

## **5. Integrated Conceptual Understanding**

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### **5.1 Water Budget on a Watershed Basis**

#### **5.1.1 Spatial Scale**

The Lakehead SPA consists of a large number of surface water river systems – the most important within the Lakehead SPA are Kaministiquia River, Neebing River, Current River, McIntyre River, and Wolf River. All the river systems drain ultimately to Lake Superior. The Kaministiquia River System is the largest watershed in the Lakehead SPA, covering a drainage area of approximately 7,812 km<sup>2</sup>. Several large lakes feed the river and the river flow is controlled by a large number of dams constructed on the river. Groundwater flow is localized towards the surface water system. In the Lakehead SPA it is assumed that the surface drainage watershed or subwatershed boundaries correspond to the groundwater flow divides. Given the shallow nature of the groundwater system this is a reliable assumption. The Lakehead SPA subwatershed study includes a large enough area that cross-boundary groundwater flow is not an issue. Topography is therefore one of the key drivers of the groundwater flow system.

Groundwater takings for Municipal drinking water consist of two wells operating alternately in Rosslyn Village to supply about 30 homes for a small community of approximately 90 people. Groundwater is also the source for private domestic water supply in the area and other surrounding townships and municipalities in the Lakehead SPA that receive no municipal drinking water service from the municipality. Approximately 22,000 people use groundwater from individual private wells. There were approximately 3,000 private wells listed in the MOE water well database, spread over the 11,526 km<sup>2</sup> of watershed area. These takings will not induce changes that will extend beyond the surface watershed or subwatershed boundaries, primarily because they are returned to the ground very close to where they are taken.

In the Lakehead SPA, the City of Thunder Bay obtains all of its water supply from Lake Superior and Loch Lomond<sup>17</sup>. The City of Thunder Bay draws 33.6 Mm<sup>3</sup>/yr (see section 4.6 for details) of water for a population of 109,016. It is also reported that within the city limit approximately 8% of the population use individual domestic wells for their water demand. Most of the treated wastewater is ultimately discharged into Lake Superior via the lower reach of the Kaministiquia River. In total, twenty-one independent quaternary watersheds (Figure 1) are identified within the Lakehead SPA. There are 13 usable HYDAT stations within the SPA which measure flow and water level for a specified drainage area. To better understand the overall movement of water in the large subwatersheds, our water budget will be calculated on the subwatershed scale (based on the upstream catchment area at streamflow gauge stations) for the conceptual understanding and for Tier 1.

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*17. The City intends to draw its entire municipal potable water supply from the Lake Superior by the fall of 2007.*

### **5.1.2 Annual Temporal Scale**

Hydrologic patterns can be subdivided into four general periods throughout the year. The actual length of each period can differ between particular locations, on an annual basis, and depending on climate.

Period 1 occurs from approximately mid-November to the late part of March. Precipitation is generally in the form of snow (Figure 6) with the thickness of the snowpack increasing. The temperature is generally below freezing (Figure 4). Evaporation from the snowpack is minimal and the recharge to the water table is almost zero, due to the frozen ground. The exception would be for periodic melting events before the ground is completely frozen. In the absence of recharge during this time, groundwater storage may deplete. Streamflow is primarily composed of groundwater discharge.

Period 2 runs from late-March to May. The rise in temperature to above freezing means that most precipitation is in the form of rain. With the melting of the snowpack, this leads to high streamflow and flooding. This is enhanced by the fact that the ground is still frozen in March and early April, and the snowmelt cannot infiltrate. Streamflow runoff is generally the highest in April/May. Percolating water exceeds the field capacity or wet limit of the soil, as suggested by a rise in the water table. In this period, evapotranspiration is not significant because the temperature is still low and plant growth minimal. This is a period of rapid transition from no groundwater recharge to significant groundwater recharge as the ground thaws.

Period 3 occurs from June to September, and is characterized by high temperatures and evapotranspirative uptake due to plant growth. Precipitation occurs in the form of rain, and the majority of it is retained by the surficial soil to satisfy an increasing moisture deficiency created by evapotranspiration. The water only soaks through to the groundwater when the field capacity (wet limit) of soil is exceeded. Limited groundwater recharge can occur during periods of soil moisture deficit through such features as fractures, and by runoff that collects in ditches (or dry kettles and swales) and may reach the water table. However, the water table is steadily declining, as groundwater discharge to streams is greater than recharge to groundwater.

