

These studies, however, did not cover the whole SPA region. The hamlet of Rosslyn Village within the Municipality of Oliver-Paipoonge uses strictly groundwater for their Municipal Drinking Water System, obtaining it from a basal sand and gravel aquifer approximately 5 m thick immediately above the bedrock. Many rural residents rely on residential private wells, from groundwater.

5. It is expected that the Loch Lomond supply will be converted to industrial supply and power generation by the year 2008. Discharge of the used water would be into the lower reaches of the Kaministiquia River. This would minimize the water transfer from the watershed and thereby reduce the overall water demand in the Lakehead SPA
6. From a water quantity perspective, the amount of water moving through the watershed greatly outweighs present and future anticipated uses and the quality is reliable.
7. Water management decisions will be more effective if the water budget is considered within a temporal climatic framework, however site specific water management will have to consider the climatic extremes as well.

6. Tier 1 Water Budget and Water Quantity Stress Assessment

6.1 Introduction

This Water Quantity Stress Assessment process is dependent on the water budget and provides a framework to evaluate the sustainability of drinking water supply systems in the context of the local watershed. The objective of the framework is to help managers identify drinking water sources that may not be able to meet current or future demands. Those sources identified to have potential problems meeting demand will be subject to risk management initiatives designed to help reduce demand and to make more efficient use of available supplies.

Water Budgets and the linked Water Quantity Stress Assessment are those components of the Assessment Report where water supply and demand are quantified, where water movement within the watershed is understood and where the sustainability of the Province's Municipal drinking water sources are evaluated. The level and complexity of water budget assessments required in any specific watershed will depend on a number of factors, in particular water-taking or water-quality stresses. The stress assessment components (the Water Quality Stress Assessment and Water Quantity Stress Assessment) are both strongly linked to water budgetting and, at successive stages, will dictate the need to loop back for additional higher level water budget investigations if necessary.

The Province has prescribed a minimum level of effort - that all regions within the Province need a basic understanding to effectively address issues and prepare source water protection plans. This minimum level of effort requires each region to complete a Conceptual Understanding and a Tier 1 Simple Approach for all watersheds in the Source Water Protection Area.

In the Tier 1 Simple Approach, estimates are made of the various climate components, including precipitation, evapotranspiration, runoff and recharge. These are distributed within the watershed according to land use, surficial geology, (and perhaps slope). The estimates of the components are performed using either simple numerical analysis or, where necessary, GIS techniques are used to assist with this process. For the watersheds of the Lakehead SPA, which contain a few small communities, two municipal drinking water supplies (one surface water and one groundwater), minimal growth, and small land use change, the Tier 1 Simple Approach is all that is required. Within the Lakehead SPA, the pathways that the water takes and the connections between groundwater and surface water are not significant in managing the water quantity and quality stresses on drinking water supplies.

This Tier 1 Water Quantity Stress Assessment analysis largely utilized the available data, collected and analyzed in the Conceptual Understanding phase, to evaluate the cumulative stress within each watershed/subwatershed. As a part of the process, an overall water taking stress limit within the Lakehead SPA was evaluated. Accordingly, the water demand was assessed against the water supply to determine whether the watershed was under significant, moderate or low stress. The Water Demand for the watersheds of the Lakehead SPA was estimated from the Ministry of the Environment Permit To Take Water (PTTW) for both surface water and groundwater (see Map 15). The surface water supply was determined from the available streamflow data (1970-1994). The municipal groundwater supply for the Rosslyn Village was calculated from the available groundwater study report.

A water quantity stress assessment is conducted for the Loch Lomond water supply plant. This is a surface water intake that is located on Loch Lomond (see Map 16). Another water quantity stress assessment is conducted for the Rosslyn Village municipal water well (see Map 15) to determine if there are any concerns regarding the sustainability of the Municipal drinking water supply for the Rosslyn Village. Some parts from the Conceptual Water Budget have been used and may be repeated while evaluating water quantity stress assessment in this section.

6.2 Water Budget Elements

The Tier 1 water budget and stress assessment is designed to screen out the unstressed watersheds, utilizing existing information collected during the Conceptual Understanding phase. The level of water budget understanding necessary in the Tier 1 level is a simple approach that estimates the various elements of the hydrologic cycle, including precipitation (P), actual evapotranspiration (AET), recharge (R) and runoff (RO). These were calculated during the Lakehead SPA Conceptual Water Budget Understanding phase using climate data (1970-1994). The recharge was estimated using the GIS techniques presented in Section 4.4.2.

The estimated/calculated P, AET, R and RO were distributed within the watershed according to land use, surficial geology and slope. GIS techniques were used to assist with this process. This approach includes a soil moisture budget or climate estimating procedure using established methods. The calculations were conducted on a monthly basis to allow for monthly and annual summations to be used in the Tier 1 stress assessment. Water surplus was calculated (precipitation minus actual evapotranspiration) according to the methodology of Thornthwaite and Mather (1957). This calculation took into account monthly mean temperature and precipitation for six climate stations within or near the Lakehead SPA. The next step was to calculate runoff and infiltration according to the coefficient method outlined by the Ministry of the Environment (1995) using soil characteristics, topography and vegetative cover.

