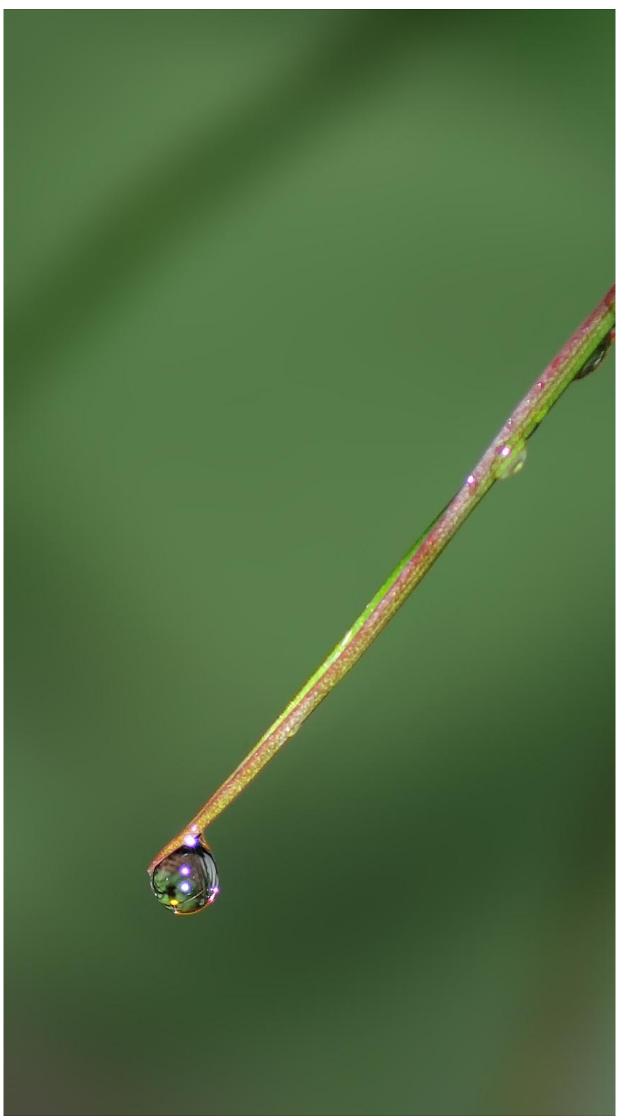
Part Three

The David Street Drinking Water System



Situated in the heart of Sudbury, Ramsey Lake is the raw water source for the David Street drinking water system located in the downtown core.

Approved on September 2, 2014
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Chapter 16 - David Street Drinking Water System

Ramsey Lake is the raw water source for the David Street drinking water system located in the downtown core of the City of Sudbury. The intake is considered a Type D intake[1]. Constructed in the late 1800s, the intake was the City's first municipal water supply. The original building still stands and is a historical landmark in the City.

Raw water is drawn from a 1.5 m diameter concrete and stainless steel pipe approximately 300 m from shore. The structure lies 10.5 m below the surface of the lake and 6 m from the lake bottom. A 50 m chlorine solution line, 50 mm raw water sample line and a chlorine diffuser are included inside the pipe.

Ramsey Lake supplies approximately 40% of the City of Sudbury's drinking water. The Wanapitei River supplies the remaining amount and is connected to the Ramsey Lake supply via the Ellis Reservoir. Although the two systems are connected, Ramsey Lake typically services the south, west and downtown areas of Sudbury. Map 3.1 illustrates the distribution system.

Over the years, the treatment system at the David Street Treatment Plant (WTP) has been upgraded many times. In 2002, the system was updated with membrane ultrafiltration. Chlorine, UV irradiation, fluoridation, pH adjustment and polyphosphate are also used.

Pumping rates based on the period between 2000 and 2008 are listed in Table 3.1.

Table 3.1 – Summary of pumping rates for the David Street intake for 2000-2008

	Pumping Rate
Annual Permitted Rate	14,600,000 m^3/year
Maximum annual	9,459,565 m^3 (in 2001)
Average annual	6,345,951 m^3/year
Average monthly	528,829 m^3/month

[1] A Type D intake is described as an intake that does not fit into the description of a Type A, B or C intake. See Rule 55.

Chapter 17 - Ramsey Lake Watershed

Spanning 43 km^2, the Ramsey Lake watershed is situated in the heart of the former City of Sudbury. Within the boundaries of the larger watershed, there are 13 subwatersheds that feed the lake (See Map 3.2). The subwatersheds are small and most do not contain defined tributaries, but rather contribute water through overland flow. Ramsey Lake itself covers 8 km^2 and wetlands cover 1.73 km^2.

The Ramsey Lake watershed, like most areas in the Sudbury region, has been heavily impacted by the proximity of mining activity since the early 1900s. Vegetation and soil cover is sparse, leaving many exposed bedrock areas throughout the watershed. The lake itself managed to escape acidification. This is thought to be attributed to the unique geology of the watershed comprised mainly of gabbro rocks.

The development of the watershed began primarily through the construction of the Canadian Pacific Rail (CPR) line, which traverses across the northern shore of the lake and is evidence of Sudbury's beginnings. The watershed hosts a number of institutions, namely Laurentian University, Science North and Health Science's North Sudbury Algoma Hospital. Ramsey Lake is a central focus for the City, offering a number of recreational and leisure opportunities, including Bell Park, swimming beaches, boating, fishing, skating and snowmobiling.

The lake level is maintained by two main water control structures. The Lake Laurentian dam, located at the outlet of Lake Laurentian, is operated by the Nickel District Conservation. The outlet of Ramsey Lake is controlled by the Ramsey Lake dam, operated by the City of Greater Sudbury. Lake levels are maintained for recreational and water supply purposes.

Chapter 18 - Water Budget and Quantity Risk Assessment

During the initial stages of the water budget assessment, it was determined that little information existed with regards to the overall flow of water within the watershed. Additional field work and measurements were taken in the field seasons of 2006-2009 to begin to develop an improved water budget for the Ramsey Lake watershed. As the development of the water budget progressed, it became evident that a combined Tier 1 and Tier 2 approach was the most appropriate given the amount and type of data available. Following the completion of the Tier 1/2 assessment, it was determined that a Tier 3 assessment was required. The following sections will briefly describe the outcome of these assessments. For a full report on methodology, assumptions and relevant calculations please refer to Appendix 2.

18.1 Tier 1/2 Water Budget

Ramsey Lake Monthly Water Budget

General methodology for the Tier 1 and 2 water budget process is outlined in Chapter 3 and Part III of the Technical Rules (2009). The monthly water budget incorporates a large amount of uncertainty, as a result of a continued lack of detailed knowledge of the outflow volumes from Ramsey Lake or the groundwater contributions. These uncertainties will be discussed in greater detail in the following sections; however the monthly water budget does present the following results:

- The largest losses from the lake are during the spring, when the average lake elevation is greater than the elevation of the top stop log;
- The removals at the David Street Water Treatment Plant are relatively constant throughout the year, and are at the same order of magnitude as estimated lake evaporation; and
- The average surface water supply (precipitation directly on the lake, plus catchment runoff) is exceeded by the removals at the Water Treatment Plant in the winter months (Dec., Jan. and Feb.) when snowpack is building.

The water budget is presented in Table 3.2, and the individual components are discussed in the following sections.

Precipitation and Snowmelt

It was assumed that for this study, the Sudbury Airport climate station was a reasonable long term climate record to represent the Ramsey Lake watershed. Based on the total record length used in this study, (1954-2007), the average annual total precipitation in the Ramsey Lake watershed was calculated to be 902 mm, of which 39% fell as snow. September produced the greatest monthly average rainfall (105 mm), while December and January both provided the maximum average monthly snowfall (57 cm). Approximately 75% of the total snowmelt was estimated to occur during

March and April, with the remainder of snowpack losses occurring on warmer winter days along with a minor loss as sublimation.

Lake Evaporation and Sublimation

Lake evaporation was calculated using different methods and the results were compared for consistency. The comparison indicated that using the Thornthwaite heat index method, along with data from the Sudbury Airport, was reliable in estimating the open water evaporation over Ramsey Lake. Evaporation from Ramsey Lake was largest during the summer months (June, July and August), and was minimal during November, a month with low average temperature and little snowpack, leading to low evaporation and sublimation estimates.

Sublimation estimates were below 10 mm per month, with an average annual total of 31 mm. This loss represents 12% of the total average annual snowpack, or approximately 3% of the total available water to the basin. The method adopted does not account for daily radiation, and as such sublimation may be underestimated in late winter, and overestimated in early winter. However, this estimate is considered to be a reasonable estimate of total sublimation, and indicates that it is a minor contributor when compared to other water budget terms.

Streamflow, Lake Level and Runoff

The simulated catchment inflow was dominated by spring snowmelt runoff, and total catchment runoff was estimated to be 505 mm (AMEC 2008). This represents an annual runoff ratio of 56%. In 1988, the MECP estimated total water inflow (as runoff) to the lake as 15 x 106 m^3/year (MECP 1988). This compares well with the AMEC annual surface runoff estimate of 18 x 106 m^3/year.

Actual discharge was calculated by flow meters in the culverts during the months of May through November in 2006, 2007 and 2008, which accounted primarily for the period of time while all stoplogs are in place. Lake discharge as estimated using daily lake level and a sharp-crested weir equation, along with general log operation rules, only allowed for discharge to occur when water level exceeded the stop log elevation. The regional estimate, while temporally representative of a lake outlet, is influenced by inflows from municipal and industrial waste water inputs upstream of Kelly Lake.

As shown in Table 3.2, the modelled and regional discharge estimates were an order of magnitude larger than the other two outflow estimates. For the purposes of this report, all methods of discharge estimation were averaged monthly. These values should be used with the understanding that they represent the best available knowledge at present of the actual lake outflow. Streamflow estimates have a direct affect on the magnitude of the groundwater flux, as the groundwater terms were calculated as a residual from the surface water balance.

