DRINKING WATER SOURCE PROTECTION
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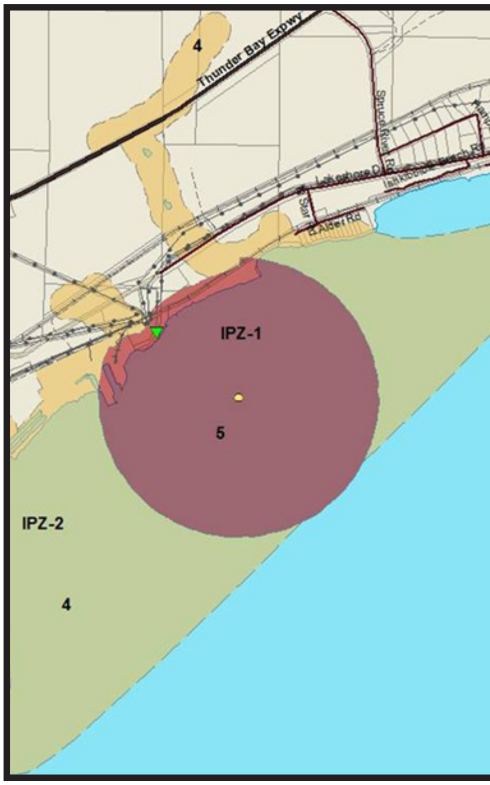
Lakehead Source Protection Area

Approved Assessment Report
for the Lakehead Source Protection Area




Bare Point Intake Protection Zone

Rosslyn Wellhead Protection Area

LAKEHEAD SOURCE PROTECTION COMMITTEE

May, 2011

Executive Summary of the "Amended Proposed Assessment Report for the Lakehead Source Protection Area"

The Ontario Government legislated the "Clean Water Act, 2006" in order to protect drinking water at the source as part of an overall commitment to human health and the environment. A key focus of the legislation is the production of a locally-developed, science-based Assessment Report and Source Protection Plan. The Lakehead Source Protection Committee is representative of the watershed community and includes members representing the Municipal, economic and industrial, and public and academic sectors. The Lakehead Source Protection Committee is responsible for the production of the Assessment Report and Source Protection Plan.

The Lakehead Source Protection Committee prepared the Assessment Report, which identifies and outlines various elements of the local watersheds and Municipal Residential Drinking Water Systems within the Lakehead Source Protection Area, as per the requirements of the "Directors Technical Rules, Clean Water Act, 2006". An Assessment Report includes the watershed characterization, Great Lakes considerations, climate change and analysis of a water budget, drinking water vulnerability and threats within the Lakehead Source Protection Area. The information within the Assessment Report will be used for the purpose of developing a Source Protection Plan.

The objective of a Source Protection Plan is to establish the measures to protect both the quality and quantity of drinking water sources within the watersheds of the Lakehead Source Protection Area. A Source Protection Plan is considered the first step in a multi-barrier approach to ensuring safe drinking water. Other barriers include measures to ensure treatment implementation, safe water distribution, monitoring and emergency response. During the development of the Source Protection Plan, the Lakehead Source Protection Committee will work together with representatives from the local watershed community (e.g., Municipalities, Conservation Authority, water users and land owners).

Watershed Characterization is a description of the entire area of both the land and water that is drained by a river and its tributaries, known as a watershed. The Watershed Characterization information will assist in developing a better understanding of the geographical conditions of the watershed. The Lakehead Region Conservation Authority developed the Watershed Characterization by compiling the available information on the physical, sociological and economic makeup of the Lakehead Source Protection Area. The Watershed Characterization includes the facts and figures on population distribution, climate, land use, water use, existing water-related monitoring systems and the natural characteristics of the watersheds within the Lakehead Source Protection Area.

A Water Budget and Water Quantity Stress Assessment report for the Lakehead Source Protection Area was prepared by a consultant, in August 2008, in accordance with the Ontario Ministry of Environment guidelines. This report provides a basic understanding of the surface and groundwater hydrology within the Lakehead Source Protection Area and was used in the preparation of the Water Budget chapter for the Assessment Report. The Conceptual Water Budget provides baseline data collection, mapping and an analysis of the information compiled in order to produce an initial overview of the function of the flow system for both groundwater and surface water in the Lakehead Source Protection Area. The main objective of the Conceptual Water Budget is to answer the following basic questions:

1) Where is the water?
2) How does the water move between reservoirs?
3) What and where are the stresses on the water?
4) What are the trends?

The main objective of the Tier 1 Assessment was to estimate and describe the movement of water within the various elements of the hydrologic cycle to identify areas that may face water quantity stress within the Lakehead Source Protection Area. The Tier 1 Assessment utilizes available data collected during the Conceptual Water Budget phase to evaluate the cumulative stress within each basin. Within the Assessment Report, the elements of the Tier 1 Assessment have been updated, where required, to reflect the "Ontario Ministry of Environment Directors Technical Rules, November, 2009".

The chapter on groundwater and surface water vulnerability provides an analysis of the Thunder Bay (Bare Point) Water Treatment Plant Intake Protection Zones and Rosslyn Village Subdivision Well Supply Wellhead Protection Areas. This chapter of the Assessment Report will be used to help develop the Source Protection Plan, which will outline measures to protect both the quality and quantity of sources of drinking water within the Lakehead Source Protection Area.

Groundwater vulnerability is defined as the tendency and likelihood for general contaminants to reach the water table after introduction at the ground surface. All groundwater is to some degree vulnerable and the analysis for the assessment reflects the ability of contaminants to reach the water table in groundwater aquifers across the region. For the purposes of the Assessment Report, the intrinsic vulnerability analysis approach was used to identify the vulnerable areas. The analysis was based on the existing hydrogeological data, land use and information from the provincial groundwater studies. The section on the Intrinsic Susceptibility Index (ISI) describes the vulnerability of the aquifer. The Intrinsic Susceptibility Index was estimated by assigning a numerical score related to the hydraulic conductivity of the material in each layer overlying the water table, multiplied by the thickness of that layer. Based on this analysis, the higher the Intrinsic Susceptibility Index, the less sensitive the aquifer is. The vulnerable areas considered in the analysis include Wellhead Protection Areas (WHPAs) and Intake Protection Zones (IPZs) around Municipal Residential Drinking Water supplies, Highly Vulnerable Aquifers (HVAs) and Significant Groundwater Recharge Areas (SGRAs). The relative vulnerability within each of these areas was characterized as high, medium or low. This categorization is intended to reflect the susceptibility of the aquifer(s) in the vulnerable areas to surface (or near surface) sources of contamination. The vulnerability score is assigned based on the intrinsic susceptibility analysis and presented in the mapping products. These results, as well as the level of confidence in the assessment, will be provided as input to the "Water Quality Risk Assessment". The results indicate that the 100 metre radius area around the Wellhead Protection Areas having a score of 10 is highly vulnerable to contamination from surface sources. Most of the area within 2-year time of travel has a medium vulnerability (V score 6) to contamination from surface sources. Some areas within the 25-year capture zone of the Rosslyn Village Subdivision Well Supply have a medium vulnerability (V score 6). It is also observed that some areas within the 5-year capture zone of the Rosslyn

Village Subdivision Well Supply have a medium vulnerability (V score of 6).

Surface water vulnerability is defined as the tendency and likelihood for general contaminants to reach the surface water intake after introduction in-water, alongshore or up-tributary. All surface water has some degree of vulnerability. Water intakes situated on the Great Lakes are less vulnerable than drinking water intakes situated on smaller surface water bodies as there tends to be more water surrounding the intake, which allows for greater dilution of a contaminant. Three vulnerable zones apply to a Great Lakes Municipal Residential Drinking Water System intake:

- Intake Protection Zone 1, a primary zone immediately around the intake having a radius of 1,000 metres (one kilometre) as defined in "Directors Technical Rules, Clean Water Act, 2006" Part VI.3, Rule 61(1)(a). This represents the most immediate and vulnerable area around the intake.

- Intake Protection Zone 2, a secondary zone having dimensions determined from calculations based upon characteristics of the local environment, such as local water movement vectors and nearby shoreline and tributary watercourse features.