6.2.1 Water Supply Estimation

6.2.1.1 Surface water Supply Evaluation

The main source of Municipal water supply in the Lakehead SPA is Lake Superior and Loch Lomond. However, Lake Superior is not considered a part of the Lakehead SPA and given its tremendous storage volume is not considered in the analysis. Currently Loch Lomond supplies municipal drinking water from the Loch Lomond water treatment plant. As mentioned in the Conceptual Understanding of Water Budget, the City of Thunder Bay intends to draw its entire potable municipal water supply from Lake Superior by the fall of 2007. Thereafter, the Loch Lomond water supply is available for other uses at the discretion of the stakeholders, and subject to appropriate regulatory approval.

There are two discharge points for Loch Lomond. The main discharge is the Lomond River. The former water taking from the lake to the City of Thunder Bay is the other one. For this evaluation the water feeding Loch Lomond must be determined. Presently, there is no gauge station for the measurement of streamflow at Loch Lomond. The gauge station 02AB008 located on Neebing River at Thunder Bay is identified as the closest to Loch Lomond. Therefore, streamflow (or water supply) at Loch Lomond is estimated using the data from gauge station 02AB008 and applying the pro rata area of the two watersheds. This calculation involves determining the monthly average streamflow at 02AB008 from the years 1970-1994. The calculated monthly average data are multiplied by the ratio of the catchment area of Loch Lomond to the catchment area of Neebing Watershed.

Figure 16 depicts the mean monthly flow distribution at Loch Lomond. From Figure 16 it is seen that the highest flow occurs in April with a value of approximately $2.53 \text{ m}^3/\text{s}$, whereas the lowest flow month is February with a mean flow of approximately $0.06 \text{ m}^3/\text{s}$. The mean annual flow at Loch Lomond is $0.68 \text{ m}^3/\text{s}$. From the flow distribution, it appears that the highest flow in Loch Lomond or alternatively at gauge 02AB008, is associated with snowmelt in the spring, whereas the lowest flow occurs in January-February when most of the surficial water remains frozen. It must however be noted that low discharge in February may not be a limiting factor given the available storage in the lake and replenishment in the spring.

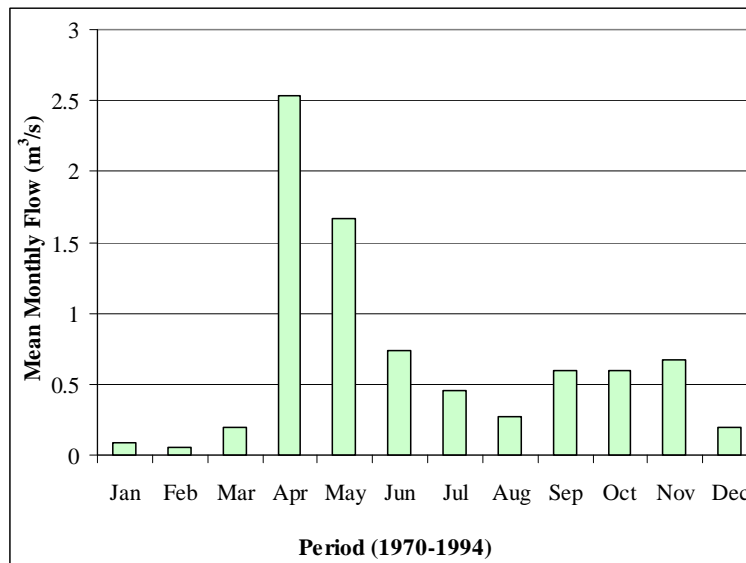


Figure 16. Mean Monthly Flow (Water Supply) at Loch Lomond

6.2.1.2 Groundwater Supply Evaluation

Within the Lakehead SPA, the only groundwater-based municipal water supply system is in Rosslyn Village. There are two wells in the Rosslyn Village; one is the production well and the second is used as standby. The following paragraphs summarize the results of a groundwater modelling study on the Rosslyn Water Well system study conducted by R.J. Burnside in association with Amec Earth & Environmental (Burnside and Amec, 2005).

According to the groundwater study report, the overburden material at the site is identified as being primarily comprised of surficial sands, till, silty clay, and basal sand and gravel units. The subject wells are reportedly screened in the water bearing basal sand and gravel unit. The basal sand and gravel unit was interpreted to extend over a distance of about 1,200 m to 1,800 m away from the Kaministiquia River in a northwesterly direction. The clay unit, overlying the aquifer, was interpreted to extend for a distance of about 2,000 m from the river. Undifferentiated till deposits were interpreted to extend down to the bedrock surface north of the surficial clay zone. Total thickness of the overburden material in the Rosslyn Village area is about 40 m. Bedrock underlying the overburden material is described as sedimentary rock of the Animikie Group. According to the pumping test data analyzed by Waters Environmental Geosciences Ltd. (Waters, 2003) transmissivity of the basal sand and gravel aquifer is expected to be about 66 m²/d. Based on this transmissivity value and taking into account that the basal unit thickness is about 3 m to 6 m, the hydraulic conductivity of the basal unit is expected to be in the order 10⁻⁴ m/s. Apparent transmissivity of the bedrock aquifer was estimated to be in the range of 0.08 m²/d to 82.3 m²/d, with a geometric mean of 2.8 m²/d (Waters, 2003). The average penetration depth of wells in the area into this aquifer is about 37 m.