Table 3.2 – Discharge estimates for Ramsey Lake outflow

Month	Outflow (m^3)				
	AMEC[1]	Monitored[2]	Estimated[3]	Regional[4]	Present Study[5]
January	191,000	N/A	653,000	2,453,000	1,099,000
February	604,000	N/A	43,000	1,865,000	834,300
March	1,154,000	N/A	45,000	2,486,000	1,228,300
April	6,656,000	N/A	1,151,000	4,722,000	4,176,300
May	2,053,000	162,000	9,000	2,112,000	1,084,000
June	1,399,000	82,000	68,000	1,497,000	761,500
July	742,000	128,000	38,000	1,350,000	564,500
August	206,000	990,000	0	1,371,000	641,800
September	481,000	188,000	0	1,385,000	513,500
October	2,247,000	223,000	0	1,559,000	1,007,300
November	3,312,000	189,000	525,000	1,921,000	1,486,800
December	1,148,000	185,000	440,000	2,385,000	1,039,500
Total	20,193,000	>2,147,000	2,972,000	25,097,000	14,437,000

Notes:

[1] AMEC (2008) based on 1974 Hydrograph at Junction Creek at Sudbury gauge station and no stoplogs in outlet

[2] Monitored based on monitored discharge July to December 2006, May to July 2007 (by AMEC) and September to October 2008 (by NDCA)

[3] Estimated using weir equation, lake level and stoplog operation, 2006 and 2007, no leakage

[4] Pro-rated discharge to Ramsey Lake basin from Junction Creek below Kelly Lake streamflow gauge (provisional flows)

[5] Average of all methods

Groundwater

During the Tier 1/Tier 2 process, although additional information was collected, it did not provide a definitive method to calculate groundwater flux between Ramsey Lake and the surrounding bedrock and surficial deposits. The NDCA has recently instrumented two groundwater wells in the Ramsey Lake catchment to better understand gradients between the catchment water table and the lake elevation. Generally, gradients exist such that the groundwater table is higher in elevation than the lake water surface (Golder 2005); however, estimates of groundwater inputs to Ramsey Lake are challenged by a limited knowledge of the extent of the surficial deposit at the northeastern shore, and the role of wetlands in providing a source of baseflow to the lake.

For the purposes of this report, groundwater contributions were estimated as the residual in the water budget equation. Using this method, groundwater was estimated to be a net gain to Ramsey Lake of approximately 840,000 m^3/year (Table 3.3).

Anthropogenic Removals

Anthropogenic removals from Ramsey Lake are primarily the water takings for municipal use at the David Street Water Treatment Plant and averaged 6.5 x 10^6 m^3/year over the period 2000-2007, and were assumed to be 100% consumed through cross-catchment transfer. Removals by the additional permits to take water in the catchment or non-municipal water were assumed to be returned to the watershed through septic beds or grounds-keeping infiltration and runoff.

Table 3.3 – Water budget for the Ramsey Lake watershed

	Inputs					Outputs			Residual	Storage		
Month	Rainfall (mm)	Snow-fall (cm)	Snow-melt (mm)	Rain/Snowmelt on Ramsey Lake(m^3)	Runoff from catchment to lake [1](m^3)	Lake Evaporation[2]	Water TreatmentPlant[3](m^3)	Lake Discharge[4] (m^3)	Groundwater [5](m^3)	Lake Elevation (m)	Change in Lake Storage (m^3)	Change in Lake Storage (m^3)
January	9	57	6	113,480	227,000	57,030	544,780	1,099,000	1,332,120	249.31	-28,210	-28,210
February	7	47	11	137,760	64,000	50,900	492,140	834,333	522,950	249.22	-652,660	-652,660
March	25	37	57	614,110	818,000	46,850	552,200	1,228,333	981,710	249.30	586,440	586,440
April	47	16	108	1,168,620	8,088,000	154,970	520,320	4,176,333	-3,297,500	249.45	1,107,500	1,107,500
May	74	2	3	578,460	712,000	564,030	525,270	1,084,000	599,040	249.40	-283,800	-283,800
June	82	0	0	616,060	1,076,000	834,720	570,440	761,500	244,120	249.38	-230,480	-230,480
July	79	0	0	594,500	877,000	977,600	620,270	564,500	76,440	249.30	-614,430	-614,430
August	83	0	0	622,580	476,000	849,760	607,150	641,750	193,590	249.18	-806,490	-806,490
Sept.	105	0	0	790,310	1,773,000	518,880	568,560	513,500	-1,457,850	249.12	-495,480	-495,480
October	76	6	5	612,530	1,780,000	226,290	501,740	1,007,250	-476,190	249.14	181,060	181,060
Nov.	49	31	17	494,110	2,011,000	7,520	491,430	1,486,750	-188,270	249.19	331,140	331,140
Dec.	14	57	13	199,850	7,000	47,820	525,710	1,039,500	2,311,590	249.31	905,410	905,410
Annual	649	253	221	6,542,370	17,909,000	4,336,370	6,520,010	14,436,750	841,750	249.28	0	0

Notes:
[1] Runoff estimated by AMEC (2008)
[2] Evaporation includes sublimation
[3] 2000 - 2007 average removals; more recent removals (2006, 2007) are less than half of 2000 removals
[4] Lake Discharge was estimated as average of all methods used in this study
[5]

Municipal Use

The David Street Water Treatment Plant provides water supply for approximately 40% of Sudbury, mainly in the south, west and downtown areas of Sudbury (CGS 2007). The Water Treatment Plant currently removes approximately 5,000,000 m^3/year, however, there has been a trend towards lower removal volumes as a result of upgrades at the Water Treatment Plant, the construction of the Ellis Street reservoir, and the use of the Wanapitei River Water Treatment Plant. Future municipal demand on the Water Treatment Plant was estimated using the forecasted growth for the City of Greater Sudbury (CGS 2005). Population growth in Greater Sudbury is estimated to be 9% by 2021, and as such a 9% increase in municipal water removal was applied to future water demand scenarios.

Non-Permitted and Rural Use

Residents in the Ramsey Lake watershed not on municipal water are most likely limited to areas of the south and eastern shores of Ramsey Lake, and south of Bethel Lake. These locations are relatively distant from the sewer/water distribution lines, and are areas where corresponding high density of Water Well Information System records were also found. Other residents with waterfront property on Ramsey Lake may utilize private lake intakes. For the purposes of this report, it was assumed that those not on municipal supply were also not on municipal sewers, and as such water removed from the ground or lake would eventually be returned to the lake or groundwater system by septic beds, resulting in negligible net water consumption.

Permit to Take Water

There are two active Permits to Take Water in the Ramsey Lake watershed, both of which are for surface water removals. One permit is for the David Street Water Treatment Plant and another is issued to Science North for aesthetic purposes, which is for a maximum of 50 days per year (Table 3.4). An additional Permit to Take Water will likely be required for the planned upgrade to the Ramsey Lake outlet structure.

Table 3.4 – Permit to take water summary, Ramsey Lake watershed

Source	Purpose	Max Pumping per day (L)	Max Days Pumping per year	Max Hours Pumping per day	Max Pumping per year (m^3)
Surface Water	Aesthetic	130,925	50	2	6,546
Surface Water	Water Supply	40,000,000	365	24	14,600,000

18.2 Tier 1/2 Water Quantity Stress Assessment

General methodology for the Tier 1 and 2 water quantity stress assessment process is outlined in Chapter 3 and Part III of the Technical Rules (2009).

Scenarios A and B – Subwatershed Stress Level Assignment

The water supply term was estimated from the water budget inputs, while the water demand was estimated as the average monthly removals from the David Street Water Treatment Plant. The water reserve was taken as 10% of the inflow to the lake basin.

Monthly stress level assignments for current and future water demand scenarios (Scenarios A and B) are displayed in Table 3.5. The estimated removals approach the calculated inflow to Ramsey Lake in winter, which increases water demand values close to 100%. This is reflected in the lowering of the lake level over those months. However, the lowering of the lake is expected during these months and in fact is part of the operational management of the lake to increase storage for the spring freshet. The watershed was calculated to have a water demand of >50% in February, August and September and, therefore, the Ramsey Lake watershed was assigned a significant stress assessment for the current demand scenario. For the future demand scenario, subwatershed stress level remained as significant, and a maximum monthly stress >50% was calculated for February, August and September.

Table 3.5 – Tier 2 Scenario A and B, monthly water quantity stress level calculations

Month	Water Supply	Current Water Demand	Future Water Demand	Water Reserve	Current Water Demand (%)	Future Water Demand (%)
January	1,672,600	544,780	593,810	167,260	36	39
February	724,710	492,140	536,433	72,471	**75**	**82**
March	2,413,820	552,200	601,898	241,382	25	28
April	5,959,120	520,320	567,149	595,912	10	11
May	1,889,500	525,270	572,544	188,950	31	34
June	1,936,180	570,440	621,780	193,618	33	36
July	1,547,940	620,270	676,094	154,794	45	49
August	1,292,170	607,150	661,794	129,217	**52**	**57**
September	1,105,460	568,560	619,730	110,546	**57**	**62**
October	1,916,340	501,740	546,897	191,634	29	32
November	2,316,840	491,430	535,659	231,684	24	26
December	2,518,440	525,710	573,024	251,844	23	25

Note: Bold numbers indicate significant stress.

Scenarios D to H – Drought Conditions

For a screening-level drought analysis on Ramsey Lake, a two-year time period with the lowest mean annual precipitation was used to estimate lake level. From available data, the time period of 1962–1963 (mean annual precipitation 640 mm) met this criterion. The following assumptions were made as part of this analysis:

- Lake elevation was at 249.37 m (top of stop log) at the onset of the drought;
- Groundwater gains/losses were considered to be negligible over the course of a year;
- Catchment runoff was estimated at 56% of total precipitation, reflective of the long term average in the watershed. This is the average annual runoff percentage as calculated by AMEC (2008); and
- Surface water loss from the outflow structure was estimated as the total long-term discharge from the water budget. This introduced uncertainty that is addressed in the Tier 3 analysis.

