen Reservoir – Aberdeen reservoir is supplied by a watershed area of 45.6 km². The watershed produces a relatively large volume of runoff to be stored in June and July from snow melt. The reservoir, with a median watershed elevation around 1,394 m, can also be supplemented from the Grizzly watershed through a constructed diversion. The capacity of this diversion is unknown;
- Grizzly Reservoir – This reservoir is approximately 10 metres higher than Aberdeen at full supply level, and regulates flow from a 51 km² watershed. The watershed has good run-off potential with a median elevation of 1,384 m;
- Haddo Reservoir – The Haddo system is supplied from both the Grizzly and Aberdeen Reservoirs. The small sub-watershed of the Haddo Reservoir consists mainly of the lake, surrounding land, including a small portion of land north of the diversion channel between the Grizzly and Aberdeen Reservoirs;
- Gold-Paradise Diversion – This sub-watershed is in the Harris Creek watershed, but is diverted into Heart Creek through approximately 3 km of interceptor channel, two head ponds, and a diversion structure on Paradise Creek. The channel intercepts water from both Paradise and McAulay (Gold) Creeks. Higher unit run-off rates are produced from this watershed due to the higher median elevation of 1,788 metres; and
- Lower Duteau Creek – This sub-watershed is not supported by any reservoir (except the headgate pond). The basin produces considerable run-off; however, little is considered usable. Past estimates assumed that only 1,700 ML of this was useable on an annual basis due to the small amount of storage and the run-off occurring early in the year (Mould 2006).

Table 2-1. Summary of Water Licenses within Greater Vernon Water

Licensee	No. of Licenses	Other Licenses		GVW Licenses	
		Consumption (ML/yr)	Storage (ML)	Consumption (ML/yr)	Storage (ML)
<u>Duteau Creek</u>					
Other Private Licenses	5				
Private Irrigation	4	485			
Fisheries and Oceans Canada	2	110 lps			
Village of Lumby	1	830			
GVW Waterworks ¹	7			2,720	
GVW Irrigation	2			21,995	
Gold-Paradise Creek Diversion (Irr)	1			9,868	
Fisheries and Oceans Canada	1		1,233		
Duteau - Aberdeen/Grizzly/Haddo	2				28,369
Duteau - Goose Lake	2				4,515
Duteau - Kalamalka Lake	1				167
Sub-total	28	1,315	1,233	34,582	33,051
<u>Kalamalka Lake</u>					
Other Private Licenses	93				
Private Irrigation	21	800			
RDCO	1	25			
Lake Country (Waterworks & IRR)	6	1,734			
Fisheries and Oceans Canada	0	Remainder			
GVW Waterworks ¹	12			8,842	
Sub-total	133	2,559	-	8,842	-
<u>Deer Creek</u>					
Private Irrigation	1	909 lpd			
Private Storage	1		37		
GVW Irrigation	12			3,700	
GVW Irrigation (King Edward Lake)	1			-	1,357
Sub-total	15	-	37	3,700	1,357
<u>BX Creek</u>					
Other Private Licenses	1				
Private Irrigation	7	570			
Private Storage	3		207		
GVW Conservation Storage	1				326
MOE Conservation Storage	1		2,467		
GVW Waterworks	4			7,716	
GVW Irrigation	1			1,505	
Sub-total	18	570	2,674	9,221	326
<u>Coldstream Creek</u>					
Other Private Licenses	4				
Private Irrigation	4	37			
Private Storage	1		17		
GVW Waterworks	1			415	
Sub-total	10	37	17	415	-
<u>Okanagan lake</u>					
GVW Watering	1			0.15	
GVW Irrigation	2			896	
GVW Waterworks	12			459	
Sub-total	14	-	-	1,355	-
Total Licenses	204	4,481	3,961	58,115	34,734

Notes:

1. Licenses C025665 (494 ML/y) and C025909 (166 ML/y) are diversion licenses from Duteau and counted in Kalamalka Lake.
2. Nicklen Lake Licenses not included.
3. Total 61 licenses for GVW
4. Source - Ministry of Environment - Web License Database (December 21, 2011)

The water supply estimates in **Table 3-1** for Duteau Creek were based on the following:

- The Duteau Creek watershed is located in the Okanagan Highlands Hydrologic Zone #23; subzone “c” (Obedkoff 2003). Streams within this hydrologic zone are generally characterized by a snow-melt dominated peak rising in April or May and peaking sometime between May and June. Rain-on-snow events occasionally occur in this region; therefore, winter flows and spring peaks can be enhanced. In addition, late rainstorms are common, recharging soil moisture heading into winter and producing short-duration peak flows. Low flows occur generally from the end of November to March, and in the hot summer months, with the lowest flows commonly occurring in January or February;
- Drainage areas and median elevations were updated using available GIS coverage and digital elevation information (Land Resources Data Warehouse 2011);

Table 3-1
Duteau Creek Watershed – Water Supply Estimates

Sub-basin	Drainage Area (km ²)	Elevation Range (m)	Median Elevation (m) ¹	Mean Annual Runoff		1:10 Year Low Flow (57% Mean)	1:50 Year Low Flow (37% Mean)
				Depth (m)	Volume (ML)		
Aberdeen Reservoir	45.6	1278 – 1860	1394	0.29	13,389	7,632	4,954
Haddo Reservoir	3.7	1266 – 1387	1300	0.24	883	503	327
Grizzly Reservoir	51.3	1284 – 1923	1384	0.29	14,735	8,399	5,452
Gold-Paradise Diversion	6.6	1658 – 1924	1788	0.70	4,611	2,628	1,706
Total (not including Lower Duteau Ck)					33,618	19,162	12,439
Lower Duteau Ck	71.2	664 – 1463	1309	0.24	17,340	9,935	6,416
Total Duteau Watershed					50,958	29,097	18,855

Notes:

1. Median elevations calculated for contributing land areas only.
2. Distribution types fit reasonably well; therefore, the results were averaged and used in calculating the mean values and 95% confidence limits.

- This analysis used the annual runoff vs. median elevation relations developed during Phase 2 of the OWSDP (Summit 2009). The Okanagan Basin's Hydrologic Group 8 runoff relationship was assumed representative of the Duteau Creek watershed, which is similar to the runoff relationship developed by Obedkoff (1998) for the Okanagan Highlands Hydrologic Zone #23 (**Figure 2**). The

OWSDP runoff relationship is naturalized to a 1996-2006 period, while the Obedkoff (1998) is naturalized to a 1961-1990 period. In order to ensure consistency of periods of records between runoff relationships and all of GVW's water sources, any differences in periods of record were eliminated by standardizing all records using the Water Survey of Canada (WSC) station "Kettle River near Ferry" (WSC Station No. 08NN013), which has records extending from 1929-2010. This station was selected because it contains the longest continuous record of natural streamflow in proximity to the Okanagan Basin and is expected to be generally representative of the hydrologic regime of the Okanagan Basin;

- The annual water supply for Duteau Creek watershed was updated using the standardized mean of the 1996-2006 period, assuming no useable runoff from the Lower Duteau Creek watershed. The standardized mean results are similar to the standardized annual runoff estimates by Obedkoff (1998) for watersheds with similar median elevations; and
- 1-in-10 and 1-in-50 year low flow annual water supply estimates were estimated using the low flow frequency analysis curve for the east side of the Okanagan Valley developed by Letvak (1985).

3.2 Okanagan Lake

Okanagan Lake abuts into the west end of the City of Vernon and is likely the largest and most reliable future source of water to meet the long term growth of the Greater Vernon area. It is the primary water source for the cities of Kelowna and Penticton, as well as a number of smaller centres.