- Intake Protection Zone 3, a tertiary zone having dimensions determined using an Events Based Approach (EBA). The Intake Protection Zone 3 is determined using an approach that quantifies the distance from which contaminants could travel in an extreme event and contaminate the surface water intake. To be determined in a future Assessment Report, as technical study related to the determination and delineation of an Intake Protection Zone-3 for the Thunder Bay (Bare Point Road) Water Treatment Plant has not been completed to date.

Vulnerability scores for these areas are determined based on several characteristics including, percentage of area inland, land characteristics, transport pathways, intake depth, intake distance offshore and recorded water quality issues. Vulnerability was determined for the surface water intake for the Thunder Bay (Bare Point) Water Treatment Plant. The vulnerability scores within the Intake Protection Zone 1 and Intake Protection Zone 2 for the Thunder Bay (Bare Point) Water Treatment Plant Intake are considered Low as Intake Protection Zone 1 has a vulnerability score of 5 (V score 5) and Intake Protection Zone 2 has a vulnerability score of 3.5 (V score 3.5). Maps included in the Assessment Report illustrate vulnerability for both the Rosslyn Village Subdivision Well Supply Wellhead Protection Areas and Thunder Bay (Bare Point) Water Treatment Plant Intake Protection Zones.

A Water Quality Risk Assessment determines the risk of specific threats entering or with the potential to enter a Municipal Residential Drinking Water System. A drinking water threat is an existing or future activity or existing condition that results from a past activity that is impacting or has the potential to impact a drinking water source. Issues are problems that currently exist in the source water or that can be reasonably predicted to be a problem in the near future if rising trends continue. Threats are activities on the landscape that, if managed improperly, may cause an issue to occur in the future. The following 21 activities are prescribed as drinking water threats in subsection 2(1) of the "Clean Water Act, 2006":

1. 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.
3. The application of agricultural source material to land.
4. The storage of agricultural source material.
5. The management of agricultural source material.
6. The application of non-agricultural source material to land.
7. The handling and storage of non-agricultural source material.
8. The application of commercial fertilizer to land.
9. The handling and storage of commercial fertilizer.
10. The application of pesticide to land.
11. The handling and storage of pesticide.
12. The application of road salt.
13. The handling and storage of road salt.
14. The storage of snow.
15. The handling and storage of fuel.
16. The handling and storage of a dense non-aqueous phase liquid.
17. The handling and storage of an organic solvent.
18. The management of runoff than contains chemicals used in the de-icing of aircraft.
19. An activity that takes water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body.
20. An activity that reduces the recharge of an aquifer.
21. The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard.

In accordance with the requirements outlined in the "Directors Technical Rules, Clean Water Act, 2006", the threats inventory within vulnerable areas was assessed for groundwater within the Wellhead Protection Areas, Highly Vulnerable Aquifers and Significant Recharge Areas, and for surface water, in the Intake Protection Zones. A hazard rating is a scientifically based value which represents the relative potential for a contaminant of concern to impact drinking water sources at concentrations significant enough to cause human illness. The rating scheme gives each contaminant of concern a high, medium, or low ranking. Hazard ratings (pathogenic and chemical) for each contaminant of concern associated with the identified land use activities were evaluated. Transport pathways (constructed or naturally occurring pathways) were also identified, as these pathways have the capacity to move a contaminant more quickly toward a drinking water source. It was concluded that threats within Intake Protection Zones scored as low risk activities. Drinking water threats that are threats occurring or have the potential to occur were analyzed for groundwater sources within wellhead protection areas, highly vulnerable aquifers and significant groundwater recharge areas. Within the Lakehead Source Protection Area, the only identified significant drinking water threats occurred within the Wellhead Protection Area-A vulnerable zone. Moderate and low threats are present in the remainder of the Wellhead Protection Area vulnerable zones.

Given the geographic location of the Lakehead Source Protection Area it is important to consider the implications of existing and future Great Lakes Agreements within the context of Source

Protection Planning. A summary of Great Lakes Agreements and considerations has been provided in the Assessment Report.

The purpose of the climate change chapter is to provide the Lakehead Source Protection Authority and Committee with the best available information needed to understand potential climate change impacts in the Lakehead Source Protection Area and to make decisions based on the implications these impacts may have on drinking water source protection. The document integrates regional climate change model predictions within an adaptive risk management decision-making framework, in order to provide an additional source of information that complements the historically-based modeling approaches being used in current Source Protection Planning in Ontario (i.e. Water Budget Reports).

The Assessment Report is intended to outline the baseline conditions within the watersheds of the Lakehead Source Protection Area. Using this document, the Lakehead Source Protection Committee can move forward with the task of developing a Source Protection Plan for Municipal Residential Drinking Water within the Lakehead Source Protection Area.

Preface

The Ontario Government legislated the "Clean Water Act, 2006" in order to protect drinking water at the source as part of an overall commitment to human health and the environment and to ensure safe, clean drinking water for all Ontarians.

Protecting "Source Water" is the first step in a multi-barrier approach to ensure the quality and sustainability of our Municipal Residential Drinking Water Supply. A key focus of Ontario's "Clean Water Act, 2006" is the production of locally developed, science-based Assessment Reports and Source Protection Plans.

Based on the "Clean Water Act, 2006" Regulations, the Lakehead Source Protection Area was defined, the Lakehead Source Protection Authority was designated and the Lakehead Source Protection Committee was formed.

The Lakehead Source Protection Committee, with support from the Lakehead Source Protection Authority, is responsible for guiding the development of a Terms of Reference, Assessment Report and Source Protection Plan for the Lakehead Source Protection Area.

As per the "Clean Water Act, 2006", the Minister of the Environment appointed Chairs for the Source Protection Committees on August 20, 2007. Subsequently, representatives from the watershed community (Municipalities, Conservation Authorities, stakeholders, water users and general public) were appointed to the Source Protection Committees. Representation on the committees varies depending on local needs. The membership of the Lakehead Source Protection Committee is as follows:

LAKEHEAD SOURCE PROTECTION COMMITTEE

Committee Chairman	Bob Hartley	Appointed by Minister of Environment (Term ends August 20, 2013)
Municipal Sector	Ken McWhirter	City of Thunder Bay (Vice Chairman)
	Jim Vukmanich	City of Thunder Bay
	Veikko Long	Municipality of Oliver Paipoonge
Industrial and Economic Sector	Hartley Multamaki	Forestry
	Guy Jarvis	Thunder Bay Port Authority
	Bernie Kamphof	Agriculture
Public and Other Interests Sector	Robert Stewart	Education
	Paul McAlister	Tourism
	Ross Chuchman	General Public
Liaison Members	Mervi Henttonen	Lakehead Source Protection Authority
	Chris Beveridge	Thunder Bay District Health Unit
	Kate Turner	Ministry of Environment, Source Protection Branch

The Source Protection Planning process began in July 2007, initiating a five-year timeline to complete a Source Protection Plan by August 20, 2012. The "Clean Water Act, 2006" sets out a three step, local, science based planning process in three key documents:

- **Terms of Reference –** a work plan outlining the development of an Assessment Report and Source Protection Plan for the Lakehead Source Protection Area.

- **Assessment Report –** a technical, science-based report to identify potential and existing risks and threats to the sources of Municipal Residential Drinking Water in the Lakehead Source Protection Area.

- **Source Protection Plan –** a strategic document that outlines policies and procedures to prevent or reduce significant threats and manage potential risks to the sources of Municipal Residential Drinking Water in the Lakehead Source Protection Area.

The Lakehead Source Protection Committee completed and submitted the Terms of Reference to the Minister of the Environment in October 2008, which was approved on May 25, 2009. The "Proposed Assessment Report for the Lakehead Source Protection Area" must be submitted to the Ministry of Environment on or before July 13, 2010.

The Lakehead Source Protection Committee developed the "Proposed Assessment Report for the Lakehead Source Protection Area" by using information collected from previous and current scientific and technical studies of the certain aspects of the watershed, under legislative guidance of the "Directors Technical Rules, Clean Water Act, 2006". The protection of source water for the purpose of this Assessment Report is specific to Municipal Residential Drinking Water Sources. There are two Municipal Residential Drinking Water Systems in the Lakehead Source Protection Area: the City of Thunder Bay's (Bare Point Road) Water Treatment Plant (a Lake Superior surface water intake) and Municipality of Oliver Paipoonge, Rosslyn Village Subdivision Well Supply (two groundwater wells). The "Proposed Assessment Report" identifies potential and existing threats and risks to the sources of water for the two Municipal Residential Drinking Water Systems in the Lakehead Source Protection Area.