The groundwater flow direction in the shallow and deep overburden and bedrock aquifers was interpreted to be primarily south to southeast, towards the Kaministiquia River. Close to the river, hydraulic heads in the shallow overburden appear to be higher than in the deep system (basal unit and bedrock aquifer). This can be attributed to the fact that water level in the Kaministiquia River (about 195 mASL) appears to be below the bottom of the shallow sand unit. Further north of the river there is no indication of significant differences between hydraulic heads in various aquifer units.

Recharge of the aquifer within the Lakehead SPA was assumed to be coming from precipitation only. Note that recharge of the deep aquifer zones is expected to occur primarily in the undifferentiated till zone located in the northern portion of the Lakehead SPA (Burnside and Amec, 2005). Groundwater from both overburden and bedrock units is expected to discharge into the Kaministiquia River and into several permanent streams located north of Rosslyn Village.

Some of Rosslyn Village²¹ is supplied from a Municipal groundwater well under MOE's PTTW (# 00-P-6073) with the maximum allowable water takings of 124.4 m³/day for each pump. Based on a groundwater flow model conducted for the Rosslyn Water Supply Well field, the total groundwater supply or inflow in the basal sand and gravel unit and further upgradient is about 6,431 m³/day most of which comes from recharge.

6.2.2 Water Demand Estimation

Within the current methodology, water demand will only relate to water taken as a result of an anthropogenic activity (e.g., municipal supply water takings, private water well takings as well as other permitted takings), that is, a consumptive use. In a strict sense, consumptive water demand refers to water taken from surface or groundwater and not returned locally in a reasonable period of time.

Referring to the Conceptual Water Budget part of this report, the consumptive surface water and groundwater use/demand was quantified based on the MOE's PTTW in the Lakehead SPA (see Table 14). The quantities of permitted water takings as reported in the PTTW database are generally presented as maximum takings over a period of time and do not usually reflect the actual takings. Consequently, using permitted water takings to estimate water demand generally far overestimates the actual demand. For the purpose of the more detailed Tier 1 analysis, the present water demand for surface or groundwater in the Lakehead SPA is calculated based on the actual water takings from the watershed.

6.2.2.1 Surface water Demand

The actual monthly surface water taking from Loch Lomond at the Loch Lomond Water Treatment Plant in the year 2002 is shown in Table 17 and in Figure 17. The 2002 monthly water takings data are used, as it was not possible to obtain the most current water supply data from the treatment plant.

21. *Some residents choose to use their own wells.*

Table 17. Summary of Quantity of Water Supplied by the Loch Lomond Water Treatment Plant in the Year 2002

Period	Water Takings (m ³ /month)	Average Daily Takings (m ³ /day)
January	848,470	27,370
February	767,820	27,422
March	849,250	27,395
April	868,980	28,966
May	942,950	30,418
June	922,840	30,761
July	946,330	30,527
August	900,700	29,055
September	850,370	28,346
October	872,170	28,135
November	684,690	22,823
December	698,230	22,524
Total (m³/yr)	10,152,800	
Permitted Water Takings (m³/yr)	28,207,930	

Data source: City of Thunder Bay website

The total actual water takings are about 10 Mm³/yr, which is about 36% of the maximum allowable takings according to the PTTW database. Table 17 also shows that the maximum monthly water takings is in the month of July.

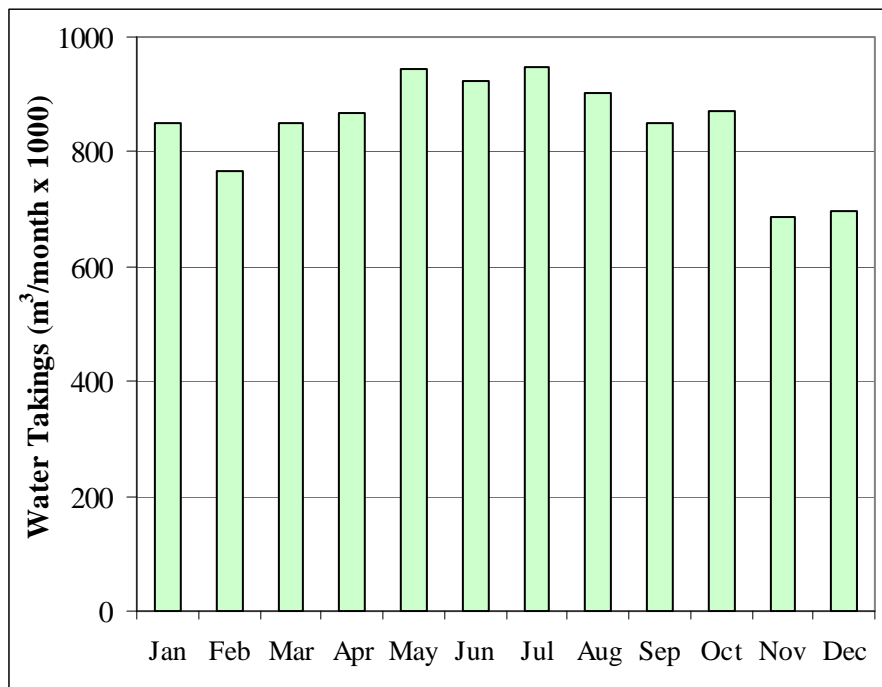


Figure 17. Monthly Water Takings from Loch Lomond Water Treatment Plant

6.2.2.2 *Groundwater Demand*

Calculated water takings from the Rosslyn municipal groundwater supply well are provided in Table 19 and graphically shown in Figure 18. As only daily average water takings data (35 m³/day, Burnside and Amec, 2005) were available for the Rosslyn Water Supply Well, monthly water takings were determined using a comparison to the monthly water takings patterns at Loch Lomond Water Treatment Plant and using the following procedure:

- a) the actual monthly takings from the Loch Lomond Water Treatment Plant were summed to get an annual total of 10,152,800 m³(Table 18);
- b) This annual total was divided by 12 to get an average monthly taking of 846,067 m³ (Table 18);
- c) the actual given monthly takings (column b in Table 18) were divided by the arithmetically averaged monthly takings (b, above) to get a coefficient for each month (column c in Table 18); and
- d) The coefficient, which is variable for each month, was then multiplied by the given monthly average takings from the Rosslyn Water Supply Well to get monthly water takings for the Rosslyn Water Supply Well (Table 19).

Table 18. Estimation of Coefficient Used for Calculating Monthly Water Takings from the Rosslyn Water Supply Well

Period	Loch Lomond Water Takings (m ³ /month)	Coefficient
January	848,470	1.003
February	767,820	0.908
March	849,250	1.004
April	868,980	1.027
May	942,950	1.115
June	922,840	1.091
July	946,330	1.119
August	900,700	1.065
September	850,370	1.005
October	872,170	1.031
November	684,690	0.809
December	698,230	0.825
Total (m³/yr)	10,152,800	
Average Monthly Taking (Total/12)	846,067	

The annual water demand for the Rosslyn Village is approximately 12,800 m³ with the highest water demand observed in the months of May and July.

Table 19. Summary of Water Takings Calculated for the Rosslyn Water Supply Well

Period	Days of the Month	Monthly Water Takings (m ³ /month)*		Coefficient **		Monthly Water Takings (m ³ /month)***
January	31	1085	X	1.003	=	1088
February	28	980	X	0.908	=	889
March	31	1085	X	1.004	=	1089
April	30	1050	X	1.027	=	1078
May	31	1085	X	1.115	=	1209
June	30	1050	X	1.091	=	1145
July	31	1085	X	1.119	=	1214
August	31	1085	X	1.065	=	1155
September	30	1050	X	1.005	=	1055
October	31	1085	X	1.031	=	1118
November	30	1050	X	0.809	=	850
December	31	1085	X	0.825	=	895
Total (m³/yr)		12,787				

Notes: * calculated by multiplying the reported average daily water takings (35 m³/day) with the days of a corresponding month

** coefficient was calculated based on the procedure described above

*** monthly water takings in column three multiplied with the coefficients in column five

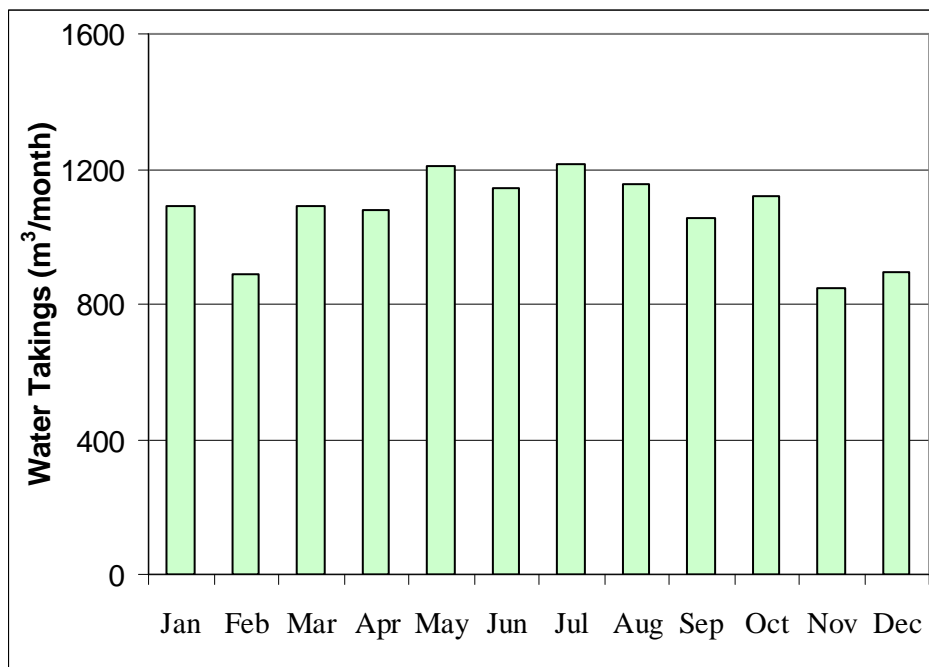


Figure 18. Calculated Monthly Water Takings from the Rosslyn Water Supply Well

6.2.3 Water Reserve Estimation (Surface Water and Groundwater)

Water reserve is an estimate of the amount of streamflow that needs to be reserved to support other uses of water within the watershed including both ecosystem requirements (instream flow needs) as well as other human uses, both future permitted uses and current and future non-permitted uses.