The water supply estimates in **Table 3-2** for Okanagan Lake were based on the following:

- Annual net inflows into Okanagan Lake developed by the River Forecast Center from 1922 – 2010. The net inflow is the difference between lake outflow and change in lake storage and is an indicator of the natural inflows into Okanagan Lake. Net inflows integrate the influence of streamflow into the lake, precipitation on to the lake, evaporation from the lake, groundwater inflows and outflows to and from the lake, and water use from the lake;
- The annual net inflow estimate was updated and assumed equal to the 1922 - 2010 mean;
- Return period estimates of 1-in-10 year and 1-in-50 year net inflows to Okanagan Lake were also estimated. For the return period estimation, four different distribution types (Pearson Type III, Log Pearson Type III, Log Normal, and Gumbel) were fitted to the data using the B.C. Ministry of Environment, Lands, and Parks (MELP) Flood Frequency Analysis Program (version 1.1). The general procedure for estimating individual return periods from the MELP program involves visually inspecting and assessing the goodness-of-fit for each distribution.

3.3 Kalamalka / Wood Lake

Kalamalka / Wood Lake (or "Kal Lake") is a valley-bottom lake that flows via lower Vernon Creek into Okanagan Lake. The lake has a surface area of 35 km² and an average depth of 142 m, which is considered deep relative to its size. Source flows into Kalamalka / Wood Lake include upper Vernon Creek, Oyama Creek, Coldstream Creek, and abundant groundwater springs. The lake typically reaches full-pool by the end of June. A weir on the lower Vernon Creek outlet controls lake levels and is operated by the MOE.

Due to its depth and lack of contributing sources, the lake has a low rate of turnover of 55-65 years. Water quality issues and additional source characterization are addressed in a recent Source Water Assessment report (Larratt Aquatic 2010). GVW operates a single drinking water intake, located approximately 250 m off the north shore of the lake at a depth of approximately 20 m.

Table 3-2
Summary of Water Source Supplies for GVW

Water Source	Mean Annual Supply (ML)	1:10 Year Mean Annual Low Flow (ML)	1:50 Year Mean Annual Low Flow (ML)
Duteau Creek Watershed	33,618	19,162	12,439
Okanagan Lake	476,834	190,250	66,300
Kalamalka Lake	27,069	10,557	3,763
B.X. Creek	9,107	5,009	3,461
Coldstream Creek	7,668	3,911	2,377
Deer Creek	5,856	3,338	2,167
Groundwater	53,352	-	-

GVW is currently allocated 8,842 ML per year from water licenses from Kalamalka / Wood Lake. A license adjudication process conducted in 2001 by the Province resulted in the following:

- No existing water licenses on the Kalamalka / Wood Lake system were adversely affected;
- A minimum of 0.085 m³/s (3.0 ft³/s) flow needs to be maintained in Lower Vernon Creek for fish flows. If any additional water were made available, either through license transfers or changes in hydrology, water licenses would be held to increase the fish flows on Lower Vernon Creek to meet a 0.235 m³/s (8.3 ft³/s) suggested requirement;
- It was felt that GVW had adequate water available in its existing water sources. Any additional water sourcing would be available off Okanagan Lake; and
- Kalamalka / Wood Lake was declared fully allocated. No further water licenses would be made available of this system and any remaining water would be designated for fish flows.

Most of the water licenses also have maximum allowable diversion rates on Kalamalka Lake. Information for the relevant GVW licenses is found in **Table 3-3**, where we note a maximum allowable diversion rate at the Kalamalka Lake Intake to the City of Vernon is 46.9 ML/d. An additional 6.71 ML/d is diverted through three other points of diversion.

There are two additional licenses (Conditional Licenses C025665 and C025909) off Duteau Creek for 493 ML/yr (maximum diversion rate of 5.91 ML/d) for diversion and use at the Kalamalka Lake Intake and 166 ML/yr (0.45 ML/d) at other points of diversion on Kalamalka Lake. These licenses were issued in 1960. These licenses are both supplemental and linked to licenses C025666 and C025732 (See table 3-3). In discussions with GVW staff, there is no control gate or valve operated off the Duteau system enabling this license or diverting water into the Coldstream Creek watershed.