The Lakehead Source Protection Committee acknowledges and thanks the Lakehead Source Protection Authority and the following Staff of the Lakehead Region Conservation Authority: General Manager/Secretary-Treasurer, Watershed Manager, Source Protection Project Manager, Source Protection Water Resources Engineer, Source Protection GIS/Data Specialist, Source Protection Communications Officer and Source Protection Administrative Assistant, for their assistance in the preparation of the "Proposed Assessment Report for the Lakehead Source Protection Area".

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1.0 Introduction

1.1 History of Conservation Authorities in Ontario

The "Conservation Authorities Act" was created by the Ontario Provincial Legislature in 1946 to ensure the conservation, restoration and responsible management of our water, land and natural habitat through programs that balance human, environmental and economic needs. A Conservation Authority is a local, autonomous organization established under the "Conservation Authorities Act", R.S.O. 1980:

> "The objects of an authority are to establish and undertake in the area over which it has a jurisdiction, a program designed to further the conservation, restoration, development and management of natural resources other than gas, oil, coal and minerals."

While Conservation Authorities have broad responsibilities for the management of renewable natural resources, they have specific powers in the area of water and related land management. Authorities are formed on the basis of a natural watershed or group of watersheds. The "Conservation Authorities Act" allows for the management of resources and handling of problems such as flood control on a complete and rational basis since water flow does not respect political boundaries. No two Conservation Authorities are exactly alike because their local focus and inherent flexibility allow them to promote and develop conservation works consistent with the environment and development patterns of their region. The powers of Conservation Authorities are detailed in Sections 21 and 28 of the "Conservation Authorities Act".

The Lakehead Region Conservation Authority (LRCA) is one of the 36 Conservation Authorities in Ontario and was constituted on January 1, 1963 under the "Conservation Authorities Act" by Order-in-Council 254/63. The Lakehead Region Conservation Authority superseded the Neebing Valley Conservation Authority which had been constituted in 1954. The Lakehead Region Conservation Authority is the most westerly Conservation Authority in the province and is one of five in the northern part of the province. The next nearest Conservation Authority in the province is the Sault Ste. Marie Region Conservation Authority. Figure 1 is a map illustrating the location of all 36 Conservation Authorities in Ontario.

Figure 1: Conservation Authorities of Ontario

Conservation Authorities are generally based on a natural watershed or group of watersheds but the Lakehead Region Conservation Authority is an exception because its jurisdiction covers only the lower portions of virtually all of its watersheds. The boundary of the Lakehead Region Conservation Authority corresponds to the boundaries of its participating Municipalities, yet most of the watercourses and their watersheds extend beyond these Municipalities in unorganized territory. Territories that are not covered by a Conservation Authority in the Province of Ontario fall under the jurisdiction of the Ontario Ministry of Natural Resources.

The overall goal of the Lakehead Region Conservation Authority is “the undertaking of schemes for the purposes of effecting flood and erosion control and the conservation, restoration and development of renewable natural resources within parts of or entire watersheds, encompassed by the Authority. The main goals of the Lakehead Region Conservation Authority related to Water and Related Land Management is “to develop and implement a program of water and related land management to prevent loss of life and minimize property damages from flooding and erosion, and maintain or enhance the quantity and quality of surface and ground water”. Water and Related Land Management goals are achieved by following the objectives listed below:

i. To continue to alleviate the flooding problem in the intercity area of Thunder Bay by maintaining the Neebing-McIntyre Floodway.

ii. To encourage proper water and land use practices on private lands in order to minimize flooding, flood damage and erosion.

iii. To enforce Ontario Regulation 180/06 “Development, Interference with Wetlands and Alteration to Shoreline and Watercourses Regulation” as provided under the “Conservation Authorities Act” for the protection of people and property throughout the watersheds.

iv. To carry out flood and fill line mapping in developed areas.

v. To provide technical assistance to, and co-operate with, individuals, Municipalities, agencies and Ministries regarding land use developments, plans, strategies or studies.

vi. To identify, conserve, and where feasible, acquire natural source and storage areas and other significant wetland areas.

vii. To develop and implement a cost effective system of stream monitoring and flood forecasting by continuing the partnership with Environment Canada to operate nine streamflow and precipitation gauges, volunteer precipitation data collection program, snow surveys, and Ontario Low Water Response Program.

viii. To identify lands subject to flooding or erosion and, where feasible and appropriate, alleviate the problem through such means as water control, remedial measures, and land acquisition.

ix. To participate in the Provincial Groundwater Monitoring Network (PGMN) and Provincial Water Quality Monitoring Network (PWQMN) programs in order to assist in the collection of water quality data.

x. To develop and manage the Authority's water-related projects and lands to produce, whenever possible, the widest variety of ancillary conservation benefits (Tree Seedling Program, stewardship programs, education and outreach, etc.)

xi. To assist and co-operate with Municipal, Provincial and Federal agencies in the management of water resources, flood plains and other hazard lands.

xii. To undertake a water and related land management community relations program for the purpose of public education encompassing those items identified above.

The main goals of the Lakehead Region Conservation Authority related to Conservation and Recreation Land Management is "to identify and conserve those natural resources of regional significance within the jurisdiction of the Authority, and to provide opportunities for semi-passive, outdoor recreational and educational experiences on a regional scale". Conservation and Recreation Land Management goals are achieved by following the objectives listed below:

i. To conserve, develop and manage Authority-owned lands on a planned basis, in order to provide natural resource benefits and outdoor recreation opportunities.

ii. To conserve unique natural resources or features through co-operation with other agencies or individuals, or where desirable and feasible, through acquisition.

iii. To provide public access to Lake Superior.

iv. To promote conservation awareness by developing an outdoor education program and by means of a public relations and information program.

v. To enforce Regulations under the "Conservation Authorities Act" which will, through proper management and enforcement where necessary, ensure the safe and optimal use of Authority-owned lands.

The mandate of the Lakehead Region Conservation Authority is to ensure the conservation, restoration and responsible management of water, land and natural habitats through programs that balance human, environmental and economic needs. The Lakehead Region Conservation Authority provides many services and is responsible for:

- Protecting life and property from flooding and erosion.
- Restoring and conserving aquatic and natural habitats.
- Providing advice and counsel to all levels of public and government on the responsible management of water.
- Providing semi passive recreation.

In addition to these services, the Lakehead Region Conservation Authority also operates the Hurkett Cove, MacKenzie Point, Silver Harbour, Mission Island Marsh, Cascades, Hazelwood Lake, Little Trout Bay and Cedar Falls Conservation Areas and carries out forest management practices for the Mills Block, Williams and Wishart Forests. The Neebing-McIntyre Floodway is owned, managed and maintained by the Lakehead Region Conservation Authority. The

Lakehead Region Conservation Authority also owns and maintains the Neebing Weir and Hazelwood Lake Dam.

1.2 History of Drinking Water Source Protection Planning in Ontario

In May 2000, water contaminated by *Escherichia coli* (abbreviated as *E. coli)* bacteria made its way into the Municipal Residential Drinking Water System of the Town of Walkerton, Ontario. Within days, seven people had died and thousands of others had become ill from drinking the contaminated water. As a result, the provincial government convened an inquiry, which was led by Justice Dennis O'Connor of the Ontario Superior Court of Justice. In 2002, Justice O'Connor released two reports: the "Walkerton Report – Part One", which described the events that took place in the community and the series of human and system failures that led to the water becoming contaminated; and the "Walkerton Report – Part Two", which provided a more general look at water safety across the province and the steps needed to prevent a similar event from occurring elsewhere. This report contained 93 recommendations, including recommendations for practices related to source water protection and training procedures for those responsible for water treatment.

In response to the "Walkerton Report", the Ontario Government developed multiple pieces of legislation in response to many of Justice O'Connor's recommendations. The first phase of this legislation was the development of the "Clean Water Act, 2006", which will implement drinking water Source Protection Planning in every watershed in Ontario. Since the "Clean Water Act" received Royal Assent in October 2006 and then was enacted in July 2007, the Provincial Government has developed additional regulations and guidance documents that support the "Clean Water Act".