The drought scenario was performed under current average pumping conditions and estimated future pumping conditions (a 9% increase in demand). The results of this drought analysis are shown in Table 3.6 and Table 3.7. A maximum lake level decrease of 2.1 m was estimated as possible under the outlined assumptions. The large lake volume is able to minimize the effect of the simulated drought conditions without exposing the intake pipe, which is located approximately 10.5 m below the water surface. This lake level would likely affect recreational activities and public perception of the health of Ramsey Lake, as was the case in the 1987-1988 low water period (see Appendix 2 for details). As there was not an estimated exposure of the intake under the two-year drought scenario, the related ten-year drought scenarios (Scenarios G and H) were not performed. Similarly, drought scenarios involving a planned system (Scenarios F and I) were not performed, as there is no planned system in the watershed.

Table 3.6 – Tier 2 Scenario D, current pumping rates, drought analysis results

Year	Current Average WTP Removal	Annual Input to Lake (Rainfall + Snowmelt + Runoff, m^3)	Total Water Volume Lost from Lake (WTP + evaporation + streamflow, m^3)	Lake volume at end of year (m^3)	Estimated water level at end of year (m)
One	6,520,010	17,912,400	25,293,130	59,619,270	248.5
Two	6,520,010	18,740,400	25,293,130	53,066,540	247.6
Total	13,040,020	36,652,800	50,586,260	53,066,541	247.6

Table 3.7 – Tier 2 Scenario E, future pumping rates, drought analysis results

Year	Future WTP Removal	Annual Input to Lake (Rainfall + Snowmelt + Runoff, m^3)	Total Water Volume Lost from Lake (WTP + evaporation + streamflow, m^3)	Lake volume at end of year (m^3)	Estimated water level at end of year (m)
One	7,106,811	17,912,400	25,879,931	59,032,469	248.4
Two	7,106,811	18,740,400	25,879,931	51,892,938	247.3
Total	14,213,622	36,652,800	51,759,862	51,892,938	247.3

Table 3.8 provides a summary of the stress levels for the Tier 2 water quantity scenarios.

Table 3.8 – Tier 2 Subwatershed stress level scenario summary

Scenario	Description of Scenario	Results and Comments
A	Existing system – average	Maximum monthly water demand > 50%; significant stress level assigned
B	Existing system – Future demand	Maximum monthly water demand >50%; significant stress level assigned
C	Planned system demand – operational year	N/A; no planned system in subwatershed
D	Existing system – two year drought	Maximum estimated lake level drawdown 1.8 m; no intake exposure
E	Existing system – future two year drought	Maximum estimated lake level drawdown 2.1 m; no intake exposure
F	Planned system – operational year – two year drought	N/A; no planned system in subwatershed
G	Existing system – 10 year drought	N/A; exposure of intake not estimated under 2 year scenario
H	Existing system – future 10 year drought	N/A; exposure of intake not estimated under 2 year scenario
I	Planned system – operational year – ten year drought	N/A; no planned system in subwatershed

Water Budget and Stress Assessment Uncertainty

There remains high uncertainty in many components of the Ramsey Lake water budget. The atmospheric exchanges (precipitation, snowmelt, sublimation and evaporation) have been calculated with a more robust methodology and increased accuracy for this study than that done for the initial Tier 1 analysis. Although the surface water inflows were based on mapping of catchment physiography, the results agreed favourably with previous MECP estimates. Surface water outflows, along with groundwater contribution, remain highly uncertain.

Given the very limited amount of data available for the Tier 1/2 analysis, the stress assignment remained high, and it was necessary to proceed to a Tier 3 analysis. The following variables were manipulated to explore the degree of uncertainty and the affect of these on the stress assessment:

- Catchment runoff was decreased by 50% and increased by 50% affecting the water supply;
- The removals at David Street were lowered to the volume removed in 2007 and raised to the volume removed in 2000, affecting the water demand; and
- The additional water calculated as groundwater input was eliminated from the water supply to the lake.

These bulk changes to the water supply and demand altered the number of months that supply was exceeded by demand, but did not change the month that the maximum occurred in, or the maximum stress level assignment to below significant. Therefore, the uncertainty assigned to the stress designation was considered as low.

Significant Groundwater Recharge Areas

Rule 46 of the Technical Rules (2009) state that a significant groundwater recharge area shall be delineated based on the models developed for the water budget assessment. The significant groundwater recharge area delineation was refined to reflect the updated information generated from the Tier 2 process. See Chapter 12 for more information about calculating significant groundwater recharge areas.

In the Ramsey Lake subwatershed, the average annual water surplus was estimated at 391 mm. A value of 215 mm (or 55% of 391 mm) was then calculated as the amount of surplus water and available for recharge on an annual basis to aquifers within the subwatershed. The glaciofluvial and glaciolacustrine sediments were designated as significant groundwater recharge areas in the Ramsey Lake watershed. Recharge values greater than 215 mm occur in these areas, and the entire area has a vulnerability score of 6 (high). See Map 3.3.

Tier 1/2 Conclusions

The average annual watershed water budget showed that the total precipitation over the lake area is approximately equal to the average water removals at the David Street Water Treatment Plant, and lake evaporation was also the same order of magnitude as these terms. All estimated water budget terms should be regarded in context of the operational water level data for Ramsey Lake, which shows minimal storage changes in the years studied.

The watershed was assigned a ‘significant’ subwatershed stress level assignment for existing and future water demand scenarios. Therefore, in accordance with provincial guidance, a Tier 3 Water Quantity Risk Assessment for the Ramsey Lake surface water intake was undertaken.

18.3 Tier 3 Water Budget and Local Area Risk Assessment

The Tier Three Water Budget and Local Area Risk Level Assignment was completed using a 2-Dimensional surface water model as outlined in the Technical Bulletin: Part IX Local Area Risk Level, for both existing and future pumping rates. A 2-Dimensional model of the Ramsey Lake watershed was constructed using the Hydrologic Engineering Center Hydrological Modelling System (HEC-HMS v3.3), made available by the United States Army Corps of Engineers (USACE 2009). The scenarios illustrated in the technical bulletin were modeled using hourly climate data over the period 1954-2005.

An enhanced field monitoring program was designed and initiated in March, 2009. Stream water level stations were installed at the inflows to Ramsey Lake and outfitted with automatically logging pressure transducers. These key monitoring locations were located at:

- Lake Laurentian outflow;
- Minnow Lake outflow;
- drainage channel at Greenwood Avenue; and
- drainage channel at Second Avenue and Bancroft Drive.

In addition, at the Ramsey Lake outflow, discharge monitors were placed in each downstream culvert and supplemented with a pressure transducer in Lily Creek immediately downstream of the culverts. Stream water levels at each location were converted to discharge through rating curves created by periodic manual streamflow measurements using a Marsh-McBirney velocity meter and stream cross-section measurements.

The surface water model was fed by the data collected in the field along with the data related to water use and groundwater levels. Details on model inputs are provided in a report found in Appendix 2. The required modelled scenarios produced water levels that did not fall below the elevations that would limit municipal water supply quantities or cause unacceptable impacts to other uses. The uncertainty analysis yielded a 'low' designation, and therefore, the risk level for the Ramsey Lake Local Area was designated as 'low'. Results from the modeling for different scenarios are illustrated below.

Local Area and IPZ-Q Delineation

Additional reports and drawings were obtained from the CGS with regard to construction activity along roadways to the northeast of the Ramsey Lake catchment, in the area of potential connection between the Wanapitei Esker with the Ramsey Lake watershed. Geotechnical investigations and construction details for the Kingsway/Falconbridge Road/Second Avenue intersection describe a generally silty-sand overburden with a shallow water table that appears to slope northward from the topographic high. These boreholes were generally shallow (<5 m) and most did not encounter bedrock. Therefore the thickness of the aquifer remains uncertain in some locations.

This limited information suggests that groundwater from this area is directed northwards. Modelling results did not suggest the presence of a major unaccounted groundwater source. As conclusive evidence was not found of a groundwater connection via the Wanapitei Esker across the topographic boundary of the Ramsey Lake watershed, and following discussions with the Technical

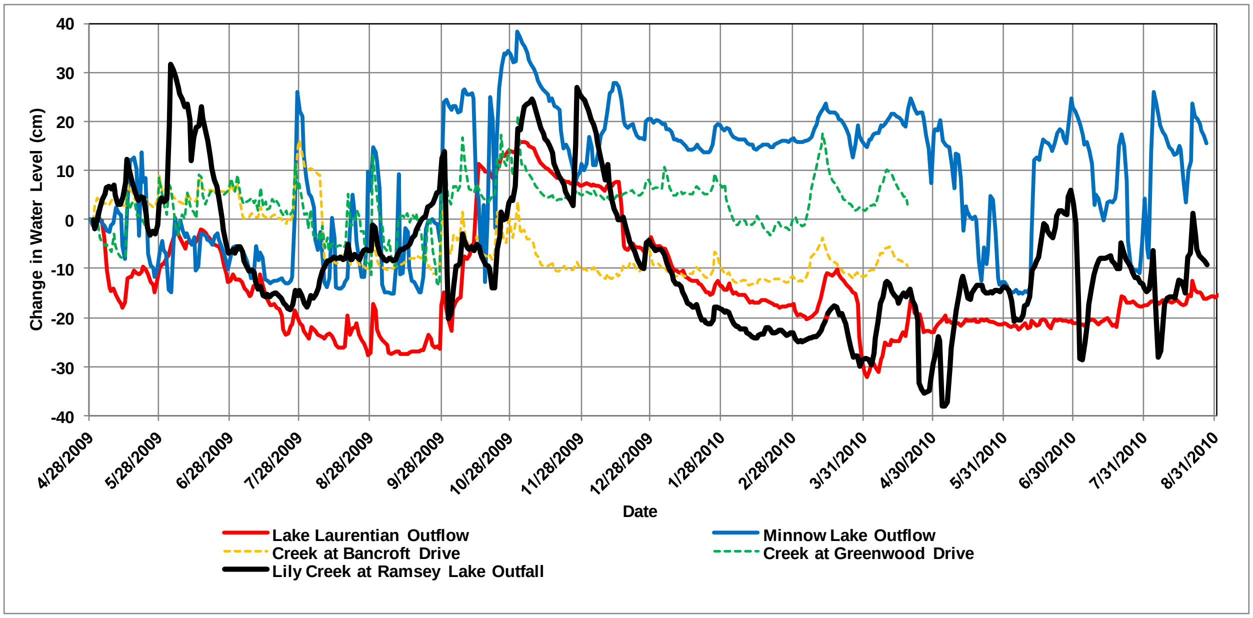
Review Committee, the Local Area and IPZ-Q was defined as the watershed boundary (Map 3.4). A focused study would be required to further determine the potential of groundwater influence from outside the catchment boundary.