The water supply estimates (**Table 3-2**) for Kalamalka / Wood Lake were based on the following:

- Annual net inflows into Kalamalka / Wood Lake were estimated by Letvak (1992), which included annual estimates from 1960-1990;

- The Kalamalka / Wood Lake net inflows cover a different time period than the remainder of GVW water sources; therefore, to eliminate any differences (e.g. climatic variability) all records were standardized using the Okanagan Lake net inflow estimates, which has records extending from 1922 to 2010. The Okanagan Lake net inflow estimates were selected because they contain the longest continuous record and are expected to be representative of the hydrologic regime and water use patterns of the Vernon area; and
- Return period estimates of 1-in-10 year and 1-in-50 year net inflows into Kalamalka / Wood Lake were estimated assuming the same annual low flow characteristics as the net inflows of Okanagan Lake.

The implication of water transfers to Kalamalka Lake and Okanagan Lake is discussed further in Technical Memorandum No. 3 – Source Storage and Supply.

Table 3-3
Summary of Kalamalka Lake Consumptive Use Water Licenses

License Number	Priority	Quantity (ML)	Maximum Allowable Diversion Rate (ML/d)	Season
Kalamalka Lake Intake (Kal Lake Pump Station - Point of Diversion 57964)				
C025666	19600119	494	5.91	All Year
C032474	19640319	996	2.73	All Year
C062306	18720531	1,863	15.31	All Year
F009242	19301121	2,389	7.73	All Year
F072833	19671128	880	7.23	All Year
C062307	18930821	975	8.01	All Year
Sub-total		7,595.9 ML/y	46.9 ML/d	
Other Intakes (Points of Diversion 57990, 57952, 57954)				
C022235	19540706	166	0.45	Apr-Sep
C025732	19590213	166	0.45	All Year
C059154	19681205	617	5.00	All Year
C024587	19580417	12	0.03	All Year
C025731	19450307	211	0.58	Apr-Sep
C036203	19410220	74	0.20	Apr-Sep
Sub-total		1,245.7 ML/y	6.71 ML/d	
Total GVW		8,842 ML/y		

Notes:

1. Stream Name: Kalamalka Lake
2. Licensee: North Okanagan Regional District
3. License Status: Current
4. Source: Ministry of Environment - Web License Database (December 21, 2011)

3.4 B.X. Creek

Diversions from B.X. Creek, once an original source of water for the City of Vernon, were decommissioned in 2000 due to water quality issues. GVW continues to hold water licenses for irrigation off the creek, and remains a possible source for non-potable agricultural supply should system separation be recommended as part of this plan. New capital would be required for a new dam, reservoir, spillway, intake and pipeline into the distribution system.

The water supply estimates in **Table 3-2** for B.X. Creek were based on the following:

- The WSC operated a hydrometric station on B.X. Creek above the municipal intake from 1960 to 1999 (WSC Station No. 08NM020, "B.X. Creek above Vernon Intake");
- The B.X. Creek natural flows above the municipal intake cover a different time period than the remainder of GVW water sources; therefore, to eliminate any differences (e.g. climatic variability) all records were standardized using the 1929-2010 records from the WSC station "Kettle River near Ferry" (WSC Station No. 08NN013);
- The annual water supply estimates for B.X. Creek are assumed equal to the standardized mean of the 1960-1996 records;
- Letvak (1985) provided an estimated low flow frequency analysis curve for the east side of the Okanagan Valley; however, using the mean annual runoff records provided by the WSC on B.X. Creek, specific low flow statistics (1-in-10 year and 1-in-50 year return periods) were calculated using the MELP Flood Frequency Analysis Program (version 1.1).