For the Tier 1 assessment of the Loch Lomond watershed (surface water source) in the Lakehead SPA, the water reserve will be estimated using the nearby streamflow data for the Neebing River at Thunder Bay gauge stations (1977-1994). This will estimate the monthly water reserve in Loch Lomond, which is stipulated by the MOE Guidance Module 7 as 10% of the total supply. For groundwater, the reserve quantity is also estimated as 10% of the estimated groundwater supply (recharge plus groundwater inflow). The water reserve in either case will be used as a threshold level in comparison to the percentage water demand.

6.2.4 Water Budget Summary

In addition to providing an integrated water budget summary for the entire Lakehead SPA, water budgets were calculated for twelve subwatersheds under the Conceptual Water Budget section of the report. As the watershed region is composed of numerous lakes and wetlands and its soil structure is mostly of silt, sand and gravel, there is a significant interaction between surface water and groundwater in terms of baseflow contribution to the streams. For example, for the Kaministiquia River Watershed at Kaministiquia, a total of about 50% of surplus water was identified as baseflow.

Considering Loch Lomond's water use in the future, a detailed water budget analysis for Loch Lomond was conducted for its contributing watershed as a part of Tier 1 analysis. The total contributing catchment area for Loch Lomond (including the lake itself) is estimated to be 76.7 km². The mean monthly and annual water balances for Loch Lomond are summarized in Table 20.

As shown in Table 20, the annual total precipitation applied to Loch Lomond is approximately 63.5 Mm³. Approximately 39 Mm³ (or approximately 61% of annual precipitation) is lost through evapotranspiration. Approximately 25 Mm³ (or approximately 39% of annual precipitation) of water remains as surplus. The amount of surplus is assumed to reach the lake through groundwater flow and runoff. Out of 25 Mm³ of surplus water, approximately 10 Mm³ has typically withdrawn from Loch Lomond for municipal water supply. As mentioned previously in Section 4, the total stream flow should theoretically be equal to the surplus, given that groundwater storage changes are negligible over longer periods of time. In this watershed, estimated surplus matches with streamflow within $\pm 15\%$. A breakdown of water surplus, streamflow, and water takings on a monthly basis is shown on Figure 19 graphically.

Table 20. Monthly and Annual Water Budget for the Loch Lomond Watershed

Month	Precipitation (Mm ³)	Actual ET (Mm ³)	Surplus (Mm ³)	Streamflow 1 (Mm ³)	Water Takings (Mm ³)
January	4.05	0.00	4.05	0.24	0.85
February	2.60	0.00	2.60	0.14	0.77
March	3.90	0.00	3.90	0.51	0.85
April	3.78	1.55	2.23	6.56	0.87
May	5.89	5.39	0.50	4.47	0.94
June	6.59	7.89	Deficit (-1.30)	1.92	0.92
July	7.42	9.11	Deficit (-1.69)	1.21	0.95
August	6.71	7.59	Deficit (-0.88)	0.73	0.90
September	7.24	5.02	2.22	1.54	0.85
October	5.36	2.18	3.18	1.61	0.87
November	4.95	0.00	4.95	1.74	0.68
December	5.01	0.00	5.01	0.53	0.70
Total	63.50	38.74	24.76	21.20	10.15

Note: 1. Mean streamflow data from Neebing River near Thunder Bay Airport (02AB08) and later calculated on areal proportional basis.

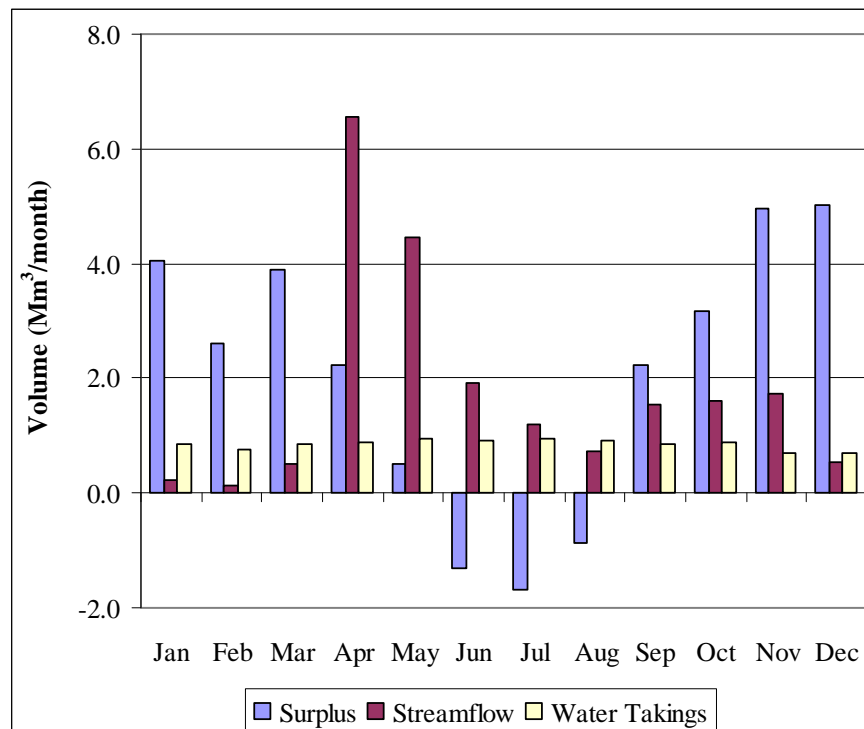


Figure 19. Water Surplus, Streamflow and Water Takings in the Loch Lomond Watershed

When comparing water surplus with water takings, it appears that May through August are the months when water takings exceed the surplus and theoretically, lake discharge goes to zero and the water levels begin to decline. This is not observed in practice indicating that some of the recharge from earlier months may be reaching the lake as baseflow, supplementing the water supply.