Preliminary Field Results

Daily average water level recorded at the monitored inflows and at Lily Creek (outflow) are displayed on Figure 3.1. The steep rising and falling limbs on these water level plots are an indication of the fast response in the watershed to precipitation and melt events, as well as responses to operations (stop log procedures) at the Lake Laurentian and Ramsey Lake outfall structures. Of interest is the sharp increases in water level at the northern inflows to Ramsey on July 26, 2009, when approximately 90 mm of rainfall occurred within 1.5 hours (Sajatovic, pers. comm). As shown in Figure 3.1, Lake Laurentian outflow and Ramsey Lake outflow at Lily Creek water level do not display these sharp increases, indicating the isolated nature of the storm as well as the buffering capacity in Ramsey Lake.

Discharge through the Ramsey Lake outfall to Lily Creek was summarized for a generally 'wet' year (2009) and a 'dry' year (2010). Data collected from the flow meters over the ice-free season of each year displays different flow regimes that reflect the wet and dry conditions, however each year discharge trends towards very low flow or stagnant (zero flow) conditions within the culverts (Figure 3.2). This occurs despite a relatively small range (±40 cm) of water level within the culvert (Figure 3.2). Therefore, the following observations can be made:

1) Discharge over the stoplogs can generate substantial flow through the outfall to Lily Creek.
2) Discharge is quickly reduced with lowering lake levels (presumably once the stoplogs are no longer overtopped and discharge is primarily through stoplog leakage). Total leakage was estimated to average approximately 50L/s.
3) The presence of recorded (and field observed) stagnant water conditions at the culvert outflow suggest that below a certain elevation leakage is negligible. Field observations suggest that negligible leakage can occur during dry periods.
4) Water level in Lily Creek is sustained by either this negligible leakage rate or a backwatering effect from Nephawin Creek (or a combination of both).



Note: Water level change calculated from daily average water level

Figure 3.1 – Recorded water level changes, Ramsey Lake Watershed 2009-2010

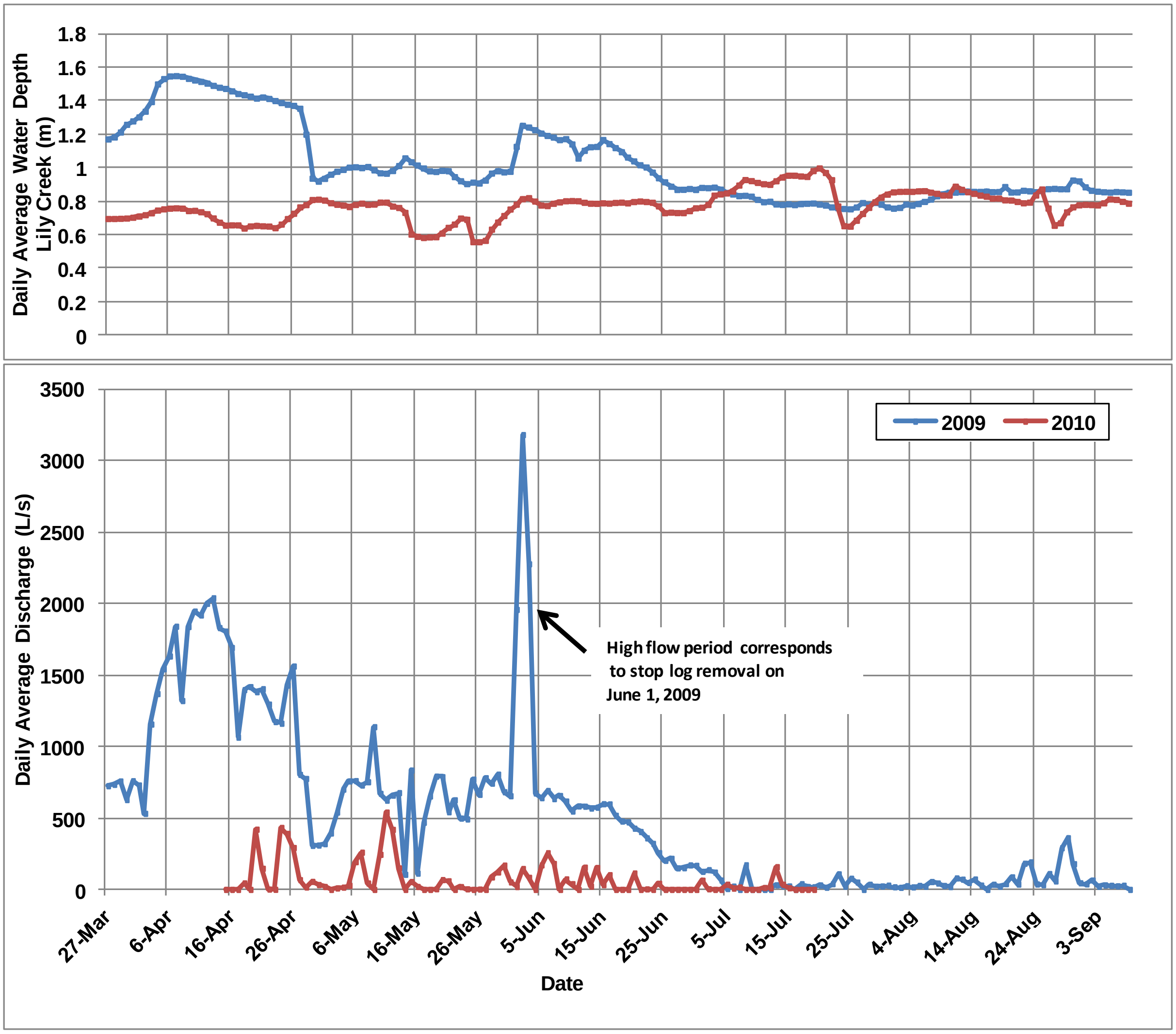


Figure 3.2 – Monitored water level and discharge, Lily Creek 2009-2012

Water Budget

The daily fluxes of water predicted with HEC-HMS and Scenario A were summarized on an annual basis and are presented for the period of 1955 to 2008 in the Tier 3 Water Budget Report, which can be found in Appendix 2. The water budget was dominated by surface flows, and did not require significant groundwater input in order to maintain water levels in the lake over the simulated period of time. This finding was consistent with the Tier One/Tier Two assessment of the watershed. However, the addition of a groundwater component to Ramsey Lake may improve correlation with observed water levels as described in a report found in Appendix 2. The analysis also indicated that the evaporative losses from Ramsey Lake are approximately equal to the municipal water withdrawals, on a monthly average basis.

Modelled Scenarios

Water budget elements for each subwatershed in Ramsey Lake were simulated for each hour within the available long term climate record or drought period. For long-term scenarios, these analyses produced approximately 450,000 data points for each hydrological parameter (including Ramsey Lake water level). As the primary objective of the Tier Three study is to determine the tolerance of the drinking water system, water level data was reduced to a minimum daily water level for display within this report. The daily minimum water level was taken as a conservative daily value that would represent the greatest simulated lake drawdown (i.e. this level would likely be closest to the specified trigger water level elevations).

Scenario A – Long Term Climate, Existing Pumping, Existing Land Cover

Water level was maintained well above the intake for the David St. WTP and did not exhibit periods where the defined exposure level of 248.7 masl was reached. Generally, low water levels occur during winter months, when snowpack is building. This is consistent with findings at the Tier One/Two level where the highest stress occurred under winter conditions with pumping from the lake.

These simulated water levels suggest that the quantity of water removed from the Local Area would be sufficient to meet the existing water demand and peak demand at the intake.

Scenario B – Drought Period, Existing Pumping, Existing Land Cover

For the ten-year drought period (1955 to 1964) and the two-year drought period (1962 to 1963) lake water level was maintained above the intake for the David St. WTP. As with the long-term Scenario A, the lowest simulated water levels occurred during winter months, when snowpack was building.

Scenario B resulted in a predicted minimum lake elevation of 249.02 masl, or approximately 10 m above the WTP intake level of 239 masl.

These simulated water levels suggest that the quantity of water removed from the Local Area would be sufficient to meet the existing water demand and peak demand at the intake.

Scenario E(1) – Long-Term Climate, Existing plus Committed Pumping, Future Land Cover

Similar to Scenario A, simulated minimum daily water level was maintained above the intake for the David St. WTP. Minimum water levels were simulated during winter months, when snowpack is building.

Lake water level did not reach the low water trigger of 248.7 masl, indicating that the lake level would not impact other uses as defined by Rule 99 of the Technical Rules (2009).