3.5 Coldstream Creek

Coldstream Creek has been identified as an additional domestic water source. The small size of the watershed and additional capital costs for water treatment, however, may not benefit GVW in the long term. However, there is potential to establish this source for irrigation use.

The water supply estimates in **Table 3-2** for Coldstream Creek were based on the following:

- The WSC operated a hydrometric station on Coldstream Creek above the municipal intake from 1968 to 2010 (WSC Station No. 08NM142, "Coldstream Creek above Municipal Intake");
- The Coldstream Creek natural flows above the municipal intake cover a different time period than the remainder of GVW water sources; therefore, the records were standardized using the 1929-2010 records from the WSC station "Kettle River near Ferry" (WSC Station No. 08NN013);
- The annual water supply estimates for Coldstream Creek are assumed equal to the standardized mean of the 1968-2010 records;
- Letvak (1985) provided an estimated low flow frequency analysis curve for the east side of the Okanagan Valley; however, using the mean annual runoff records provided by the WSC on Coldstream Creek, specific low flow statistics (1-in-10 year and 1-in-50 year return periods) were calculated using the MELP Flood Frequency Analysis Program (version 1.1).

3.6 Deer Creek

Deer Creek at the outlet of King Edward Lake is considered a limited source for expanding irrigation water supply (NOWA 2002). Upgrades were completed in 2011 to provide a seasonal supplement to the irrigation supply. Its future potential is limited due to potential water quality issues and small size of the watershed (20.3 km²).

The water supply estimates in **Table 3-2** for Deer Creek were based on the following:

- The drainage area (20.3 km²) and median elevation (1387 m) was calculated using available GIS coverage and digital elevation model (Land Resources Data Warehouse 2011);
- Using the annual runoff vs. median elevation relations developed during Phase 2 of the OWSDP, the runoff relation for Hydrologic Group 8 (same as Duteau Creek watershed) was assumed to be representative of the runoff relationship of the Deer Creek watershed (**Figure 2**). Similar to the other water sources, the Deer Creek estimates were standardized using the 1929-2010 records from the WSC station "Kettle River near Ferry" (WSC Station No. 08NN013);
- The annual water supply estimates for Deer Creek watershed are assumed equal to the standardized mean of the 1996-2006 period. The standardized mean result is similar to annual runoff estimates by Obedkoff (1998) for watersheds with the same median elevation; and
- Letvak (1985) provided an estimated low flow frequency analysis curve for the east side of the Okanagan Valley; therefore, the curve was assumed to represent low flows characteristics of the Deer Creek watershed for the 1-in-10 and 1-in-50 year return period.

3.7 Groundwater

Groundwater remains a key potential source for non-potable supply within GWV. High volume wells are viable options for non-potable agricultural supply should system separation be recommended as part of this plan. As part of this study, aquifers within the Vernon area identified by Summit & Golder (2009) were reviewed. A total of five aquifers were identified within the Vernon area and estimates of total sustainable aquifer discharge were calculated for each aquifer (**Table 3-4**).

As earlier stated, a key parameter in Kalamalka Lake water supply is groundwater. The impacts of large volume extractions downstream are unknown.

Table 3-4
Aquifers within the Vernon Area.

Aquifer number	General location	Annual Discharge (11 yr mean) ¹	
		(ML)	Average Day (ML/d) ²
266	Coldstream Valley	17,900	49
269	Vernon Centre	14,700	40
270	B.X. Valley	12,800	35
271	Swan Lake area	152	0.4
262	Okanagan Landing	13,800	38

Note:

1. Discharge volumes represent the total volume of water that can be removed sustainably (at the cost of end uses down gradient) before mining of an aquifer occurs.
2. Well capacity and water quality will vary by location.

There is speculation under current Water Act modernization proceedings that licenses for groundwater extraction may be required in the near future. Given the quantities for supply being considered as options in this Master Water Plan, there may be significant costs or regulatory requirements in the future related to

large volume well installations. These costs may come in the form of restrictions, monitoring requirements, environmental approvals in sensitive aquifers or even moratoria on new large withdrawals.