The goal of Source Protection Planning under the "Clean Water Act" is to contribute to the environmental, social and economic wellbeing of the people of the Province of Ontario. As recommended by the "Walkerton Report", Drinking Water Source Protection Planning is one of many barriers used in a multi-barrier approach to ensure safe drinking water.

Drinking Water Source Protection will work to ensure that clean and safe drinking water is available for future generations. Protecting water at the source is an important way to ensure the health of humans, ecosystems and economies. Our actions today affect the quantity and quality of water available for future uses as protecting sources of water is essential to ensuring human health. Source Protection Planning will affect everyone to different degrees. First of all, it will ensure Municipal Residential Drinking Water Sources are protected and communities will have a healthy source of water now and in the future. The impacts of Source Protection Planning on individual landowners will vary across the watershed, depending on where they live, what sorts of activities they engage in, land uses in proximity to drinking water sources and how much they want to get involved. As this is an open and transparent process, the public can become involved each step of the way.

As a result of their history of watershed planning, Conservation Authorities were selected and contracted by the Ontario Ministry of Environment to work throughout the Province to complete Drinking Water Source Protection Planning within their watershed regions. The Ontario Ministry of Environment and Ontario Ministry of Natural Resources provides funding and guidance to Conservation Authorities for Source Protection Planning and reviews and approves all steps in the planning process as regulated under the "Clean Water Act". Conservation Authorities are responsible for the planning phase of Drinking Water Source Protection for Municipal Residential Drinking Water Sources located within their Source Protection Area and will provide financial and technical oversight and support to the Source Protection Committee during the Source Protection Planning process. Conservation Authorities have established Source Protection Authorities and Source Protection Committees to guide the process of Drinking Water Source Protection Planning. The Source Protection Authority is responsible for administrative support to the Source Protection Planning process, the recruitment of the Committee Chair, who was appointed by the Minister of Environment, and establishing the Source Protection Committee. The Source Protection Committee guides the development of the Source Protection Plan in conjunction with Municipalities, property owners and other stakeholders in order to protect Municipal Residential Drinking Water quality and quantity. Municipalities oversee Land Use Plans and growth strategies for the design and operation of Municipal Residential Drinking Water Systems and sewage treatment plants and will be responsible for the implementation of the Source Protection Plan.

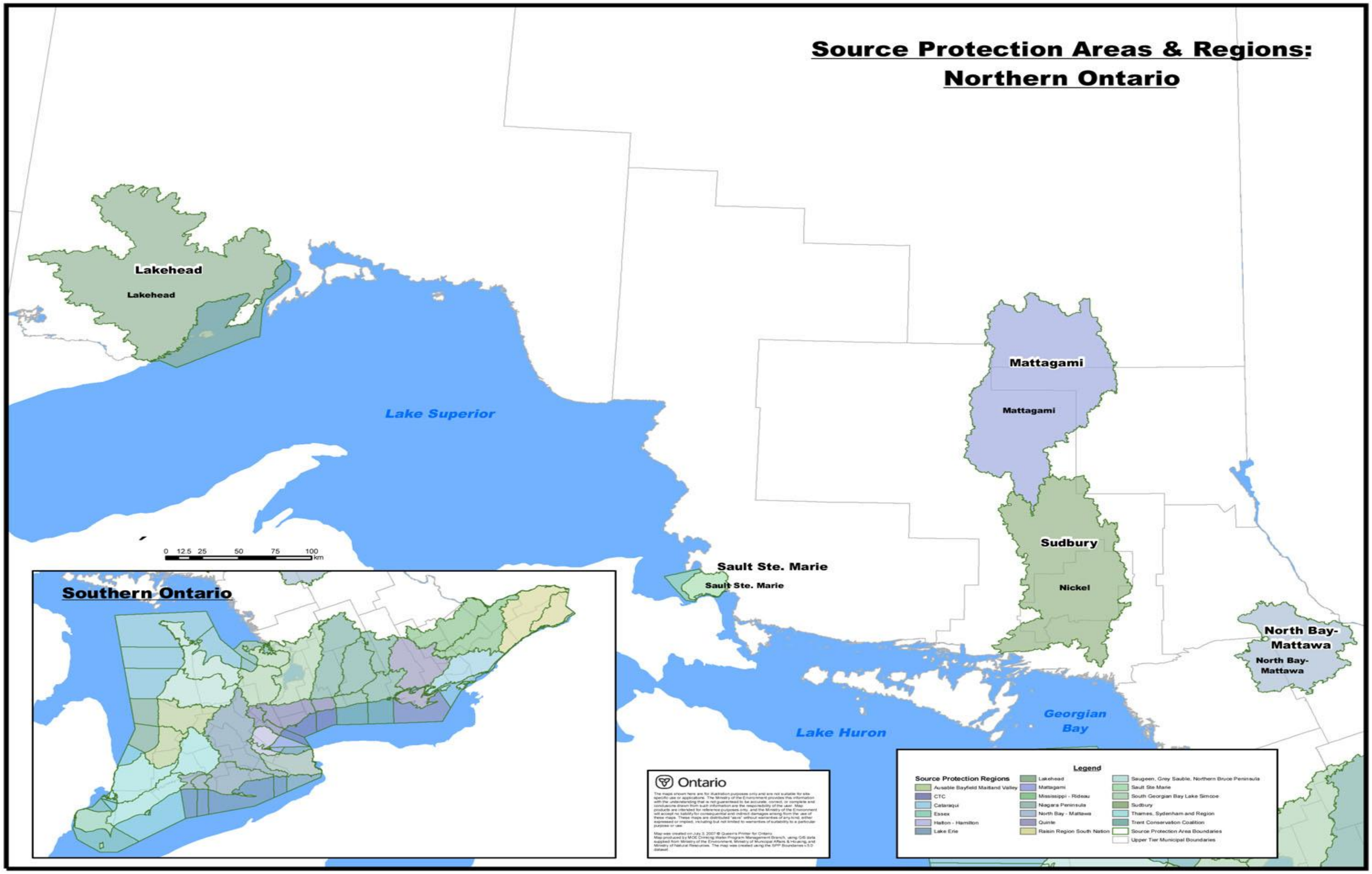
The Source Protection Committee consists of representatives from a variety of sectors. The Source Protection Committee oversees the process of gathering information about the watershed, assessing threats, assembling this information into an Assessment Report and then into a comprehensive Source Protection Plan. During the process of the three phases of Source Protection Planning, the Source Protection Committee will be responsible for the development and completion of the following:

1. Terms of Reference.
2. Assessment Report.
3. Source Protection Plan.

A final report will be developed for each of these three phases of the planning process with ample opportunity for public input during the development of each of the three stages. The final draft of each report will be submitted to the Ontario Ministry of Environment for a review and approval process. The Lakehead Source Protection Committee completed the first phase of the planning process, the Terms of Reference, in October 2008. The Minister of Environment provided approval of the "Lakehead Source Protection Area Terms of Reference" on May 25, 2009. Work on the Source Protection Plan will begin, after approval of the Assessment Report, by the Director of the Ontario Ministry of Environment, Source Protections Branch. When the final draft of the Source Protection Plan is completed, it will be submitted to the Minister of Environment for review and approval. Once approved, recommendations and policies in the Source Protection Plan can then be implemented in the Lakehead Source Protection Area.

A Source Protection Plan outlines the steps that the province, Municipalities, landowners, industries, farmers and others need to take to protect water quality and quantity in our streams, rivers, lakes and groundwater systems. These watershed-based plans will identify the threats to water quality and water quantity, identify vulnerable areas and then propose steps to reduce any risks to our water. The public process of developing a Source Protection Plan involves watershed residents, Municipalities, conservation authorities and other agencies. Figure 2 illustrates the Source Protection Areas and Regions in the Province of Ontario as defined under the "Clean Water Act".