These simulated water levels suggest that the quantity of water removed from the Local Area would be sufficient to meet the existing plus committed water demand at the intake, and that the low water levels would not unacceptably affect other uses on Ramsey Lake.

Scenario E(2) – Long-Term Climate, Existing plus Committed Pumping, Existing Land Cover

Simulated water level resultant from existing plus committed pumping rates was above the WTP intake elevation of 239 masl. Additionally, long term simulated minimum water level was on average approximately 50 cm greater than the low water trigger elevation of 248.7 masl, although winter water level occasionally approached 20 cm above this level.

These simulated water levels suggest that the quantity of water removed from the Local Area would be sufficient to meet the existing plus committed water demand at the intake, and that the low water levels would not unacceptably affect other uses on Ramsey Lake.

Scenario E(3) – Long-Term Climate, Existing Pumping Rates, Future Land Cover

Long-term simulated minimum water levels were maintained above the WTP intake elevation and the low water trigger elevation for the modelled time period (1954 to 2005). Simulated water level for Scenario E(3) was similar to Scenario A despite the land cover change, indicating low sensitivity in the basin to planned development in the watershed in terms of water quantity reaching Ramsey Lake.

These simulated water levels suggest that the quantity of water removed from the Local Area would be sufficient to meet the existing water demand at the intake with future planned development changes to watershed characteristics.

Scenario F(1) – Drought Period, Existing plus Committed Pumping, Future Land Cover

Simulated water levels in Ramsey Lake were below 249.0 masl in the 10-year drought and in the 2-year drought scenarios. However, this water level maintains nearly 10 m of freeboard above the WTP intake and as such these results suggest that the Local Area could provide the allocated quantity of water to the intake.

Scenario F(2) – Drought Period, Existing plus Committed Pumping, Existing Land Cover

Simulated Ramsey Lake water levels were maintained above the intake for scenario F(2) for both the 10-year drought and the 2-year drought. As with the corresponding long-term Scenario E(2), the lowest simulated water levels occurred during winter months, when snowpack was building. These results suggest that the Local Area could provide the allocated quantity of water to the intake.

Scenario F(3) – Drought Period, Existing Pumping, Future Land Cover

Scenario F(3) simulated water level was similar to the prior drought condition results. For both the 10-year drought and the 2-year drought, approximately 10 m of freeboard remained between the winter drawdown lake level and the WTP intake elevation. This suggests that under these conditions the Local Area could provide the allocated quantity of water to the intake.

Scenario X(1) – Drought Period, Rated Capacity Pumping, Existing Land Cover

Scenario X(1) was completed as a 'worst case' combination of drought climate and increased pumping at the David St. WTP. The results of this simulation show water level that falls to the low water trigger during the winter months in both the 10-year drought and in the 2-year drought. However, the WTP intake elevation remains approximately 10 m below the lowest lake drawdown elevation.

Scenario X(2) – Drought Period, Rated Capacity Pumping, Future Land Cover

Scenario X(2) was completed to investigate the combination of drought climate and increased pumping from Scenario X(1)while incorporating land cover changes within the watershed at the David St. WTP. The results of this simulation indicated little to no difference in simulated water level from the X(1) Scenario under the 10-year drought and in the 2-year drought. For this Scenario, the WTP intake elevation remains approximately 10 m below the lowest lake drawdown elevation.

Results Summary, Tolerance and Preliminary Risk Assignment

Simulated Ramsey Lake water levels were consistently above the defined trigger elevations for the required Scenarios. Changes to land cover, municipal demand and climate affected the absolute magnitude of water level, however the lake dynamics remained similar and the largest drawdowns were noted during winter months, a time period where municipal demand exceeded watershed runoff. Lake drawdown during winter months remains an operational target for the CGS as well; this assists in creating storage for anticipated spring freshet without unacceptable high water levels on the populated lake or large spring discharge downstream through Lily Creek which may create unwanted high water levels for residents.

Along with these simulated water levels, operational evidence suggests that Ramsey Lake is able to meet peak demand. Recent pumping records (2006 to 2008) indicated that the David St WTP has pumped at less than 35% of its permitted rate, and the interconnected Wanapitei River WTP has pumped at up to 62% of its permitted rate over the same period. Although the rated capacity of these WTPs is less than the permitted rates, the additional pumping available at these treatment plants as well as the storage availability at the Ellis Reservoir are indications of the ability of the system to deliver during peak demand periods, which are typically on time scales of one week or less.

Increasing pumping rates to the rated capacity for a period of ten years resulted in regular lowering of the lake level to the defined low water trigger elevation, again during the winter months. This provides an indication that additional pumping may be possible to meet additional municipal water demands on the system.

Table 3.9 provides a summary of Scenarios and designated preliminary risk assignments.

Table 3.9 – Tier 3 risk level summary

Scenario	Municipal Demand	Land Cover	Triggers	Tolerance	Risk
A (long-term)	Existing	Existing	WTP Intake	High	Low
B (drought)	Existing	Existing	WTP Intake	High	Low
E(1) (long-term)	Existing + Committed	Future	WTP Intake; Low Water for other uses	NA	Low
E (2) (long-term)	Existing + Committed	Existing	WTP Intake; Low Water for other uses	NA	Low
E(3) (long-term)	Existing	Future	WTP Intake	NA	Low
F(1) (drought)	Existing + Committed	Future	WTP Intake	NA	Low
F(2) (drought)	Existing + Committed	Existing	WTP Intake	NA	Low
F(3) (drought)	Existing	Future	WTP Intake	NA	Low

Based on these results, a preliminary risk level assignment of 'low' was assigned to the Local Area, subject to the Uncertainty Analysis.

Uncertainty and Sensitivity Analysis

Uncertainty and Sensitivity Analysis was addressed through the following procedures during the course of this project.

1) <u>Hourly Climate Data:</u> Data provided by Environment Canada and the MNR were checked for data gaps. Where possible, data were summarized and extrapolated to better fit the required time period (Section 3.2.3). The use of Ottawa radiation data is a known limitation in the dataset, but provided an adequate comparison to available sunlight data from Sudbury.

2) <u>Water Level and Discharge Simulations:</u> Calibration was limited to available Ramsey Lake level data and downstream regional discharge for the period 2000 to 2005. Although the statistical correlations for simulated vs. observed data were <0.7, the temporal trends in rising and falling limbs on the hydrographs and lake level plots were similar and provided confidence in the long-term ability of the model to reproduce Ramsey Lake dynamics.

3) <u>Scenario Results:</u> Where possible, Ramsey Lake water levels produced in the simulations were checked against recorded observations. For example, consideration was given to the known low lake Ramsey Lake water level that occurred during the mid to late 1980s. During 1986 through 1988, the elevation of Ramsey Lake fell to below 248.0 masl (Golder 2009a), and this period of low water level was not replicated by the model. This result was not unexpected for the following reasons:

    a) As per the Technical Rules (2009), long-term modelled pumping rates were reflective of existing (2007) or existing plus committed pumping rates for that period (Golder 2009a).

b) Operational strategies (i.e. stop log insertion and removal dates) for the Ramsey Lake outfall were not available for the interval in question, and could not be explicitly incorporated in the model set-up.

A more period-specific study would be required to simulate this 1980s period, however, it is worth recognizing that extended periods of water levels below the optimal operating levels have occurred in the past on Ramsey Lake.

The sensitivity of the model was inherent in the Scenarios and the results produced. Specifically, the changes predicted through increasing development (and decreasing permeability) had a minimal effect on the simulated lake level. This is likely due to the dominance of bedrock and runoff dominated surfaces that are currently present in the watershed.

Increasing pumping rates had a greater effect on the drawdown of the lake, and the X(1) and X(2) Scenarios display this most effectively; sustained increases in pumping rates to the rated WTP capacity caused drawdown to the low water trigger elevation during the winter months. The rated capacity pumping is approximately 30% greater than the currently estimated existing plus committed demand for the watershed.

Although model performance could be improved through increased data collection, these uncertainty and sensitivity analyses show that confidence can be placed in the assessments of tolerance and risk. As such, the uncertainty for the current study can be considered 'low'.

Risk Level Assignment

The results as summarized in Table 3.9 indicated that simulated water levels produced a tolerance of 'high' for Scenarios A and B and a risk level of 'low' for each of the other required modelled Scenarios. Additionally, the Uncertainty and Sensitivity Analysis provided justification for a 'low' level of uncertainty in the modelling exercise. Therefore, the risk level assigned to the Ramsey Lake Local Area was 'low'.

Significant Groundwater Recharge Areas

For the Tier Three analysis, Significant Groundwater Recharge Areas (SGRA) were reviewed from the Tier One/Two delineations. The Local Area and IPZ-Q were defined as the Ramsey Lake watershed in the Tier Three project. As such, the methods anddelineations provided in section 18.2 and shown on Map 3.3 remain valid.

Tier 3 Conclusion

The additional field data collected for the Tier 3 analysis was fed to the 2-Dimensional surface water model. The model simulated water level for different scenarios using the approach set out in the Technical Bulletin: Part IX Local Area Risk Level, for both existing and future pumping rates. The required modelled scenarios produced water levels that did not fall below the elevations that would limit municipal water supply quantities or cause unacceptable impacts to other uses. The uncertainty analysis yielded a 'low' designation, and therefore, the risk level for the Ramsey Lake Local Area was designated as 'low'.

Chapter 19 - Ramsey Lake Water Quality Risk Assessment

19.1 Ramsey Lake Intake Protection Zones

Chapter 2 and Part VI of the Technical Rules (2009) explain the delineation methodology for the intake protection zones.

Intake Protection Zone 1

For Type D intakes, the intake protection zone 1 (IPZ-1) is prescribed to be a circle with a 1 km radius centred on the intake. The centre point of the circle is the point of entry of the raw water. Where the circle abuts land, a 120 m setback from the high water mark is applied (Rule 61).