4. Discussion and Summary

GVW is currently dependent on the Kalamalka/Wood Lake and Duteau Creek watersheds for water supply, while Coldstream Creek, B.X. Creek, and groundwater have been historical sources. With water licence restrictions on Kalamalka/Wood Lake and annual variabilities in the annual upland water supplies, Okanagan Lake has been identified as the most sustainable future supply source. The implication of potential transfers of these licenses to Kalamalka Lake and Okanagan is discussed in more detail in Technical Memorandum No. 3 – Source Storage and Supply.

Climate change imposes a risk to streamflows and water supplies in the Okanagan Basin, which could potentially impact GVW due to its dependence on lake and upland water sources. Climate change studies for the Okanagan Basin suggest that the total precipitation and evapotranspiration will not significantly change, however the average temperature is expected to increase (Summit 2010). As a result, the predicted temperature increases are suggested to cause warmer winter temperatures, resulting in more winter precipitation in the form of rain, thereby increasing streamflows during the winter. As such, peak flows are predicted to occur approximately 2 to 4 weeks earlier with smaller magnitudes, while summer low flow periods are suggested to be extended over the long term (Summit 2010).

In addition to the climate change predictions, various future water demand, population growth, water efficiencies, and irrigation type scenarios were also completed for the Okanagan Basin during Phase 2 of the OWSDP. As such, GVW should consider the following Phase 2 results for the Okanagan Basin (outlined by Summit (2010)) prior to making future water management decisions:

- The levels of Okanagan Lake are likely to remain within their “normal” range of lake levels during normal and wet years, but could be near or below the “normal” range during dry years. This has potential implications for the allocation of water licences on Okanagan Lake.
- The impacts of climate change on upland reservoirs will likely include an earlier filling due to an earlier onset of spring temperatures, smaller storage volumes due to smaller snow accumulations in the winter, an earlier drawdown of storage due to smaller spring snowmelt runoff volumes, and less stored water available in the late summer due to a longer summer season.
- In a future 3-year drought, climate change is expected to increase annual water demands by 16% relative to the present, which could increase to 25% if the irrigated agricultural land base increased to its potential size.

5. Recommendations

The following recommendations are included to help ensure long term water supply reliability for GVW:

1. Due to GVW's dependence on water supply from the Duteau Creek watershed, it is recommended that a more extensive hydrometric monitoring network be considered (in addition to the three current gauging stations) in order to measure water levels in and outflows from each reservoir of interest. By monitoring the water levels and outflows, a preliminary water balance could be developed for each reservoir (and associated sub-basin), which would help provide improved estimates of inflows into each reservoir. By implementing this monitoring program, together with GVW's snow survey, soil moisture, and groundwater monitoring programs, forecasting of water

supply for each year could be improved, which would help with water management and planning decisions;

2. If a groundwater supply source is deemed feasible, it is recommended that a groundwater supply assessment and characterization be completed prior to any supply well development;
3. Should a new water source ever be required in the future, the best option both technically and viably is a new license out of Okanagan Lake. Therefore, GVW should consider a long term license reserve from Okanagan Lake for 50,000 ML/year.