Figure 2: Source Protection Areas and Regions in the Province of Ontario



1.3 What is an Assessment Report?

An Assessment Report looks at the factors influencing the quality and quantity of water found within the entire watershed. An Assessment Report is the second key requirement, in the Source Protection Planning process that the Source Protection Committee is responsible for developing under the "Clean Water Act". Assessment Reports include the technical components outlined below and include information such as the physical characteristics of the land, land uses, location of drinking water sources, how much water is being used, how much is available for future uses, where vulnerable water sources are located, issues currently compromising drinking water sources, and threats to drinking water sources from overuse and contamination. Once completed, the Assessment Report will provide the Source Protection Committee and Ontario Ministry of Environment with information that will help determine how best to protect the quality and amount of their local water resources. The Assessment Report will be the basis for developing the Source Protection Plan and making local policy decisions, in partnership with Municipalities, for protecting drinking water quality and quantity of Municipal Residential Drinking Water Systems.

1.3.1 Watershed Characterization

In order to initiate specific activities aimed at protecting the sources of drinking water within a watershed, it is necessary to understand the physical, sociological and economic characteristics of the watershed. The purpose of the Watershed Characterization chapter (Chapter 2) in the Assessment Report is to achieve a sufficient overview and understanding of the characteristics that can contribute to the threat, vulnerability and risk to source water. The Watershed Characterization chapter is a "snapshot in time" of the watershed and the information will include a description of the local watershed area including information on natural characteristics, population distribution, land use, water quality and water quality.

1.3.2 Water Budget

The purpose of the Water Budget chapter (Chapter 3) in the Assessment Report is to achieve a sufficient overview and understanding of the water quantity and/or how much water there is available for human use and aquatic life within the watershed. To determine the quantity of the water contained within the watershed, calculations are made on how much water enters a watershed, how much water is stored and how much water leaves the watershed. This information will assist in determining the water available for human uses, while ensuring there is still enough left for natural processes as there has to be enough water in a watershed to maintain streams, rivers and lakes and to support aquatic life. Descriptions of how features such as topography, bedrock, soils, climate, water systems, water uses and their impacts on the Water Budget are detailed in chapter three.

The first step in the technical analysis of Water Budgets is the Conceptual Water Budget. In general, the Conceptual Water Budget determines the amount of water in and its movement through the entire watershed. This includes an overview of the natural inputs and outputs within each watershed, including precipitation (rain or snow), evaporation and transpiration, infiltration and recharge (rainwater that soaks into the ground and becomes groundwater), runoff and groundwater flow. The Conceptual Water Budget also takes into consideration the surface water and groundwater features, land cover (the proportion of urban versus rural uses), human-made structures (dams, channel diversions, water crossings) and water takings for human uses. A future growth projection of the effects that the local climate has on the water budget was also included.

The Tier 1 Water Budget is an analysis carried out at the subwatershed level, in order to determine whether or not a water source can meet water use demands in the subwatershed and not be under stress. The determination of the Tier 1 Water Budget looks at the amount of available water versus the amount of water currently being taken and used, as well as future takings and usage. It also calculates how quickly a natural water source replenishes itself, known as a recharge rate, which will vary due to factors such as land use, topography and geology. If it is determined that a subwatershed could be under stress, a Tier 2 Water Budget is required.

The word stress is used to talk about potential concerns with water quantity and means more analysis needs to be carried out to better understand the water source, its water uses and environmental needs of the area. The level of stress is determined by comparing the amount of water that is available in a subwatershed to the amount of water being used by humans and needed for the environment. The higher the stress level assigned the greater the amount of water being used and the more likely the water source cannot supply enough water for all needs. It is important to understand when, where and how water is leaving a drinking water source and compare it to how quickly that source can be naturally replenished. Water quantity stressors include water that is taken by Municipalities for drinking water, industry for manufacturing and processing, business for activities such as food and beverage processing, agricultural for irrigation and private well use and other land use activities that reduce or divert water sources. Climate change may also lead to water quantity stress if water supplies become variable or reduced or if a drought occurs.

A subwatershed is considered under stress when human demand and environmental needs for water are too high for the natural supply. Based on the amount of available water that is consumed, the stress level for the subwatershed is classified into one of three categories: low, moderate, or significant. Subwatersheds containing communities with a history of water shortages at a well or intake are classified as having a moderate stress level. For watersheds where this is the case, a Tier 2 Water Budget analysis is required. If the stress level of the subwatershed is moderate or significant, a Tier 3 Water Budget is needed, which is an analysis of local areas containing Municipal Residential Drinking Water Systems, such as areas around a well or areas contributing to a surface water intake. The "Assessment Report for the Lakehead Source Protection Area" only requires a Conceptual and Tier 1 Water Budget analysis as there are no known subwatershed stress levels identified as a result of completing a Water Budget.

1.3.3 Surface Water and Groundwater Vulnerability Analysis

The Vulnerability Analysis as detailed in Chapter 4 is a study that determines how vulnerable both surface water and groundwater are to contamination. Because it is above ground, surface water or water that is found in lakes, rivers and streams is vulnerable to many types of contaminants. The Surface Water Vulnerability Analysis requires that vulnerable areas around intake pipes (also known as water quality Intake Protection Zones) be identified, mapped and given vulnerability scores. An uncertainty assessment is also done to identify where the science may need to be improved in future source protection planning cycles. The groundwater vulnerability analysis looks at underground sources of drinking water. There are three main areas that are vulnerable to contamination: wellhead protection areas, highly vulnerable aquifers and significant recharge areas. This study identifies and maps these vulnerable areas and assigns vulnerability scores. An uncertainty assessment is also conducted to identify where improvement of the science in the Assessment Report may be necessary in future Source Protection Planning cycles.

Water Quality Wellhead Protection Area (WHPA)

Wells of all types, Municipal and private, urban and rural, pump water from underground. This groundwater comes from moisture, created by rain or snow that seeps below ground and pools in cracks or spaces in the soil, sand and rock. These underground sources of water are usually referred to as aquifers. The level of groundwater, the watertable, rises and falls depending on the season, temperature, amount of rain or snow that percolates through the ground and the amount of water withdrawn from the aquifer.

A wellhead is simply the location of the well, usually associated with the physical structure of the well casing that appears above ground. A water quality Wellhead Protection Area is the area around the wellhead where land use activities have the greatest potential to affect the quality of water that flows into the well. The amount of land involved in a Wellhead Protection Area is determined by a variety of factors such as the topography, amount of water being pumped, aquifer type, soil type surrounding the well, and direction and speed of groundwater travel. All of these factors help to determine how long it takes water to move underground to the well and how much land around the wellhead should be protected. Generally, the farther away a source of contamination is, like a chemical or pathogen, the less likely it is to be a problem.

Water Quality Intake Protection Zone (IPZ)

This protected area around a surface water intake is known as a water quality Intake Protection Zone and in most locations, includes both the water and land that surrounds the intake. Intake Protection Zones in a large lake where the intake pipe is located far from shore, such as a Great Lake, may end up in the shape of a circle and never touch shore, however, water quality Intake Protection Zones in smaller lakes or on rivers may also include the land surrounding it, as well as several smaller feeder rivers or tributaries.

The area of water and land within an Intake Protection Zone is determined by a variety of factors such as the amount of time it would take any material spilled in or near a river, for instance, to flow downstream to the water intake. This is called the "time of travel". A fast or slow flowing river can change the area of a water quality intake protection zone significantly. For example, a fast flowing river may end up with a larger Intake Protection Zone than a slow moving river of the same size.

The "Clean Water Act" requires that several Intake Protection Zones be identified: one for the area immediately adjacent to the intake (Intake Protection Zone 1); one for the area further upstream where a spill might reach the intake before the plant operator can deal with it (Intake Protection Zone 2); and a third that is based on specific events like weather situations that could cause contaminants to get close to an intake (Intake Protection Zone 3). This "Assessment Report for the Lakehead Source Protection Area" will only detail information in relation to

Intake Protection Zones 1 and 2, while information related to Intake Protection Zone 3 may be included in a future Assessment Report.

How Vulnerability of a Water Quality Protection Area is Determined

Once Intake Protection Zones and Wellhead Protection Areas are identified and mapped, scientific calculations, along with professional experience, are used to determine how vulnerable each zone or area is to contamination. This is termed the "vulnerability score" and the higher the number, ranging from two to ten, the more vulnerable the area and surface water or groundwater source is. Vulnerability scores are used to look at the potential sources of contamination to determine how much of a threat it is or could be (e.g. the chance of that contamination being released). Areas closest to the Intake Protection Zone 1 or Wellhead Protection Area A will be assigned higher vulnerability scores as they are more vulnerable to contamination than areas further away from the water intake pipe (Intake Protection Zones 2 and 3) or wellhead (Wellhead Protection Areas B, C, and D).