Map 3.5 illustrates the IPZ-1 for the David Street intake. The resultant IPZ-1 for Ramsey Lake covers most of the western bay of the lake and part of the Bethel Peninsula. There was considerable discussion amongst the technical team regarding the applicability of using a 1 km radius to determine the IPZ-1 in Ramsey Lake. The IPZ-1 boundary is drawn within metres of one section of the south shore, but does not capture the entire south shoreline. The technical team considered expanding the IPZ-1 to include the south shore, however, little information was available to support the extension of this zone. A synopsis of the points of discussion is described in the next section under intake protection zone 2. It was determined that until further supporting information is gathered, the delineation of IPZ-1 should remain as a 1 km radius.

Intake Protection Zone 2

Intake protection zone 2 (IPZ-2) is based on the time that is sufficient for a water treatment plant operator to respond to an adverse water quality condition (Rule 65). The time of travel is required to be a minimum time of two hours to the intake (Rule 66).

In order to determine the distance traveled related to time of travel in a lake, knowledge of the dynamics of the movement of water through the lake is required. Measurement of currents is complex as they are based on lake bathymetry, stratification, wind speed and direction, chemistry, temperature, shape, orientation, and inflows and outflows of the lake. Currents will vary widely between different lakes and will often be determined by the time of year and wind conditions.

Ramsey Lake is a relatively complicated lake to model current velocities. The lake is oriented east to west, is populated by a number of islands and has numerous small bays carved into the shoreline. The lake has a natural division between the eastern and western portions of the lake where the lake narrows from the Bethel Peninsula jutting out into its waters. The western bay, where the intake is located, is characterized by deeper waters, while the eastern portion of the lake consists of relatively shallow, warmer waters.

There have been two studies that have attempted to characterize the currents in Ramsey Lake. The first, a master's thesis completed at Laurentian University by Francois Prevost, used a fluid dynamics software, Fluent, to model the circulation in the lake and was completed in 2005 (Prevost, 2005). The second was conducted by AMEC and ASI as part of the source protection technical studies completed in 2006. The study installed current meters at two locations in the lake during the ice free months of 2006 and deployed drogues at three locations during two sampling events throughout the year. See Appendix 2 for both reports (Multi-Dimensional System Modelling in the Anthropogenically Impacted Watershed of Ramsey Lake; Francois Prevost, 2005; and the Intake Characterization, Determination of Intake Protection Zones, and Assigned Vulnerability Scores for Ramsey Lake Intake within The City of Greater Sudbury; AMEC 2008).

Both studies offer some information and insight into the velocity of water movement in the lake; however neither of them was specific to determining if the IPZ-1 and 2 were appropriate delineations of the lake. After much deliberation amongst the technical team, it was agreed that the drogue studies completed in 2006 provided the best information available to determine a 2 hour time of travel. Based on these studies, the maximum observed current velocity of 0.06 m/s would result in a distance of 432 m in 2 hours. More details on this methodology can be found in the 2008 AMEC Report on Ramsey Lake in Appendix 2.

A 2 hour time of travel with a distance of 432 m is smaller than the limit of IPZ-1. Therefore, following Technical Rules (2009) 65 and 66, there is no IPZ-2 in Ramsey Lake, but there is an IPZ-2 delineated on land adjacent to the lake because of transport pathways. IPZ-2 includes all the stormwater drains and the area within the storm sewershed adjacent to IPZ-1, as shown on Map 3.6. There is a high degree of uncertainty with this delineation which is discussed further in the vulnerable area delineation uncertainty section below. It is strongly recommended that this be studied in greater detail in order to delineate an appropriate protection zone for Ramsey Lake.

Intake Protection Zone 3

The delineation of the intake protection zone 3 includes the area within each surface water body that may contribute water to the intake and a 120 m setback from the high water mark. Transport pathways may also be included as stated in Rule 70.

The IPZ-3 for Ramsey Lake is illustrated on Map 3.7. It covers all contributing tributaries and storm sewers in the watershed. A 120 m setback was applied to all water bodies and storm sewers. Storm drains in the eastern portion of the watershed are primarily in the form of ditches along road ways and therefore the protection zone included a 120 m setback from the road network.

Vulnerable Area Delineation Uncertainty

As required by Rule 108, an uncertainty analysis of the delineation of intake protection zones and vulnerability scoring are presented in Table 3.10.

Table 3.10 – Summary of intake protection zone delineation uncertainty

IPZ	Level of Uncertainty	Comments
IPZ-1	High	As commented in the Technical Experts Committee Report to the Minister of Environment[1], Recommendation #39 states that the 1 km delineation should be replaced in subsequent planning cycles with a science based approach. Therefore, there is a high degree of uncertainty at this time regarding the applicability of a 1 km zone within Ramsey Lake.
IPZ-2	High	Urban development and bedrock are the dominant land use and land cover within IPZ-2. This storm sewershed has a small drainage area and has little attenuation capacity. The storm water from the entire sewershed drains directly into IPZ-1. The very high uncertainty associated with the storm sewer flow data makes the delineation of IPZ-2 highly uncertain.
IPZ-3	High	IPZ-3 begins at the end of IPZ-1 and 2 (delineations of IPZ-1, 2 and 3 are interdependent) and therefore also has a high uncertainty due to the uncertainty in those protection zones. Storm drains are also poorly mapped in the eastern part of the watershed and therefore a high degree of uncertainty exists in the delineation of the IPZ-3 in this area.

1 Technical Experts Committee Report to the Minister of Environment (Science-based Decision-making for protecting Ontario's Drinking Water Resources, November 2004)

19.2 Vulnerable Area Scoring

For surface water intakes, source and area vulnerability factors are given to determine an overall vulnerability score. The factors for Ramsey Lake are described below.

Source Vulnerability Factor

The Source Vulnerability Factor options for a Type D intake are 0.8, 0.9 or 1.0. A source vulnerability factor of 1.0 was given for Ramsey Lake due to the following reasons:

- The intake is only 300 m from shore;
- The Water Treatment Plant has experienced past water quality issues related to iron and manganese from bottom sediments; and
- The intake was raised by 3 m due to high magnesium levels in the thermocline

Area Vulnerability Factor

The area vulnerability factor is based on the percentage of the protection area covered by land, land cover, soil type, permeability of the land and the slope of any setbacks, the hydrological and hydrogeological conditions of any transport pathway, and the proximity to the intake (Rule 92).

An area vulnerability factor for Ramsey Lake was given to each subwatershed as each subwatershed is relatively small and mainly consists of overland flow to the lake. The factor was primarily based on land cover and permeability of the land. Proximity to the intake was not weighted as heavily as the land cover and permeability of the land, due to the relatively long retention time in the lake. The majority of the Ramsey Lake watershed is covered in bedrock and therefore has little infiltration capacity to attenuate contaminant runoff. Many of the tributaries into the lake are intermittent in nature and respond quickly to storm events. A summary of the vulnerability scores given are described in the next section.

Summary of Vulnerability Scores

Table 3.11 summarizes the vulnerability scoring and rationale given to each subwatershed for the Ramsey Lake vulnerable areas.

Table 3.11 – Summary of Ramsey Lake intake protection zones and vulnerability scores

Intake Protection Zone	Source Vulnerability Factor	Area Vulnerability Factor	Vulnerability Score	Comments
IPZ-1	1.0	10	10	This score is fixed (Rule 88).
IPZ-2	1.0	9	9	Urban development and bedrock are the dominant land use and land cover in these subwatersheds. All subwatersheds have small drainage areas and have little attenuation capacity.
IPZ-3 Minnow Lake	1.0	9	9	
IPZ-3 Moonlight Beach	1.0	9	9	
IPZ-3 North Shore	1.0	9	9	
IPZ-3 Frobisher	1.0	9	9	
IPZ-3 South Shore	1.0	9	9	
IPZ-3 Frenchman's Bay	1.0	9	9	
IPZ-3 Bethel Lake Peninsula	1.0	9	9	
IPZ-3 West South Bay	1.0	9	9	
IPZ-3 Bethel Lake	1.0	9	9	
IPZ-3 Lake Laurentian	1.0	6	6	These subwatersheds are mostly covered by wetlands and lakes and therefore have a high capacity for attenuation of contaminants.
IPZ-3 Laurentian Wetland	1.0	6	6	

Vulnerable Area Scoring Uncertainty

Uncertainty surrounding the vulnerable area scoring assignment is based on the ability for the vulnerability factors to effectively assess the relative vulnerability of the hydrological features. The vulnerability scores for the Ramsey Lake intake protection zones were primarily based on land cover within the watershed and the use of professional judgment. They are shown in Table 3.12.

Table 3.12 – Uncertainty analysis for the vulnerable area scoring

	Uncertainty	Comments
Source Vulnerability Factor	Low	As the source vulnerability factor has been scored conservatively, there is high confidence that the factor will address any concerns to the intake.
Area Vulnerability Factor – Score of 9	Low	IPZ-2 and IPZ-3 have been scored conservatively in the urban areas and therefore there is a high degree of confidence that the value given will protect the intake.
Area Vulnerability Factor – Score of 6	High	The IPZ-3 in the wetland areas has been given a moderate score. A high degree of uncertainty exists as it is unknown if a moderate score is sufficient to protect the intake from contamination.

19.3 Ramsey Lake Drinking Water Quality Threats Activities

The assessment of potential threats to drinking water quality followed Technical Rules (2009) 118 to 125 and the methodology as outlined in Chapter 2. The list of prescribed drinking water threats is located in Table 1.7 in Part 1 of this report.

Identification of areas where threats can occur

The areas where a potential threat is or would be significant, moderate or low are illustrated on Maps 3.5 to 3.7. According to the Technical Rules (2009):

- Areas with a vulnerability score of 8 or greater can have the potential for a significant, moderate or low threat.
- Areas with a vulnerability score of 6 or greater can have the potential for a moderate or low threat to occur.
- Areas with a vulnerability score of 4 or greater can have the potential for a low threat to occur.
- Areas with a vulnerability score of less than 4 cannot contain a drinking water threat.