Period 4 occurs from October to early December. Precipitation comes from rain and some snow. The growing season is finished and transpiration is low and evaporation declines as temperatures drop. The soil moisture has returned to field capacity as shown by the water table rise. This is the second major period of the year when groundwater recharge exceeds discharge. The December period more closely resembles Period 1 in the Lakehead SPA, as the frost sets into the ground.

Water availability within the various components of the hydrologic cycle also varies on longer than seasonal scales. For example, there are periodically 2- to 3-year periods of above average precipitation or below average precipitation. The vertical position of the water table can vary by 2 m over a year, but can vary by another 2 m from year to year, depending upon the availability of recharge from precipitation. The climatic information used for the Lakehead SPA water budgetting purposes has been

taken over a 25-year period to be representative of average conditions. 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 extremes as well.

### 5.1.3 Water Budget Approach

In initiating the water budget analyses for the Lakehead SPA watershed, the following approach has been used:

1. Consideration of a long enough period of time, in which storage changes and natural inter-basin flows can be safely assumed to be minimal.
2. Use of average saturation state conditions, where input data and calibration targets represent average climate conditions, average groundwater levels, and average streamflow conditions.
3. Selection of the period of 1970 to 1994, as this is the period where complete streamflow and precipitation records are coincident.

The question then became: What scale one needs to consider when conducting calculations? The answer was: Whatever scale is necessary depending on the application and local sensitivity. For the purposes of this conceptual water balance study, a subwatershed scale was considered large enough to balance the water budget. It is also necessary to understand the saturation state of the Lakehead SPA required for a particular application. As discussed above, streamflow and groundwater levels vary seasonally, but at different rates (streamflow being much more dynamic, and groundwater being attenuated by soil permeability). For this reason a long, 25 year period was deemed appropriate.

To summarize, the design of water budget investigations must incorporate:

- a) climate data representative of the geographic area of concern;
- b) an area large enough to balance the water budget (a more regional understanding of the flow system must account for estimates of groundwater transfers); and,
- c) data from a period covering a range in saturation states, both annually and long-term (drought versus non-drought conditions).

To calculate the simple water balance/budget for the subwatershed, a simple empirical water balance equation will be used to conceptualize the water available and the water being used to supply drinking water in the watershed. The approach is expressed as follows (MOE, 2007):

$$P + Sw_{in} + Gw_{in} + ANTH_{in} = ET + Sw_{out} + Gw_{out} + ANTH_{out} + \Delta S \quad \text{Equation (1)}$$

Where:

- P** = Precipitation
- SW<sub>in</sub>** = Surface water inflow into the system from outside
- GW<sub>in</sub>** = Groundwater inflow into the system from outside
- ANTH<sub>in</sub>** = Anthropogenic or human inputs
- ET** = Evapotranspiration losses
- SW<sub>out</sub>** = Surface water outflow from the system
- GW<sub>out</sub>** = Groundwater outflow from the system
- ANTH<sub>in</sub>** = Anthropogenic or human removals
- ΔS** = Change in storage (both surface and groundwater)

Equation (1) applies to the entire subwatershed. Internal to the watershed the precipitation follows a more intricate pathway. The evapotranspiration is derived from surface water and groundwater. The groundwater recharge is only a portion of the actual infiltration, some of it being lost to transpiration. Evaporation comes from both open water ways, canopy interception and temporary puddle storage. Streamflow is made up of both runoff and groundwater discharge (called baseflow). Hydrologists have simplified the Precipitation Equation, expressed at a local scale, to:

$$P = AET + S \quad \text{Equation (2)}$$

Where:

- P** = Precipitation
- AET** = Actual Evapotranspiration
- S** = Surplus (difference between P and AET)

The surplus is further broken down into runoff (RO) and recharge (R) by:

$$S = RO + R \quad \text{Equation (3)}$$

Therefore Equation (2) can be restated as:

$$P = AET + RO + R \quad \text{Equation (4)}$$

For the preliminary estimation of the water balance components (i.e., actual evapotranspiration, surface runoff and recharge for equation (4) above), the climactic data as determined in Section 4.4.2 was used for the periods 1970-1994 for all stations.