6.3 Subwatershed Stress Assessment

The Tier 1 stress assessment is designed to efficiently screen out safe subwatersheds and highlight those where the degree of stress warrants refined water budget efforts for stress characterization. The stress assessment evaluated the ratio of the consumptive water demand for permitted and non-permitted users to the available water supplies, minus water reserves within the subwatershed. For groundwater, a calibrated numerical model exists and was used for the Tier 1 stress assessment, whereas for the Loch Lomond surface water source, available existing data were used for the stress assessment.

At Tier 1, for each drinking water supply, two scenarios were evaluated: i) current conditions; and ii) 25-year future demand.

The % Water Demand was evaluated independently for groundwater and surface water. The subwatershed stress level was then determined based on the greater level of stress evaluated for either the groundwater or surface water system in question.

Table 21. Tier 1 Stress Assessment Scenarios (MOE, 2007)

Time Period	Average Annual % Water Demand	Highest Monthly % Water Demand
Current Conditions	Groundwater Supplies	Groundwater and Surface Water Supplies
25-Year Future Demand	Groundwater Supplies	Groundwater and Surface Water Supplies

Table 21 presents the list of scenarios for groundwater and surface water supplies. As this table indicates, groundwater systems are evaluated for both average annual and monthly conditions, whereas surface water conditions are evaluated monthly. The reason for this is that the rate of groundwater flow is so slow that there are only subtle differences between months, whereas monthly flow in surface water varies widely.

Based on percentage Water Demand (which will be compared to prescribed thresholds, discussed below), each subwatershed was assigned a stress level for groundwater and for surface water. Based on MOE Module 7, those subwatersheds receiving a low level of stress will require no further water budgetting or water quantity stress assessment work. Monitoring is still anticipated to occur within these areas, and databases should be maintained in an up-to-date manner. This is considered necessary in case future conditions change within the watershed, and the stress needs to be reassessed.

Tables 22 and 23 identify the Tier 1 stress thresholds for surface and for groundwater, respectively.

Table 22. Tier 1 Stress Thresholds (Surface Water) (MOE, 2007)

Surface Water Quantity Stress Level Assignment	Maximum Monthly % Water Demand
Significant	> 50%
Moderate	20% - 50%
Low	<20%

Table 23. Tier 1 Stress Thresholds (Groundwater) (MOE, 2007)

Groundwater Quantity Stress Assignment	Average Annual	Monthly Maximum
Significant	> 25%	> 50%
Moderate	> 10%	> 25%
Low	0-10%	0-25%

For surface water, stress categories are assigned to each subwatershed by comparing their maximum calculated monthly stress to the thresholds listed above. These thresholds apply to both current and future conditions. The resulting surface water stress level assignment is the maximum of the current and future assessment values.

For groundwater, the thresholds for monthly maximum conditions are higher than average annual thresholds because groundwater systems can typically tolerate short-term water demands that may not be sustainable over the entire year. The resultant groundwater stress level assignment is the maximum of the current and future assessment values for both annual and monthly conditions.

6.3.1 Inland Surface Water Source – Loch Lomond Water Supply

The only municipal water supply in the Lakehead SPA was Loch Lomond, which will soon be decommissioned. Despite this, a surface water stress calculation was performed for Loch Lomond considering that its water is still in use.

The following equation was used to calculate water quantity stress. However, for surface water, the annual average flow does not have practical significance and the percentage Water Demand is calculated on a monthly basis:

$$\% \text{ Water Demand (Surface Water)} = \frac{Q_{\text{DEMAND}}}{Q_{\text{SUPPLY}} - Q_{\text{RESERVE}}} \times 100$$

The terms of the equation were determined as follows:

- **Q_{Supply} (Surface Water Supply):**
 Calculated on monthly basis using the measured streamflow data (1970-1994) of a nearby station and applying the pro rata of catchment area of two subwatersheds. Monthly lake reserve is calculated based on a lake area of 20 km², and a lake depth of 10 m, and dividing the total volume by 12 (see also Section 6.2.4);
- **Q_{Demand} (Surface Water Demand):**
 Taken as the estimated water takings from Loch Lomond in the latest year available, 2002;
- **$Q_{Reserve}$ (Surface Water Reserve):**
 Calculated as 10% of the lake reserve;
- **% Surface Water Demand:**
 Calculated using the expression mentioned above.

Table 24 provides monthly percentage surface water demand calculated using the above expression. Also shown in Table 24 is the monthly stress level assignment based on the threshold values listed in Table 22.