The MECP has established an online tool that incorporates the Provincial Table of Drinking Water Threats into an interactive mapping tool, accessible via http://swpip.ca/. With the address search function, this tool lets you identify what vulnerable area(s) a property is located in and what the vulnerability score is at that location. It also identifies a list of circumstances of all is or would be significant, moderate or low drinking water threats. For more detailed instructions on how to use the above mentioned website refer to Appendix 5.

Managed Lands

The storage, handling and application of agricultural source material, non-agricultural source material, pesticides and fertilizers can result in potential contamination of municipal water supplies. The methodology used to calculate percentage of managed lands in the vulnerable areas is described in Chapter 2. The percentage of managed lands in the area was assessed to be between 40 and 80% (moderate) and is illustrated on Map 3.8.

Impervious Surfaces

Impervious surfaces are measured as an indicator of the amount of area where road salt can be applied. The percentage of surface area within a vulnerable area which will not allow surface water or precipitation to be absorbed into the soil is measured. As a small urban watershed, most of the land area within the watershed is impervious, with the large majority of this area being in the range of 8-<80%, followed by the next greatest amount of area in the 1-<8% range, and a little less area in the <1% range. The percentage of impervious area is illustrated on Map 3.9. The calculation of impervious surface led to the vulnerable area being designated as a significant threat or a moderate threat for the application of road salt depending on the vulnerability score.

The methodology used to calculate percentage of impervious surfaces in the vulnerable areas is described in Chapter 2.

Livestock Density

The calculation of livestock density is based on the calculation of nutrient units per acre of agricultural managed lands. The methodology used to calculate the livestock density in the vulnerable areas is described in Chapter 2.

In the Ramsey Lake intake protection zones, there are no agricultural lands and the area has a score of under 0.5 nutrient units per acre. The results are illustrated on Map 3.10.

Enumeration of Significant Drinking Water Threats

Table 3.13 lists the current number of significant drinking water threat activities in the Ramsey Lake vulnerable areas in accordance with Rule 9 and the Drinking Water Threats Tables.

Table 3.13 – Drinking water quality threat activities for the Ramsey Lake intake

Drinking Water Threat Category	Number of Occurrences with Threat Classification		
	Significant	Moderate	Low
IPZ-1 – Vulnerability score of 10			
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.*	1		
The application of commercial fertilizer to land.*	1		
The handling and storage of fuel.	1		
The application of road salt.*	1		
Local threat: Transportation of hazardous substances along transportation corridors.	1	1	
IPZ-2 – Vulnerability score of 9			
The application of commercial fertilizer to land.*	1		
The application of road salt.*		1	
Local threat: Transportation of hazardous substances along transportation corridors.	1	3	
IPZ-3 - Subwatersheds with a vulnerability score of 9			
The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act.	2		
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.*	1		8
The application of commercial fertilizer to land.*	1		
The application of road salt.*		1	
The storage of snow.		1	
The handling and storage of fuel.		7	
The handling and storage of a dense non-aqueous phase liquid.		16	
The handling and storage of an organic solvent.		19	1
Local threat: Transportation of hazardous substances along transportation corridors.	1	2	
IPZ-3 - Subwatersheds with a vulnerability score of 6			
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.*			
The application of commercial fertilizer to land.*		1	
The application of road salt.*			1
Local threat: Transportation of hazardous substances along transportation corridors.		2	1

* Note that there are additional threats in certain categories that have been identified as significant threats using the issues method. These are listed in Table 3.17 – Drinking water quality issues and associated threats for the Ramsey Lake intake.

19.4 Ramsey Lake Drinking Water Quality Threats Conditions

A drinking water condition is a situation that results from a past activity and meets the criteria laid out in Chapter 2 and Rule 126. For a more detailed review of methodology for identifying drinking water conditions, please refer to Part 1, Chapter 2. The areas where a significant, moderate or low condition could exist are the same for the locations where a potential threat could occur. For an illustration, please see Map 3.5 to 3.7.

Currently, there are no known conditions within the Ramsey Lake vulnerable areas.

19.5 Ramsey Lake Drinking Water Quality Issues

Sodium

Raw (or pre-treated) water quality from 1991 to 2007 was studied to determine if any water quality issues exist. Data retrieved from the Drinking Water Surveillance Program conducted by the Minsitry of the Environment, Conservation and Parks(MECP) was used in the analysis. Trend analyses were updated to February 2013 for the 2013 amendment of the assessment report.

An elevated and rising level of sodium is of concern in Ramsey Lake and is considered to be a drinking water quality issue for this intake. The Ontario Drinking Water Standard for sodium is 200 mg/L, however if sodium exceeds 20 mg/L the local medical officer of health must be notified so that it may be passed on to local physicians. Chloride levels in Ramsey Lake have been consistently above 50 mg/L in recent years and they appear to be increasing. Figure 3.3 depicts the increasing trend from 1991 to 2013.

Elevated levels of sodium are primarily attributed to the application of road salt. The Ramsey Lake watershed is highly urbanized and consists of a number of major roadways where road salt is applied during winter months. The watershed also includes a public works yard with road salting facilities that store road salt and sand-salt mixtures throughout the year. Road salt can be considered a non-point source pollutant and, therefore, the entire vulnerable area for Ramsey Lake is considered the issue contributing area. Note that in the future, when the assessment report is updated, new developments will become part of the vulnerable area and the issue contributing area. In the meantime, the source protection committee is aware that the discharge point of a pipe from a new stormwater management system into an existing intake protection zone / issue contributing area is a significant drinking water threat, therefore the stormwater discharge points from these new developments are subject to policies for stormwater and sodium.

The issues contributing area is delineated on Map 3.11.

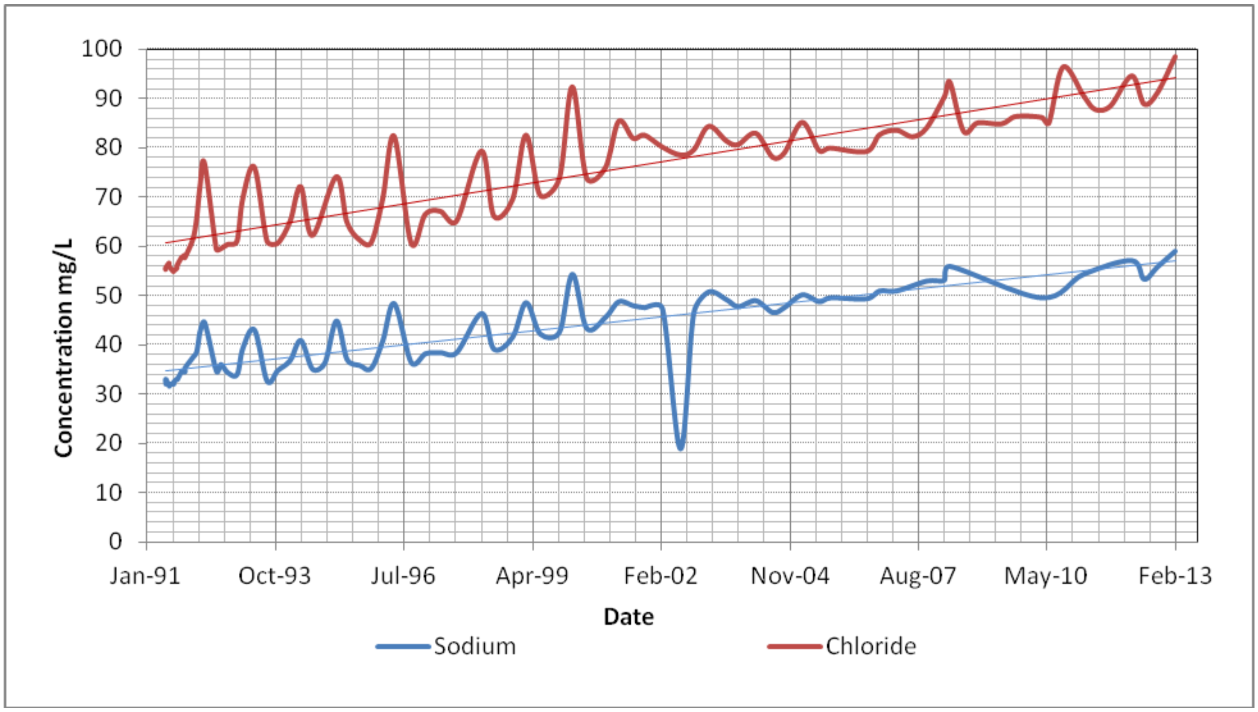


Figure 3.3 – Sodium and chloride levels in Ramsey Lake from 1991 to 2013

Microcystin LR

Cyanobacteria, more commonly known as blue green algae, are ubiquitous bacteria that live in fresh and saline water environments. Some species of cyanobacteria produce a toxin within their cells, which is released after the cell dies. The information surrounding the environmental conditions contributing to the presence of toxins and algae blooms is building in scientific literature, however much is still unknown.

Ramsey Lake has been subject to cyanobacterial blooms historically and relatively recently. In the mid-1960s, algae covered the lake and taste and odour issues were identified in the drinking water supply. Copper sulphate was used to mitigate the blooms and keep the algal growth to a minimum. More recently, a small localized bloom was confirmed in a small bay near South Bay in the fall of 2008, and in the summer of 2010, a bloom was confirmed near the Sudbury Canoe Club. Two blooms were also confirmed in late July 2011, that were located in the South Bay area and the Bell Park area. In 2012 blooms were observed in area surrounding the Sudbury Canoe Club and tested positive for Microcystin LR.