It should be noted that one of the objectives of the water budget exercise in terms of the Source Water Protection Program is to determine the available water in the stream and ground, as well as the water being used for drinking purposes, and water lost through evapotranspiration from the basin. The groundwater recharge (**R**) is available to wells and for ultimate discharge into the watercourses as baseflow. Coupled with runoff (**RO**) these represent the water surplus (**S**) as derived in Section 4.4, and given in Equation (3). For the recharge component of the above equation, it is safe to assume that the recharge water is not leaving the basin. Based on the deflection of this water by the low permeability bedrock, recharge is ultimately discharged to the surface water as baseflow into a stream. The water taken from the basin will be calculated from the Permit to Take Water information.

Attention has been paid to consumptive versus non-consumptive use. The surplus in Equation (3) simply represents the available water to which consumptive use factors may be applied.

## **5.2 SPA Water Budget Calculations**

In calculating the water budget, measured meteorological data and related parameters (like evapotranspiration, water surplus) were interpolated for the Lakehead SPA from values measured (or calculated) at six meteorological stations.

Individual month and annual interpolations were made using an inverse distance weighting technique. Inverse Distance Weighting (IDW) interpolation determines intermediate values by using a linearly weighted combination of the set of observed weather data. The weighting function was selected as the inverse of the square of the distance from the weather stations. Once the interpolation was completed for each parameter, an average value for the Lakehead SPA (or watershed) was determined from mean of the interpolated values over the area of interest. In plain language, the water amounts (expressed as depths for each cell in the grid) were multiplied by the area to derive an annual volume of water for each cell. These were summed and then divided by the entire area to obtain an average value for the entire area of interest.

### **5.2.1 Precipitation**

In Section 4.1, it was noted that climate data for six stations within and surrounding the Lakehead SPA were calculated for the period 1970 to 1994 (see Table 2). The mean annual precipitation for each of these six stations was computed for that time period to agree with the time frame for streamflow records available in the Lakehead SPA.

The point observations of mean annual precipitation for the six climatic stations were entered into the GIS database and the mean annual precipitation was interpolated over the entire Lakehead SPA with IDW (Inverse Distance Weighted) formulation technique as mentioned previously. The interpolated annual precipitation is presented in Map 1 in Appendix B and calculated monthly and annual precipitation for each station is presented in Appendix A. Table 12 presents annual average precipitation estimated by this method for the different watersheds (above specific stream gauges) in the Lakehead SPA. Among the six selected meteorological stations, precipitation ranges from 771 mm/yr to 908 mm/yr (see Table A4 in Appendix A) with an arithmetic average annual precipitation of 850.8 mm/yr. An area weighted interpolated annual average for the entire Lakehead SPA is approximately 843 mm/yr, which is used in the following analyses.

Table 12 was compiled for the twelve watersheds with gauges, with consistent periods of record (1970-1994). As noted previously (Section 4.7.2), a water budget was not completed for gauge stations 02AA001 and 02AB011 because of lack of information and flow measurement inaccuracy.

**Table 12. Summary of Water Budget on Subwatershed Basis**

Catchment Name	Area (km <sup>2</sup> )	Average Annual Precip (mm)	Average Annual Actual ET (mm)	Average Annual Surplus (mm)	Average Annual Runoff (mm)	Average Annual Recharge (mm)	Annual Stream-flow (mm)	Baseflow (mm) <sup>1</sup>
Kaministiquia River at Outlet of Dog Lake	3397	841.5	507.2	334.4	158.6	175.8	280.3	ND
Kaministiquia River at Kaministiquia	6455	846.4	509.4	337.0	166.0	171.0	287.3	201
Neebing River near Thunder bay Airport	205	798.7	502.7	296.0	135.1	160.9	277.0	140
Shebandowan River at Sunshine	2852	853.4	512.2	341.2	173.9	167.3	266.4	118
Kaministiquia River at Kakabeka Falls Powerhouse	6746	845.3	509.3	336.0	165.9	170.1	254.6	ND
Kashabowie River at Outlet of Kashabowie Lake	514	852.2	511.3	341.0	193.0	148.0	237.6	ND
North Current River near Thunder Bay	116	815.3	504.1	311.2	174.9	136.2	332.0	ND
Current River near Stepstone	499	825.6	504.7	320.9	171.5	149.4	336.3	138
McIntyre River at Thunder Bay	137	804.3	503.4	300.9	139.5	161.3	289.8	ND
McIntyre River above Thunder Bay	80	811.1	504.3	306.8	150.1	156.6	321.5	141
Current River at Stepstone	404	828.0	504.7	323.4	172.4	150.8	306.3	ND
Wolf River at Highway No. 17	716	856.1	501.8	354.2	175.6	178.5	298.5	154