Significant Groundwater Recharge Area

An aquifer is an area of soil or rock underground that has the ability and space to store and release (discharge) a significant amount of water. Water that seeps into an aquifer is called recharge. The natural recharge of an aquifer comes from rain and melting snow. The land area where the rain or snow seeps down into the ground and flows to an aquifer is called a recharge area. Recharge areas often have highly permeable soil, such as sand or gravel, which allows the water to seep easily into the ground. Areas of bedrock without much overburden having numerous fractures and cracks can also be recharge areas. In some areas, where the soils are less permeable or more compact, it can be more difficult to determine where recharge areas are located. A recharge area is where water from precipitation is transmitted downward to an aquifer. Areas which transmit the most precipitation are often referred to as significant recharge areas. For the purposes of the "Clean Water Act", an area can only be delineated as a Significant Groundwater Recharge Area if the area has a hydrological connection to a surface water body or aquifer that is a source of drinking water for a Municipal or Private Drinking Water System.

Highly Vulnerable Aquifers

Aquifers are considered highly vulnerable based on overburden depth and permeability. Soil or rock that has many large cracks and larger void spaces allows water to flow quickly into an aquifer. Generally, the faster the water is able to flow through the ground to an aquifer, the more vulnerable the area is to contamination.

1.3.4 Drinking Water Quality Threats Analysis

Chapter 5 details the Drinking Water Quality Threats Analysis, which examines and determines existing water quality issues in raw water sources and identifies and describes threats that contribute to or have the potential in these raw water sources to impact Municipal Drinking Water Sources. It also identifies what activities would pose a threat to drinking water if they were located in a vulnerable area in the future.

Drinking water issues can be chronic, which means they have existed over a long period of time, or reoccur seasonally and are likely to continue if nothing is done to address the activities that cause them. Through the Source Protection Planning process, issues that impact water quality will be linked to specific land uses and areas so that actions can be taken to manage them.

Drinking water threats are classified as significant, moderate or low. All activities, for example an oil or chemical leak, that could pose a significant threat to a drinking water source if something did go wrong are called significant threats and are the focus of Source Protection Planning under the "Clean Water Act". Conditions consist of contamination that already exists and are associated with past activities that could affect the quality of drinking water and can be considered significant threats if they occur in an area of high vulnerability.

In accordance to the "Clean Water Act", industries, businesses and private landowners that are in or near Intake Protection Zones or Wellhead Protection Areas and engage in any type of activity that could pose a significant threat to a drinking water source may be required to make some changes. In instances where a landowner or business is operating in a manner that poses a significant risk to a drinking water source, they may have to make substantial changes to the operation. The landowner or business can co-operatively work together with the regulating body in order to reduce the effect any changes will have on their business or activity.

A very clear benefit of protecting vulnerable areas such as Intake Protection Zones, Wellhead Protection Areas, Significant Recharge Areas or Highly Vulnerable Aquifers is preventing drinking water contamination. It costs less to protect water in the first place than to clean it up after it has been contaminated. Other benefits include:

- Protecting public health.
- Not having contaminated wells.
- Reducing the cost of water treatment.
- Ensuring a long-term supply of clean water.
- Ensuring a positive climate for economic growth.

1.3.5 Source Protection Plan

In general, a Source Protection Plan builds on the information collected in the Assessment Report to establish policies to protect drinking water sources. The "Clean Water Act" states that the Source Protection Plans must address significant threats to drinking water quality and quantity. Source Protection Plans will contain policies that will work to reduce or eliminate a significant drinking water threat. There are various tools and approaches for the protection of drinking water that may be included in a Source Protection Plan. Many of these are already available to people who manage land uses and activities, such as Municipalities. Some of these will be familiar to people, such as Land Use Planning (by-laws and zoning), Regulations (a Nutrient Management Plan is needed in order to apply animal waste) and stewardship (education, outreach and Best Management Practices). Others may be less familiar, for example, monitoring water quality to make sure an activity is not impacting the local area in a way that would negatively impact drinking water sources, or constructing storm water retention ponds to manage and clean storm water runoff.

The Source Protection Plan for the Lakehead Source Protection Area will be developed separately from this Assessment Report and must be completed and submitted to the Minister of Environment no later than August 20, 2012.

2.0 Watershed Characterization

The Watershed Characterization chapter is a description of the watershed that assesses the watershed's fundamental, natural and manmade characteristics, and includes the natural landscape, population distribution, land use and broad understanding of the water quality and quantity conditions within the Lakehead Source Protection Area. Chapter 1 was developed using the report entitled "Watershed Characterization Report – A Draft Report for Consideration of the Lakehead Source Protection Committee" (Lakehead Region Conservation Authority, 2008)", which is a compilation of available background information for the Lakehead Source Protection Area from reports completed by the Lakehead Region Conservation Authority and other available sources. Prior to the final draft being produced, the "Watershed Characterization Report – A Draft Report for Consideration of the Lakehead Source Protection Committee" (Lakehead Region Conservation Authority, 2008) was peer evaluated by: Conservation Ontario; Ontario Ministry of Natural Resources, Northwest Regional and Thunder Bay District offices; Thunder Bay Port Authority; Ontario Ministry of Environment; and Mr. Herb Bax. Revisions and information updates as recommended by the peer evaluators were incorporated into the final report. During the development of the Assessment Report, the Lakehead Source Protection Committee made every attempt to update and revise the content of the Watershed Characterization chapter when updated information and data was available.

2.1 Description of the Watershed

Watersheds, also called drainage basins, are made up of all of the land and water areas draining toward a particular river or lake. The watershed can be divided into definitive areas based on the relationship between the surface drainage and its importance to the main watershed course. Tracing the network of lakes, rivers and streams and the relationship between them and the main basin is fundamental in mapping out the areas into which the watershed can be divided. Lake Superior is a large drainage basin (82,170 square kilometres) that has multiple watersheds contributing to the volume of water entering the lake. Larger watersheds can be divided into smaller subwatersheds based on the lakes, rivers and streams that contribute to the water in Lake Superior. The Lakehead Source Protection Area is a portion of the secondary Lake Superior watershed Nipigon and Northwestern Lake Superior Watershed - 02A. The boundaries of the Lakehead Source Protection Area were determined for the purposes of Source Protection Planning by the flow of all of the water contained within the portion of the secondary watershed, which would pass through the jurisdiction of the Lakehead Region Conservation Authority to reach Lake Superior. The area covered by this boundary, including the portion of area delineated into Lake Superior, is 13,696 square kilometres. A figure of 11,526 square kilometres, which is equal to the area of the landbase within the Lakehead Source Protection Area, will be used as the watershed area for the purposes of the "Assessment Report for the Lakehead Source Protection Area".

The Lakehead Source Protection Area can be further divided into three tertiary subwatersheds: Dog, Black Sturgeon and Arrow. Quaternary watersheds are the next level of subwatersheds within the Lakehead Source Protection Area. There are 21 quaternary watersheds within the

Lakehead Source Protection Area, three of which fall only partially within the boundary. The portions of quaternary watersheds 2AC-01 and 2AC-03, located within Sleeping Giant Provincial Park, are not considered within the boundary of the Lakehead Source Protection Area for the purposes of Source Protection Planning due to the fact that it is a designated Ontario Provincial Park. The portion of quaternary watershed 2AA-01 overlapping the boundary of the Fort William First Nation is not considered part of the Lakehead Source Protection Area for the purposes of Source Protection Planning due to the fact that this is federal land and the Provincial government has no jurisdiction on federal lands. Table 1 summarizes the tertiary and quaternary watersheds and their drainage areas within the Lakehead Source Protection Area**.**

Assessment Report Map # 1 – Lakehead Source Protection Area
Map Binder – Map Sleeve #1

This map illustrates the boundaries of the Lakehead Source Protection Area within the Lake Superior Secondary Watershed – Nipigon and Northwestern Lake Superior Watershed - 02A. Also shown on the map are three tertiary watersheds (Arrow, Dog and Black Sturgeon) and 21 full and partial quaternary watersheds, delineated in yellow and identified by their watershed code. The jurisdictional boundary of the Lakehead Region Conservation Area is indicated by a red outline. The inset map shows the location of the Lakehead Source Protection Area within the province of Ontario.