Table 24. Summary of Tier 1 Surface Water Stress Assessment for the Loch Lomond

Month	Streamflow (Mm3)	Lake Reserve (Mm3)	Inflow into the Lake (Mm3)	Water Takings (Mm3)	% Water Demand	Stress Level Assignment
January	0.24	16.67	16.91	0.85	5.57	Low
February	0.14	16.67	16.81	0.77	5.07	Low
March	0.51	16.67	17.18	0.85	5.48	Low
April	6.56	16.67	23.23	0.87	4.03	Low
May	4.47	16.67	21.14	0.94	4.84	Low
June	1.92	16.67	18.58	0.92	5.45	Low
July	1.21	16.67	17.88	0.95	5.84	Low
August	0.73	16.67	17.40	0.90	5.73	Low
September	1.54	16.67	18.21	0.85	5.14	Low
October	1.61	16.67	18.28	0.87	5.25	Low
November	1.74	16.67	18.41	0.68	4.09	Low
December	0.53	16.67	17.20	0.70	4.50	Low

Presently (based on the information provided to calculate the percentage water demand), the maximum monthly surface water demand of approximately 6% is in the month of July. The stress level associated with the percentage water demand is assigned to LOW in accordance with the thresholds as listed in Table 22. Future water demand is not calculated, as the potential water use from the lake is not known and indeed the existing use is expected to stop by the fall 2007.

6.3.2 Groundwater Source – Rosslyn Water Supply Well

In the Lakehead SPA, the only groundwater based municipal water supply system is in the Rosslyn Village in the Municipality of Oliver Paipooonge. Therefore, a groundwater stress calculation is performed and a stress level is assigned for the Rosslyn Village subwatershed. The Tier 1 groundwater water stress assessment for the Rosslyn Village subwatershed needed to determine the following terms/parameters by using a simple calculation:

$$\% \text{ Water Demand (Groundwater)} = \frac{Q_{DEMAND}}{Q_{SUPPLY} - Q_{RESERVE}} \times 100$$

- **Q_{Supply} (Groundwater Supply):**
 Obtained as the combination of groundwater recharge plus the groundwater inflow into the watershed from the calibrated 3-D groundwater flow model developed for the subject well (Burnside and Amec, 2005);
- **Q_{Demand} (Groundwater Demand):**
 Calculated as the estimated average annual and monthly rate of groundwater takings in the subwatershed. For monthly calculations the average annual recharge is divided by 12 to obtain the monthly water demand;
- **Q_{Reserve} (Groundwater Reserve):**
 Calculated as 10% of the groundwater recharge (supply);
- **% Water Demand:**
 Groundwater in the subwatershed is calculated using the expression described above.

The above terms and calculations for Tier 1 of the Rosslyn Village groundwater stress assessment have been summarized in Table 25.

The above table indicates that currently The Rosslyn Village’s water requirement are met with pumping one production well. The consumption rate is far below the maximum allowable water takings (PTTW) and therefore, it is unlikely that the village should exceed its permit allowance.

The annual maximum (based on PTTW database) and average annual percentage groundwater demand is 2.15% and 0.60%, respectively. The stress assessment for either scenario is low (see Table 25) as they are below the threshold value of 10. Since 99% of the water supply consists of recharge, there is no significant difference in the calculation of monthly water demand from the annual demand. There is no 25-year population trend available, however if one assumes an increase of 10% the above figures do not change appreciably (<1%) and therefore a Low stress level is determined for the 25 year scenario.

Table 25. Summary of Tier 1 Groundwater Stress Assessment for the Rosslyn Water Supply Well

Tier 1 Components	m ³ /yr	m ³ /month	Comments
Recharge	2,315,560	195,963	From a 3-D GW Flow Model (Burnside and Amec, 2005)
GW Inflow	31,755	2,646	From a 3-D GW Flow Model (Burnside and Amec, 2005)
Water Supply (Recharge + GW Inflow)	2,347,315	195,609	
Maximum Water Takings (Water Demand)	45,398	3,783	PTTW # 00-P-6073
Average Annual Water Takings (Water Demand)	12,787	1,065	Based on daily average water takings
Reserve	234,731	19,561	10% of Water Supply
% Water Demand (Maximum Water Takings)	2.15	2.18	Considered Max Water Takings + Reserve; monthly % water demand accounts for only recharge instead of total water supply
% Water Demand (Actual Water Takings)	0.60	0.61	Considered Ave Annual Water Takings + Reserve; monthly % water demand accounts for only recharge instead of total water supply
Stress Assessment Assignment	Low	Low	% Demand <10% of threshold level

6.3.3 Uncertainty

Uncertainty is inherent in the water budget estimation process. The accuracy of estimates is reliant on the quality of input data. Input data of observations pertaining to climate, streamflow and hydrology may contain errors. All of these factors can lead to uncertainty in the water budget estimates that are then applied to the subwatershed stress assessment, which may compound the uncertainty. This uncertainty particularly becomes important if a subwatershed has been assigned a low stress level. Subwatersheds that are assigned a stress level near the low-moderate threshold of 10% should check all calculations to ensure that all estimates can be considered conservative. This is not the case for the Lakehead SPA where the % Water Demand is generally < 6% (Table 24).

The Tier 1 stress assessment seeks to determine threats to water quantity on a watershed/subwatershed basis utilizing existing observed data or simple, ideally conservative, estimates of various elements of the hydrologic cycle. In some cases some of these estimates may be subject to considerable uncertainty. For example, for a surface water stress assessment, surface water supply was calculated based on a nearby gauge and the streamflow data was pro-rated to calculate water supply in the lake. In addition, the monthly lake reserve assumed a constant volume of water in the lake throughout the year. Both estimates may contain considerable uncertainty in the calculation of final percentage water demand.