Note: 1. Baseflow was calculated using an automated baseflow separation program described by Arnold et al., 1995, ND: Not determined

### 5.2.2 Evapotranspiration

Actual evapotranspiration (AET) is calculated using the Thornthwaite and Mather (1957) method, which takes into consideration the average monthly temperature and the hours of daylight, as well as soil moisture storage. This method is very widely used in water balance estimates and was chosen here for its simplicity and its ability to directly utilize the available climate data. This method produces an estimate of the potential evapotranspiration (PET) and calculates AET by considering soil moisture storage. Based on the application of this method, AET estimated for the six stations ranges from 496 mm to 524 mm, with an arithmetic average of 506 mm annually. An areally-weighted mean annual AET total of 508 mm is derived and used in Table 13 (found in Section 5.2.4)<sup>18</sup>.

As noted in Section 5.2.1, the interpolated annual AET is presented in Map 5 in Appendix B, and calculated monthly and annual AET for each station is presented in Appendix A.

### 5.2.3 Streamflow

The annual flow volumes (when divided by the catchment area are expressed as equivalent annual depths) for the twelve subwatershed/catchment areas are provided in Table 12, with the annual mean streamflow variances from 237.6 mm to 336.3 mm. The mean annual water balance for the entire Lakehead SPA is summarized in Table 13 (found in Section 5.2.4). The average stream flow for the entire watershed in this study was calculated on a pro rata basis: that is, the flow rate of each individual watershed was divided by the corresponding watershed area, all of which were summed and then multiplied by the total area of the watershed.

<sup>18</sup>. Areally-weighted mean annual AET values were also reported for different watersheds in the SPA in Table 12.

### 5.2.4 Summary of the Lakehead SPA Water Budget

Table 13 below provides a summary of the integrated water budget for the entire Lakehead SPA. The description column of the table provides some insight as to assumptions and limitations of the analysis.

**Table 13. Summary of the Conceptual Water Budget of the Lakehead SPA (Total Drainage Area: 11,526 km<sup>2</sup>)**

Parameters	Annual Depth (mm)	Annual Volume (106 m <sup>3</sup> )	Description
<b>Precipitation</b>	842.8	9,714	▶ Interpolated and area averaged annual mean precipitation. Precipitation calculated by arithmetic average of the six stations is 850.8 mm
<b>Actual Evapotranspiration (AET)</b>	508.0	5,855	▶ Interpolated and area averaged annual average AET. (Arithmetic average of AET calculated using Thornthwaite and Mather (1957) is 506.2 mm/yr)
<b>Surplus</b>	334.8	3,859	▶ Spatially distributed average value. ▶ (Arithmetic average value is 344.6 mm/yr)
<b>Recharge</b>	167.8	1,934	▶ Determined in GIS platform
<b>Runoff</b>	167.0	1,925	▶ Determined in GIS platform
<b>Mean Streamflow</b>	290.6	3,350	▶ Area weighted mean annual streamflow
<b>Max Streamflow</b>	748.4	8,626	▶ Area weighted maximum annual streamflow
<b>Min Streamflow</b>	62.3	718	▶ Area weighted minimum annual streamflow
<b>Consumptive SW Takings</b>	5.3	61.2	▶ According to PTTW Database Provided in Table 14-- See also Table 10
<b>Non-consumptive SW Takings</b>	54.6	629	▶ Total Surface water takings minus the consumptive surface water takings
<b>Consumptive Groundwater Takings</b>	0.32	3.75	▶ According to PTTW database provided in Table 14 and including water takings from private wells for about 22,000 people consuming water at a rate of 335 L/day/capita
<b>Non-consumptive GW Takings</b>	0.69	7.93	▶ Total groundwater water takings minus the consumptive groundwater takings

To simplify the interpretations of Table 13, the following narrative is meant to assist the reader. It is expressed solely in terms of average annual amounts. All values are expressed in terms of a volume of water in “million cubic metres per year (Mm<sup>3</sup>/yr)”.