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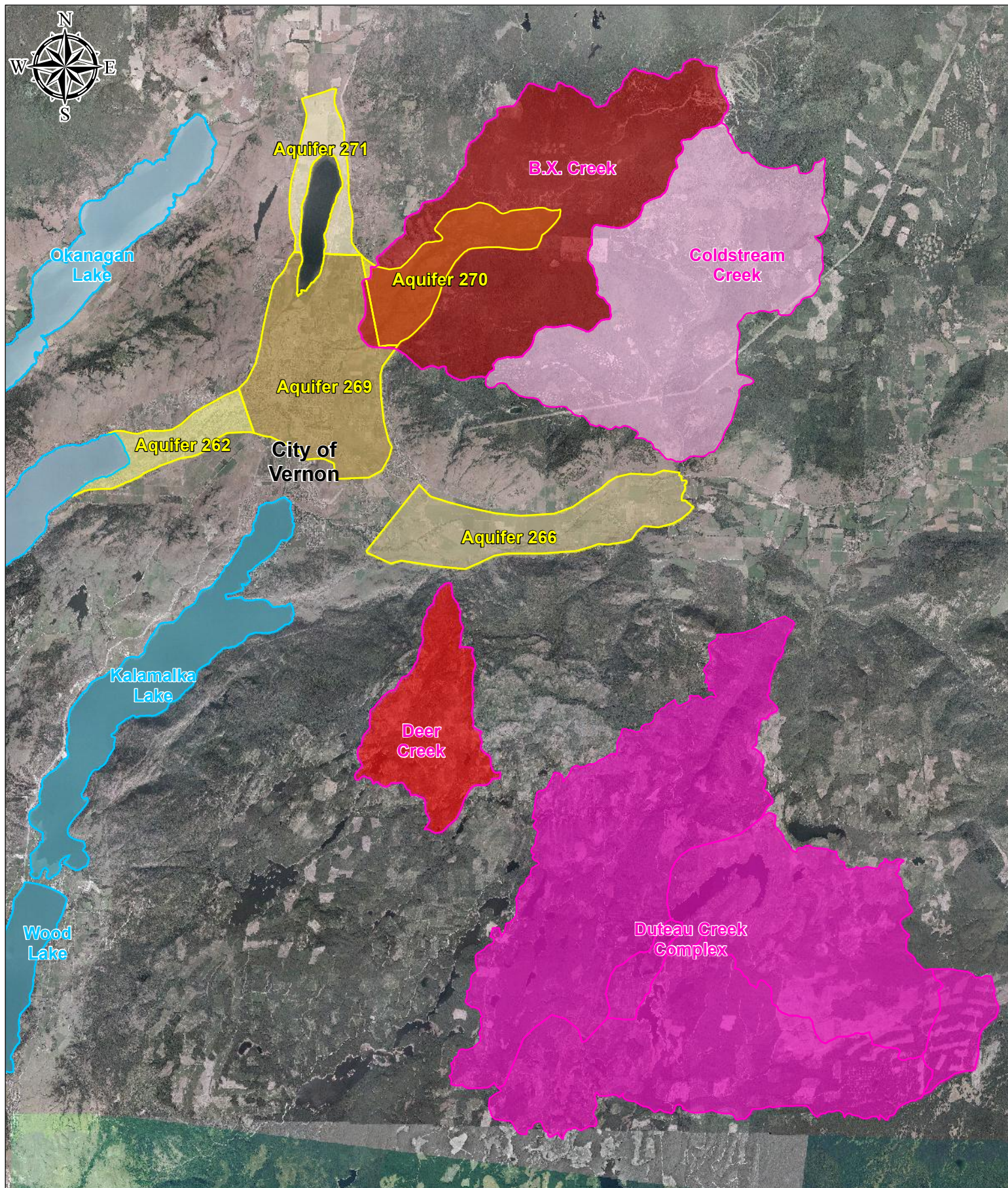
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Appendix A- Figures



Lake Sources

■ Kalamalka / Wood Lake
■ Okanagan Lake

Aquifer Sources

■ 262 ■ 267 ■ 271
■ 266 ■ 270

Watershed Source Areas

■ B.X. Creek ■ Deer Creek
■ Coldstream Creek ■ Duteau Creek

0 5 km

DATE:
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(132)