There may also be uncertainty associated with the Tier 1 groundwater stress assessment for the Rosslyn Village subwatershed, especially in terms of calibrated water supply estimates from a 3D-groundwater flow model (Burnside and Amec, 2005). Since the consumptive water takings are extremely low compared to its supply and the population is not expected to increase significantly, there is very much less possibility that the subwatershed will move to a moderate stress level.

6.4 Significant Recharge Areas

As part of the water budgetting exercise recharge rates were determined across the Lakehead SPA. As described in Section 4.4.2, recharge is the process by which water moves from the ground surface, through the unsaturated zone, to arrive at the water table (MOE, 2007). Given that recharge is an integral part of understanding the flow systems across the watershed, it was important for the Water Quantity Stress Assessment Report to address the issue of “significant” recharge areas. As identified in Guidance Module 7, the use here of the term “significant” is different than that used to define a level of risk in the source water protection stress assessment process.

The Lakehead SPA requires only a Tier 1 analysis and significant recharge areas were delineated using the more simple methods outlined in Appendix B of Guidance Module 7.

The identification of the Significant Recharge Areas for any given watershed is considered a two-step process. The first step is to delineate those areas that provide the most volume over the smallest area of recharge to the watershed. These areas are labelled as “High Recharge Volume Areas”. The second step is to consider which of these areas, or other low volume recharge areas might be considered significant within the context of the watershed.

Gartner Lee conducted significant recharge area mapping using the High Volume Recharge Area Delineation method (# 3) described in Guidance Module 7. In this methodology, high volume recharge areas were delineated based on those areas that have a recharge rate of greater than 1.15 times the average annual recharge rate to the watershed under consideration. The high volume recharge areas for the entire Lakehead SPA are mapped on Map 17.

The High Volume Recharge Areas delineated above are all certainly strong contenders to be identified as Significant Recharge Areas. However, it should be pointed out that even some areas with a lower recharge rate might be considered significant if they are essential in maintaining an important hydrological or ecological function. One example of this is subwatershed of the Rosslyn Water Supply Well as described below.

The high volume recharge areas in the Lakehead SPA (Map 17) provides general recharge to subsurface aquifers in areas with little or no water use or no municipal water demand and are thus not deemed significant in the context of this surface water driven system which is highly regulated²². The only exception is the subwatershed containing the Rosslyn Water Supply Well. The 25-year time-of-travel area, as defined in the Burnside and Amec (2005) groundwater modelling study report is 0.15 km². This is the same as Well Head Protection Area (WHPA). Even though the average recharge rate of approximately 168 mm/yr is less than the 193 mm/yr high volume recharge threshold, it is nonetheless deemed significant because it is in the WHPA. Map 18

22. *This does not say that the ecologic function is insignificant, however evaluation of this important function is beyond the scope of this document.*

shows a conservative estimate of the significant recharge area for the Rosslyn Water Supply Wells of approximately 1 km². (This estimate allows for seasonal spreading of the capture zone and must be treated with caution. Should land use regulations be considered, a more detailed analysis is necessary, but is beyond the scope of this undertaking.) Finally, in the Rosslyn Village subwatershed, groundwater ultimately discharges to the stream and river systems. Although there are some volume high recharge areas within the Rosslyn Village/wells subwatershed, these are not shown in Map 18. The mapping of the high volume recharge areas was conducted at a scale suitable for the entire Lakehead SPA, using map sources that ranged from 1:20,000 to 1:1,000,000. The spatial accuracy is such that it is inappropriate to present at smaller scale.

6.5 Data and Knowledge Gaps

As stated in Section 6.3.3, there is no measured water supply data for Loch Lomond. There is also no climate station near Loch Lomond. Precipitation and temperature data were obtained from Thunder Bay Airport to calculate water budget components for the Loch Lomond subwatershed. Daily usage figures for Rosslyn were unavailable for this work. The significant recharge area for Rosslyn has only been conservatively estimated for the purpose of this study, and should be more carefully delineated should land use restrictions be considered. We are unclear if there are recorded groundwater takings for Rosslyn's municipal wells and if not, they should be recorded to facilitate not only source protection, but well operation decisions.

Calculation of the contributing water to Loch Lomond has been undertaken using secondary sources that do not consider its elevation or special geographic relation to Lake Superior. Should this become a municipal drinking water source in future, consideration may be given to acquiring site specific meteorological and streamflow data.

6.6 Summary

The Tier 1 Water Budget and Water Quantity Stress Assessment can be summarized as follows:

- a) Tier 1 Water Budget and Water Quantity Stress Assessment were carried out on two municipal drinking water supplies: Loch Lomond (surface water based) and Rosslyn Water Supply Well (groundwater based). However, Loch Lomond has already been decommissioned as the source of drinking water supply and may be used in future for other purposes which are undetermined at this time. Analysis was performed for both current and future conditions;
- b) Water quantity stress assessment identified LOW levels of stress for both the Loch Lomond and Rosslyn Water Supply Well watersheds;

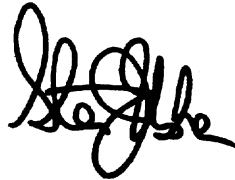
- c) High volume recharge areas have been mapped for the entire Lakehead SPA following MOE Method 3. Low volume recharge areas linked with the Rosslyn Village Well head protection area can be considered significant recharge areas, but may require refinement should land use restrictions be considered; and
- d) Based on the Low Stress level assignment it is recommended that there is no need to proceed to Tier 2 for those water supplies in the Lakehead SPA.

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