A total of 9,714 Mm<sup>3</sup>/yr falls as precipitation, of which 5,855 Mm<sup>3</sup>/yr is returned to the atmosphere by evapotranspiration (that is, about 60%). This leaves 3,859 Mm<sup>3</sup>/yr as a surplus, available for runoff or recharge. By way of comparison, the average streamflow out of the watershed is 3,350 Mm<sup>3</sup>/yr, which is made up of both runoff and baseflow. There is about a 13% difference in these values, with the measured streamflow being lower than the calculated surplus. This difference is considered to be an acceptable margin of variance, given the uncertainties in parameter estimation, measurement error, and spatial distribution of precipitation.

The surplus of 3,859 Mm<sup>3</sup>/yr is partitioned between runoff and recharge in the following way. About 50% of the surplus, or 1,925 Mm<sup>3</sup>/yr directly runs off, where as the remaining 1,934 Mm<sup>3</sup>/yr infiltrates into the ground and recharges the water table (expressed as a Baseflow Index this is 1,925/3,859 = 0.50 for the entire watershed).

The present use of this surplus total of 3,859 Mm<sup>3</sup>/yr is 702 Mm<sup>3</sup>/yr, of which 637 Mm<sup>3</sup>/yr (SW: 629 Mm<sup>3</sup>/yr; GW: 8.0 Mm<sup>3</sup>/yr see also Table 14 for details) is comprised of non-consumptive uses<sup>19</sup>. As previously defined, non-consumptive uses involve the use of the water that is returned to the local watershed of origin in a reasonable time frame. Consumptive uses do not return this water directly to the watershed of origin. Table 14, summarizes the volume of actual consumptive surface water and groundwater demand from the watershed. Actual consumptive surface water takings that include water takings for industrial supply, municipal water supply, and agricultural (irrigation, livestock etc.) use are about 61.17 Mm<sup>3</sup>/yr, which is only about 9.0% of the values reflected in the PTTW database<sup>20</sup>. Similarly, the actual consumptive groundwater demand from the watershed is about 3.75 Mm<sup>3</sup>/yr, which is approximately 32% of the peak takings listed in the PTTW database.

**Table 14. Consumptive Surface Water and Groundwater Use/Demand in the Lakehead SPA**

Water Use	Water Takings (Mm <sup>3</sup> /yr)	Consumptive Factor	Consumptive Use (Mm <sup>3</sup> /yr)
<b>Surface Water</b>			
Total Surface Water Takings according to PTTW	690.36		
Permitted Takings: Power Generation, Dam/Reservoirs	480.36	0.0	0.0
Permitted Takings: Other- Industrial	160.74	0.25	40.18
Permitted municipal water takings (only from Loch Lomond)	10.22	0.2	2.04
Permitted Takings: Agriculture (Irrigation, Livestock)	21.05	0.9	18.95
<b>Total Consumptive Surface Water Use/Demand</b>			<b>61.17</b>
<b>Groundwater</b>			
Total Groundwater Takings according to PTTW	<b>11.68</b>		
Permitted Takings: Other- Industrial	<b>11.35</b>	<b>0.25</b>	<b>2.84</b>
Permitted Takings: Municipal Water Supply	<b>0.09</b>	<b>0.20</b>	<b>0.02</b>
Permitted Takings: Agriculture (Irrigation, Livestock)	<b>0.24</b>	<b>0.90</b>	<b>0.22</b>
Water Takings: Private wells	<b>2.69</b>	<b>0.25</b>	<b>0.67</b>
<b>Total Consumptive Groundwater Use/Demand</b>			<b>3.75</b>

In calculating the actual consumptive water takings provided in Table 14, the following assumptions were made:

- a) consumptive water loss for power generation is 0%. That is, all of the water drawn from the watershed is returned to the watershed;
- b) consumptive water loss for industrial water use is 25% and the rest is returned to the watershed through drains;
- c) consumptive water loss for municipal water use is 20% (except as noted in Table 14) and the rest is returned to the watershed through residential septic tanks; and,
- d) consumptive water loss for irrigation water use is 90% through evapotranspiration etc., and the rest is returned to the watershed through infiltration into the ground or runoff to the ditches.

19. For the purpose of this summary, both ground and surface water sources are considered together.

20. This is because the PTTW database only lists maximum takings and not actual takings.

The consumptive use, including Thunder Bay’s withdrawal only from Loch Lomond, is about 65 Mm<sup>3</sup>/yr (SW: 61.17 Mm<sup>3</sup>/yr; GW: approximately 3.75 Mm<sup>3</sup>/yr: see also Table 14 for details), or 1.68% of the surplus. The total use (consumptive and non-consumptive) is about 18% of the surplus.