In response to the 2008 bloom, an ad hoc committee was formed with members of the City of Greater Sudbury, Sudbury & District Health Unit, the Ministry of the Environment, Conservation and Parks and the Nickel District Conservation Authority. This group was spearheaded by the City's Water/Wastewater Services department to help ensure that the drinking water quality of Ramsey Lake would be protected from a possible future bloom occurrence. As a result, the Greater Sudbury Source Protection Committee decided to enumerate Microcystin LR as a drinking water issue and an issues contributing area was delineated in accordance with Technical Rule 114. The issue contributing area is delineated on Map 3.11.

Issues Approach to Threat Identification

Technical rule 115 requires that threats be listed for those drinking water issues listed under rule 114. Prescribed drinking water activities contributing to drinking water issues are considered significant threats if located within the issues contributing area, regardless of the vulnerability score.

Phosphorus contributes to the production of cyanobacteria and Microcystin LR. Therefore, any activity contributing phosphorus that occurs within the issues contributing area (Map 3.11) would be considered a significant threat. Likewise, any activity that contributes to the sodium issue would be considered a significant threat.

Tables 3.14 and 3.15 identify the threat activities that can contribute to the drinking water issues identified for this intake.

Table 3.14 – Prescribed threat activities that could contribute to phosphorous

The application of agricultural source material to land.
The application of commercial fertilizer to land.
The application of non-agricultural source material to land.
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.
The establishment, operation or maintenance of a waste disposal site.
The handling and storage of commercial fertilizer.
The handling and storage of non-agricultural source material.
The handling and storage of agricultural source material.
The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard.

Table 3.15 –Prescribed threat activities that could contribute to sodium

The application of road salt.
The handling and storage of road salt.
The storage of snow.

There are presently occurrences of five activities out of the 12 listed in Tables 3.15 and 3.16 that are prescribed drinking water threats related to phosphorus or sodium in the issues contributing area. These are listed in Table 3.16 and are considered significant drinking water threats.

Table 3.16 - Drinking water quality issues and associated threats for the Ramsey Lake intake

Drinking Water System	Drinking Water Issue	Associated Threat	Number of properties in Ramsey Lake Watershed
Ramsey Lake Intake	Microcystin LR (blue green algae)	Septic systems	210
		The application of commercial fertilizer to land	4,550
		Discharge of untreated stormwater from a Stormwater retention pond	2
		Lift stations	8
	Sodium	The application of road salt	4,550
		The handling and storage of road salt	205
		Storage of Snow	19

Table 3.17 shows the list of circumstances for threats that have been identified through the issues process.

Table 3.17 – Table references for significant drinking water threats and associated circumstances related to phosphorus and contributing to the issue of Microcystin and prescribed activities contributing to the issue of sodium

Drinking Water Threat	Circumstances	No. of Occurr-ences
Septic Systems	1. The system is an earth pit privy, privy vault, greywater system cesspool, or a leaching bed system and its associated treatment unit. 2. The system is subject to the *Ontario Building Code Act 1992.* 3. The discharge from the system may result in the presence of Phosphorus (total) in groundwater or surface water. 1. The system is an earth pit privy, privy vault, greywater system cesspool, or a leaching bed system and its associated treatment unit. 2. The system is a sewage system works within the meaning of the *Ontario Water Resources Act.* 3. The discharge from the system may result in the presence of Phosphorus (total) in groundwater or surface water.	210
The application of commercial fertilizer to land	1. The commercial fertilizer is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is less than 40% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is less than 0.5 nutrient units per acre. 2. The application may result in the presence of Phosphorus (total) in groundwater or surface water. 1. The commercial fertilizer is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is at least 40%, but not more than 80% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is less than 0.5 nutrient units per acre. 2. The application may result in the presence of Phosphorus (total) in groundwater or surface water.	4,550
The application of road salt	1. The road salt is applied in an area where the percentage of total impervious surface area, as set out on a total impervious surface area map, is not more than 1 percent. 2. The application may result in the presence of Sodium in groundwater or surface water. 1. The road salt is applied in an area where the percentage of total impervious surface area, as set out on a total impervious surface area map, is more than 1, but not more than 8 percent. 2. The application may result in the presence of sodium in groundwater or surface water. 1. The road salt is applied to an area where the percentage of total impervious surface area, as set out on a total impervious surface area map, is more than 8, but less than 80 percent. 2. The application may result in the presence of sodium in groundwater or surface water.	4,550
The handling and storage of road salt	1. The storage of road salt in a manner that may result in its exposure to precipitation or runoff from precipitation or snow melt. 2. The quantity stored is less than 500 tonnes. 3. Runoff from the area in which the salt is stored may result in the presence of Sodium in groundwater or surface water. 1. The storage of road salt in a salt dome or similar facility designed to protect the salt from exposure to precipitation or runoff from precipitation or snow melt.	205

Drinking Water Threat	Circumstances	No. of Occurr-ences
	2. The quantity stored is more than 5,000 tonnes. 3. Runoff from the area in which the salt is stored may result in the presence of Sodium in groundwater or surface water.	
Discharge Of Untreated Stormwater From A Stormwater Retention Pond	1. The system is a storm water management facility designed to discharge storm water to land or surface water 2. The drainage area associated with the storm water management facility is not more than 1 hectare and the predominant high density residential land use 3. The discharge may result in the presence of Phosphorus (total) in groundwater or surface water. 1. The system is a storm water management facility designed to discharge storm water to land or surface water 2. The drainage area associated with the storm water management facility is more than 1 but not more than 1 hectares and the predominant high density residential land use 3. The discharge may result in the presence of Phosphorus (total) in groundwater or surface water. 1. The system is a storm water management facility designed to discharge storm water to land or surface water 2. The drainage area associated with the storm water management facility is more than 10 but not more than 100 hectares and the predominant high density residential land use 3. The discharge may result in the presence of Phosphorus (total) in groundwater or surface water. 1. The system is a storm water management facility designed to discharge storm water to land or surface water 2. The drainage area associated with the storm water management facility is more than 100 hectares and the predominant high density residential land use 3. The discharge may result in the presence of Phosphorus (total) in groundwater or surface water.	2
The storage of snow	1.The snow is stored at or above grade 2. The area upon which snow is storage is at least 0.01, but not more than 0.5 hectares. 3. Runoff from the area in which the snow is stored may result in the presence of Sodium in groundwater or surface water 1.The snow is stored below grade 2. The area upon which snow is storage is at least 0.01, but not more than 0.5 hectares. 3. Runoff from the area in which the snow is stored may result in the presence of Sodium in groundwater or surface water 1.The snow is stored at or above grade 2. The area upon which snow is storage is at least 0.5, but not more than 1 hectares. 3. Runoff from the area in which the snow is stored may result in the presence of Sodium in groundwater or surface water 1.The snow is stored below grade 2. The area upon which snow is storage is at least 0.5, but not more than 1 hectares. 3. Runoff from the area in which the snow is stored may result in the presence of Sodium in groundwater or surface water	19

Drinking Water Threat	Circumstances	No. of Occurr-ences
	1.The snow is stored at or above grade 2. The area upon which snow is storage is at least 1, but not more than 5 hectares. 3. Runoff from the area in which the snow is stored may result in the presence of Sodium in groundwater or surface water 1.The snow is stored below grade 2. The area upon which snow is storage is at least 1, but not more than 5 hectares. 3. Runoff from the area in which the snow is stored may result in the presence of Sodium in groundwater or surface water 1.The snow is stored at or above grade 2. The area upon which snow is storage is more than 5 hectares. 3. Runoff from the area in which the snow is stored may result in the presence of Sodium in groundwater or surface water 1.The snow is stored below grade 2. The area upon which snow is storage is more than 5 hectares. 3. Runoff from the area in which the snow is stored may result in the presence of Sodium in groundwater or surface water	
Lift Stations	1. The system is part of a wastewater collection facility that collects or transmits sewage containing human waste, but does not include a sewage storage tank or a designed bypass. 2. The system is designed to convey more than 250, but not more than 1,000 cubic metres of sewage per day. 3. The discharge from the system may result in the presence of Phosphorus (total) in groundwater or surface water 1. The system is part of a wastewater collection facility that collects or transmits sewage containing human waste, but does not include a sewage storage tank or a designed bypass. 2. The system is designed to convey more than 1,000, but not more than 10,000 cubic metres of sewage per day. 3. The discharge from the system may result in the presence of Phosphorus (total) in groundwater or surface water 1. The system is part of a wastewater collection facility that collects or transmits sewage containing human waste, but does not include a sewage storage tank or a designed bypass. 2. The system is designed to convey more than 10,000, but not more than 100,000 cubic metres of sewage per day. 3. The discharge from the system may result in the presence of Phosphorus (total) in groundwater or surface water 1. The system is part of a wastewater collection facility that collects or transmits sewage containing human waste, but does not include a sewage storage tank or a designed bypass. 2. The system is designed to convey more than 100,000 cubic metres of sewage per day. 3. The discharge from the system may result in the presence of Phosphorus (total) in groundwater or surface water	8

Chapter 20 - Data Gaps

The analyses for this drinking water system were carried out using the best data available to meet the assessment report requirements. Completing scientific assessments on the quality and quantity of water undoubtedly raises a number of questions and uncertainties regarding the methodologies used, availability of data, reliability of data and overall outcome. As new information arises, either from increased or continuous monitoring, improved models, or a change in methodology, the results from this report will have to be updated to reflect the additional information.

The assessment report is a constantly evolving document as new information becomes available and refinements in approaches are made. Changes in land use will also impact the identification of potential threats to water quality and quantity. Data gaps to be filled include:

- Definite streamflow discharge from Ramsey Lake to Lily Creek is vital for more precise water budgeting;
- Information regarding groundwater gradients will improve the understanding of groundwater contribution to Ramsey Lake; and
- Discharge measurements of inflow streams during dry periods will give an indication of the baseflow contribution to Ramsey Lake.