Table 1: List of Quaternary Watersheds and Drainage Areas within the Lakehead Source Protection Area

Tertiary Watershed	Quaternary Watershed	Watershed Identification Number	Drainage Area (Square Kilometres)
Arrow (2AA)	Cloud, Jarvis, and Whiskey-jack Creeks, Lomond River	2AA01	373 (partial)
	Lower Pigeon, Little Pine and Pine River	2AA02	474
	Arrow River	2AA03	12
Dog (2AB)	Kaministiquia River	2AB01	723
	Slate River	2AB02	182
	Whitefish River	2AB03	586
	Shebandowan River	2AB04	1177
	Oskondaga and Swamp Rivers	2AB05	341
	Dog Lake	2AB06	1132
	Dog River	2AB07	2280
	Neebing River	2AB08	232
	McIntyre River, McVicar Creek	2AB09	210
	Current River	2AB10	663
	Matawin River	2AB11	864
	Kashabowie River	2AB12	527
Black Sturgeon (2AC)	Wildgoose, Blind and Twin-pine Creeks, Blende River	2AC01	79 (partial)
	MacKenzie River	2AC02	443
	Portage Creek	2AC03	90 (partial)
	D'Arcy, Pearl and Big Pearl Lakes, D'Arcy, Welch and Coldwater Creeks	2AC07	381
	Black Sturgeon River, Little Squaw and Squaw Creeks	2AC09	27
	Wolf River	2AC14	730
Total (Square Kilometres)			**11,526**

Note: Each area does not include upstream watersheds. E.g. Shebandowan does not include Kashabowie.

2.1.1 Municipalities

The Lakehead Source Protection Area is 11,526 square kilometres. Within this area is the jurisdiction of the Lakehead Region Conservation Authority, consisting of eight organized Municipalities: the Townships of Gillies, Conmee, O'Connor and Dorion; Municipalities of Neebing, Oliver Paipoonge and Shuniah; and City of Thunder Bay, totalling 2,718 square kilometres. Table 2 is a summary of the area in square kilometres, population and population density of the eight organized Municipalities.

Assessment Report Map # 2 - Administrative Boundaries, Settlements and First Nation Reserves within the Lakehead Source Protection Area
Map Binder – Map Sleeve #2

This map illustrates the administrative boundaries related to the Lakehead Region Conservation Authority (red outline), eight member Municipalities, settlements and local communities within the Lakehead Source Protection Area. The unorganized territory within the Lakehead Source Protection Area is indicated by the area shaded in pale yellow. Federal land related to the Fort William First Nation is indicated in orange. The inset map shows the location of the Lakehead Source Protection Area within the province of Ontario.

Table 2: Summary of Municipal Population and Population Density

Municipality	Area (Square Kilometres)	Population (Canada 2006 Census)	Population Density (Persons Per Square Kilometre)
Township of Conmee	169.84	740	4.36
Township of Dorion	218.71	379	1.73
Township of Gillies	93.86	544	5.80
Township of O'Connor	108.67	720	6.63
Municipality of Neebing	847.91	2,913	3.44
Municipality of Oliver Paipoonge	355.00	5,757	16.22
Municipality of Shuniah	587.93	2,913	4.95
City of Thunder Bay	333.79	109,140	326.97

Assessment Report Map #3 - Population Distribution and Density per Dissemination Area within the Lakehead Source Protection Area
Map Binder – Map Sleeve #3

This map illustrates the population distribution and density per dissemination area within the Lakehead Source Protection Area. Statistics Canada defines a dissemination area as the geographic area canvassed by one census representative, the boundaries following recognizable physical features such as roads and rivers and is the smallest geographic area for which census population data is made available by Statistics Canada. This map was developed using electronic population by dissemination area data provided by Statistics Canada (2001 Census Data – most recent data available in this format). Population distribution is indicated by purple graduated shading. As the colours darken, the population distribution increases. Population density is indicated by using burgundy coloured dots in graduated sizes. As the size of the dot increases, the population density increases. The dissemination areas are delineated with grey boundaries. For reference purposes, the map also includes the jurisdictional boundary of the Lakehead Region Conservation Area delineated in red and major roads. The inset map shows the location of the Lakehead Source Protection Area within the province of Ontario.

Unorganized Townships

The remainder of the Lakehead Source Protection Area is made up of Unorganized Townships and unsurveyed territory. Two of the more populated Unorganized Townships are Gorham and Ware, located just north of the jurisdiction boundary of the Lakehead Region Conservation Authority. Population totals for the individual Unorganized Townships within the Lakehead Source Protection Area could not be quantified, therefore remain a data gap, but a population total within the unorganized territory in the Thunder Bay District is 6,225 individuals. It is important to note that this total also includes populations for unorganized territories outside of the Lakehead Source Protection Area, as the figure was based on the District of Thunder Bay, as per the census division, and provided by Statistics Canada (2001 census – most recent data available in this format).

Unorganized territory is considered crown land in northern Ontario and falls under the jurisdiction of the Ministry of Natural Resources for land use planning and management issues, and the Ontario Ministry of Environment for environmental management and water quality and quantity issues. The following is a list of the Unorganized Townships that lie within the Lakehead Source Protection Area, either partially or in their entirety:

Adrian	Aldina	Ames	Begin
Blackwell	Cockeram	Conacher	Dawson Road Lots
Devon	Duckworth	Fraleigh	Forbes
Fowler	Gibbard	Glen	Goldie
Golding	Gorham	GTP Block #1	GTP Block #2
GTP Block #3	GTP Block #4	GTP Block #5	Haines
Hagey	Hogarth	Horne	Jacques
Jean	Lamport	Laurie	Lismore
Lybster	Marks	McMaster	Michener
Parry	Robson	Sackville	Savanne
Sibley	Soper	Stirling	Strange
Ware	Wardrope		

2.1.2 Federal Lands

Fort William First Nation

Fort William First Nation is the only First Nation on Federal reserve land within the Lakehead Source Protection Area. Formed in 1853, the reserve, currently occupying 5,815 hectares, is located due south of the Thunder Bay city limits, on the south shore of the Kaministiquia River, near the outlet of Lake Superior and the north side of Mount McKay. The Aboriginal Canada Portal 2004 states that as of September 2003 the community had a registered population of 1,646 persons. Fort William First Nation receives its residential drinking water from the City of Thunder Bay Municipal Residential Drinking Water supply system.

Other Federal Lands

After direct consultation with the eight organized Municipalities and Ministry of Natural Resources District Planner, it was confirmed that no other federal lands occur within the Lakehead Source Protection Area.

2.2 Drinking Water Systems

Assessment Report Map #4 – Drinking Water Systems
Map Binder - Map Sleeve # 4

This map indicates the known locations of Municipal and non-Municipal Drinking Water Systems.

Assessment Report Map #4A – Rosslyn Village Subdivision Well Supply
Map Binder - Map Sleeve # 4A

This map illustrates the location of an area served by the Rosslyn Village Subdivision Well Supply Municipal Residential Drinking Water System. The location of each of the two Municipal groundwater wells are indicated. The map inset indicates the location of the Rosslyn Village Subdivision Well Supply Municipal Residential Drinking Water System within the Lakehead Source Protection Area.

Assessment Report Map #4B – Thunder Bay (Bare Point) Municipal Residential Drinking Water System
Map Binder - Map Sleeve # 4B

This map illustrates the location of an area served by the Thunder Bay (Bare Point) Municipal Residential Drinking Water System. The map inset indicates the location of the Thunder Bay (Bare Point) Municipal Residential Drinking Water System within the Lakehead Source Protection Area.

2.2.1 Municipal Residential Drinking Water Systems

Rosslyn Village Subdivision Well Supply

The Hamlet of Rosslyn Village is located about 17 kilometres west of the City of Thunder Bay and approximately 400 metres northeast of the Kaministiquia River, as shown on Assessment Report Map #4A – Rosslyn Village Subdivision Well Supply (Map Binder - Map Sleeve # 4A). Rosslyn Village has a Municipal Residential Drinking Water System, currently servicing (as of January 2010) 29 residences and historically as many as 50. Water is supplied from one of two Municipal wells as shown on Assessment Report Map #4A – Rosslyn Village Subdivision Well Supply (Map Binder - Map Sleeve # 4A) which are operated alternately. Average daily water use is 35,000 litres per day and a maximum use of approximately 50,000 litres per day has been recorded.