### 5.3 Water Use Percentage

As per the Interim Water Budget Technical Direction document, the percentage of water used in the watershed region was also calculated. Table 13 gives the summary of the conceptual water budget of the Lakehead SPA. Stream flow volumes are compared to the water use to estimate the “Percent Of Water Use” for Lakehead SPA and these are presented in Table 15.

**Table 15. Stream Flow Volume Versus Surface Water Use Scenarios**

Streamflow	Volume (Mm <sup>3</sup> /yr)	Water Use <sup>1</sup> (Mm <sup>3</sup> /yr)	% Water Use
Mean Streamflow Volume	3,350	61.17	1.83
Minimum Streamflow Volume	718	61.17	8.52
Maximum Streamflow Volume	8,626	61.17	0.71

*Note: 1. Consumptive surface water use/demand (for details see Table 14)*

Table 15 shows that on average, consumptive surface water demand is 1.83% for the entire Lakehead SPA and is used for different purposes, including drinking water. These values are based on the PTTW database for surface water takings and include only the actual water takings from Loch Lomond as reported in Table 14. Surface water takings from Lake Superior are not considered in this calculation as the water is not taken from the watershed. These consumptive water demands are also compared to the minimum and maximum stream flow volumes. The percentage of water use versus the water available will be assessed using the Tier 1 Water Quantity Risk Assessment guidelines. These scenarios are presented to understand the water use, with respect to the water available, which is very low. This information will be used in Section 6 to assess the water demand against the supply (taking into account a reserve) to determine whether the watershed is under a significant, moderate or low stress.

Overall, the water balance summary for the Lakehead SPA illustrates that the flow at the selected long-term gauge stations appears reasonable with respect to the climate data on an annual basis. It also indicates that the consumptive water use, on average, in the watershed is relatively small (only 1.83%). For the worst-case scenario of a minimum stream flow volume of 718 Mm<sup>3</sup>/yr, the water use is still only approximately 8.5% of the water available.

Table 16 provides a groundwater use scenario and compares consumptive groundwater demand/use with groundwater recharge. Annual groundwater recharge is calculated based on the

estimated annual average recharge of 167.8 mm, determined in GIS, and multiplied with the area where most of the wells are concentrated. This area is estimated to be about 4,395 km<sup>2</sup>. According to the PTTW database and based on the assumption that approximately 22,000 people use 335 L/day/capita, the total consumptive groundwater demand in the entire Lakehead SPA is about 3.75 Mm<sup>3</sup>/yr, which represents less than 1% of recharged water in the selected portion of the Lakehead SPA. These are just estimated values. Further detailed studies on the delineation of actual recharge area are required in order to more accurately compare groundwater recharge with groundwater use.

**Table 16. Groundwater Recharge Versus Groundwater Use Scenarios**

Parameters	Amount
Recharge Area (km <sup>2</sup> )	4,395
Recharge Rate (mm/yr)	167.8
Total Groundwater Recharge (Mm <sup>3</sup> /yr)	737.5
Consumptive Groundwater Use (Mm <sup>3</sup> /yr)	3.75
% Consumptive Groundwater Use	0.51

## 5.4 Summary

The conceptual understanding can be summarized as follows:

1. Surface water plays a vital role in the watershed region and most of the drinking water is supplied from surface water sources. Lake Superior is the only source of municipal drinking water in the City of Thunder Bay area after the decommissioning of the Loch Lomond water intake pipe and water filtration plant. However, Lake Superior does not constitute a part of the watershed.
2. The geologic framework of the area governs the surface and subsurface groundwater pathways. The area is dominated by shallow permeable soils overlying low permeability bedrock. Infiltrating water recharges the local water table and is deflected by the bedrock to local watercourses, wetlands and streams and finally to Lake Superior. Maximum determined overburden thicknesses occur in the City of Thunder Bay near the mouth of the Kaministiquia River.
3. Water movement is dominantly by surface water, flowing south and east towards Lake Superior.
4. Groundwater studies were conducted in 2005 for the LRCA covering the City of Thunder Bay and extended from Whitefish Lake in the west to the head of Black Bay in the east, Lake Superior in the south, to Dog Lake in the north.

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**

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### **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.