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DA

PREPARED FOR:
**North Okanagan
Regional District**

Figure 1-1: Greater Vernon Water (GVW) Supply Sources

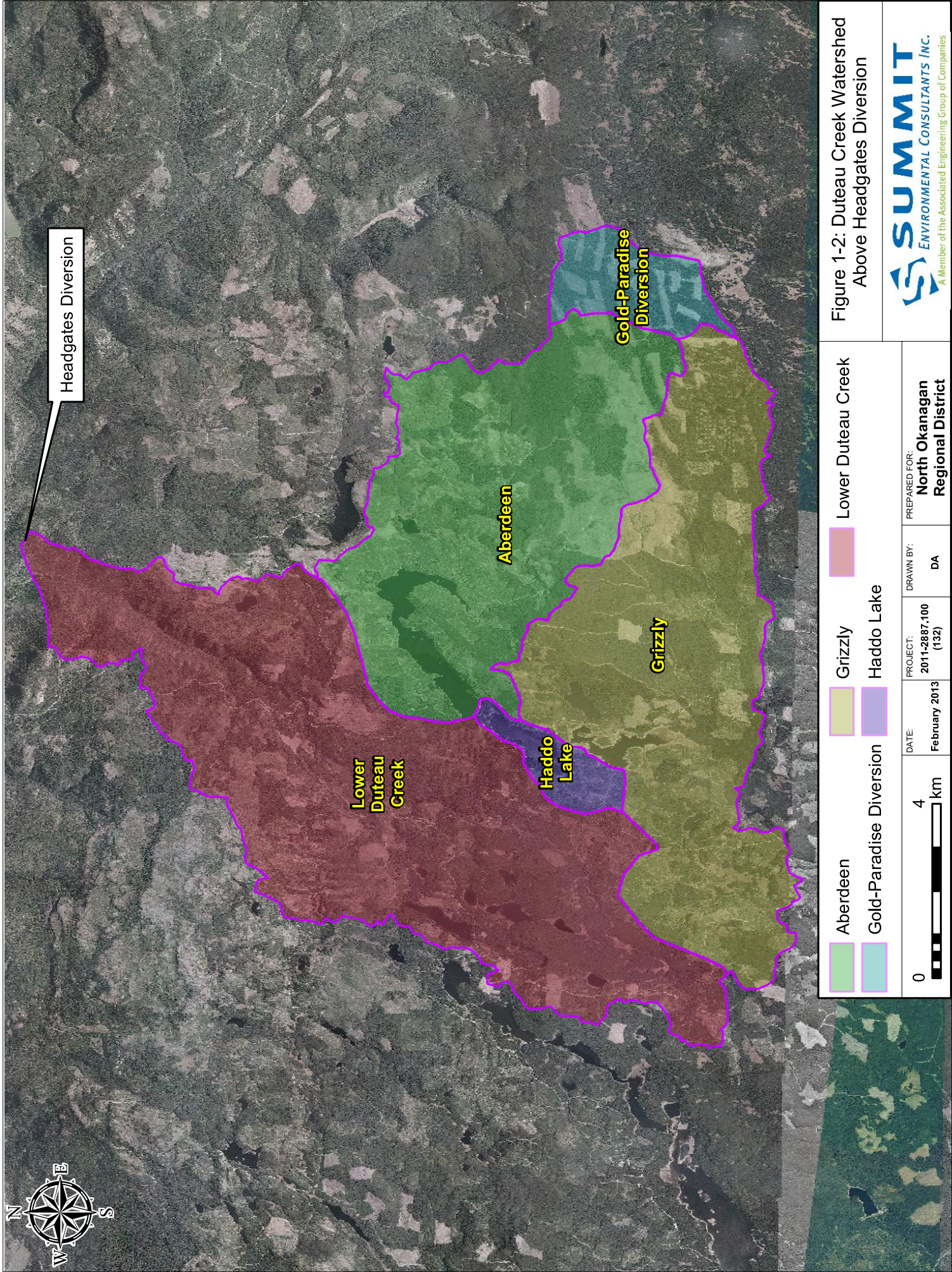


Figure 2. Normal annual runoff relation comparison (adapted from Summit 2009)