Thunder Bay (Bare Point Road) Water Treatment Plant

The Thunder Bay (Bare Point Road) Water Treatment Plant is owned and operated by the City of Thunder Bay. The primary intake for the water treatment plant is located in Lake Superior (as shown on Assessment Report Map #4B – Thunder Bay (Bare Point) Municipal Residential Drinking Water System (Map Binder - Map Sleeve # 4B), approximately 840 metres into Lake Superior, at a depth of 10.2 metres. The rated capacity of the system is 113.5 million litres (2007), servicing a population of 102,500 (2007). It should be noted that the Thunder Bay (Bare Point Road) Water Treatment Plant also supplies treated drinking water to the following areas outside the City of Thunder Bay limits; the Fort William First Nation and Whitewater subdivision, located in the Municipality of Oliver Paipoonge.

2.2.2 Non-Municipal Drinking Water Systems

The Ontario Ministry of Environment provided the Lakehead Source Protection Committee with a partial database listing of non-Municipal Drinking Water Systems located within the province of Ontario. The Lakehead Source Protection Committee reviewed this list to determine which non-Municipal Drinking Water Systems were located within the Lakehead Source Protection Area. In an attempt to add additional data, the Lakehead Source Protection Committee consulted with the Thunder Bay District Health Unit. The Lakehead Source Protection Committee could not locate any additional data sources indicating the: classifications of the Non-Municipal Drinking Water Systems; numbers of users served by each system; average annual and monthly pumping rates; and location of monitoring wells related to the system. It should be noted that the locations of the Non-Municipal Drinking Water Systems as indicated on Assessment Report Map #4 – Drinking Water Systems (Map Binder - Map Sleeve # 4), are general locations based on the information provided in the database. The level of accuracy of these locations is unknown, as the locations were determined by inputting the address of the system owner into GOOGLE EARTH® (2009) and were not located in the field using a Geographic Positioning System (GPS). Appendix I contains a listing of the non-Municipal Drinking Water Systems from the dataset located within the Lakehead Source Protection Area.

2.3 Naturally Vegetated Areas

Assessment Report Map #5 – Land Cover
Map Binder - Map Sleeve # 5

This map illustrates land cover including wooded areas, wetlands, agriculture and Provincially Significant Wetlands within the Lakehead Source Protection Area. As there is no spatial data available related to riparian areas for the Lakehead Source Protection Area, riparian areas are not shown.

Table 3 is a summary of the types, area and percentage of the naturally vegetated areas within the Lakehead Source Protection Area.

Table 3: Naturally Vegetated Areas within the Lakehead Source Protection Area

	Area (Square Kilometres)	**Area** (Hectares)	**Area Percentage within Lakehead Source Protection Area**
Lakehead Source Protection Area	11,526.01	1,152,600.84	N/A
Provincially Significant Wetlands	37.31	3,730.72	0.32
Other Wetlands	510.43	5,1043.14	4.43
Wooded Area*	8,867.63	886,762.63	76.94

* NOTE: There is a portion of data unavailable for the wooded areas covering the Lakehead Source Protection Area. This area was included in the total area but was not included in the total wooded areas calculation. As this area is well outside the urban settled areas within the Lakehead Source Protection Area and is most likely a wooded area, the actual total wooded area would likely be higher.

2.3.1 Wetlands

Wetlands occupy an important transitional zone between land and water and may have fresh, brackish or saline waters, depending on the type of water body they are associated with. Wetlands are defined as lands that are seasonally, temporarily, or permanently covered by shallow water or where the water table is at or close to the surface and can be classified within the five classes: bog, fen, swamp, marsh and shallow open water.

Wetlands are complex environments that require careful, rigorous examination to fully document their values. The values are often subtle or cumulative in their significance. While some wetlands are recognized as significant because of their uniqueness, others are also important due to cumulative losses of typical wetlands which reduce the overall number of wetlands.

Provincially Significant Wetlands

A Provincially Significant Wetland area is identified by the Ontario Ministry of Natural Resources using evaluation procedures established by the province. A Locally Significant Wetland is not a provincial designation, but identified by a Municipality or a Conservation Authority as a wetland having ecological importance. The following is a listing of the Provincially Significant Wetlands and other wetlands within the Lakehead Source Protection Area. During the development of the Assessment Report, the Lakehead Source Protection Committee contacted each Municipality to confirm that there were no known Locally Significant Wetlands identified within the Lakehead Source Protection Area.

The following have been assessed and classified as Provincially Significant Wetlands within the Lakehead Source Protection Area:

Caldwell Lake Wetland
Cloud Bay Wetland
Horseshoe Lake Wetland
Hurkett Cove Wetland
Mills Block Wetland
Mission Island Marsh
Neebing Marsh
Neebing River Wetland
Pearson Township Wetland
Pine Bay Wetland
Rosslyn Oxbow Wetland
Sturgeon Bay Wetland
William's Bog

Other Wetlands

Although the following have not been classified as Locally Significant Wetlands, their unique characteristics are recognized as local points of interest.

Arthur Bog
Chippewa Marsh
McKellar Island
Northern Wood Preservers Marsh
Pardee Wetland

2.3.2 Woodlands and Riparian Areas

Woodlands contribute to improved water quality and quantity by decreasing the speed of overland water flow and erosion, increasing evapotranspiration and intercepting rainfall, and increasing infiltration to shallow groundwater areas. Land development through urbanization plays a significant role in changing the hydrologic balance in a watershed. In a woodland where the natural landscape is not disturbed, precipitation is dispersed mainly as infiltration and evapotranspiration. But when natural forests and rural farmlands are converted into residential and commercial communities, there is a tendency for more permeable (porous) surfaces to be turned into less permeable or impermeable surfaces, which are also referred to as impervious surfaces/areas. This increase in impervious area results in a significant increase in surface runoff in terms of rate, volume and frequency. The increased runoff entering into streams can erode the banks and bed of the channel resulting in a wider and deeper channel. Land cover change not only affects water quantity but can adversely affect water quality in terms of increases in sediments and nutrients attached to the sediment particles.

The Lakehead Source Protection Area is classified as a Humid Western Ontario Site Region that is divided into two parts. The southwest portion is in the Pigeon River Site Region and the northeastern portion is in the Lake Nipigon Site Region. The principal differences between the two regions are the mean annual temperature, frost free periods and average annual precipitation. White spruce, balsam fir, aspen species, Jack pine and white birch are common tree species throughout both sites. A point of interest, often found on the slopes of the Nor'Wester Mountains in gravelly soils, are populations of red and sugar maples and other tolerant hardwoods common to the Great Lakes-St. Lawrence Forest.

Approximately 70 percent of the Lakehead Source Protection Area lies beyond the legal jurisdiction of the Lakehead Region Conservation Authority. This area outside of the jurisdiction of the Lakehead Region Conservation Authority falls under the land management jurisdiction of the Ontario Ministry of Natural Resources. For the purposes of forest management of the Crown forest in Ontario, the province is divided into geographic planning areas known as forest management units. Most of these management units are managed by individual forest industrial companies under a Sustainable Forest Licence (SFL).

A riparian area is defined as an area of streamside vegetation, including the stream bank and adjoining floodplain, which is distinguishable from upland areas in terms of vegetation, soils, and topography. Riparian areas influence water quality by controlling erosion from overland flow, limiting the introduction of sediments to surface waters and reducing the concentrations of nutrients, pesticides and some pathogens. In Forest Management Plans, riparian areas are protected through spatial analysis that is based on the slope values of the Digital Elevation Model surface, at a distance of 30, 50, 70, and 90 metres from the lakeshore or stream bank (high water mark). All slopes up to 15 percent are assigned a minimum 30 metre buffer between the shoreline and the forest operations. Slopes greater than 15 percent are assigned buffers from 50 to 90 metres correlating to the determined slope.

Within the area of jurisdiction of the Lakehead Region Conservation Authority, riparian areas are managed under the administration of the Regulation – "Development, Interference with Wetlands and Alterations to Shorelines and Watercourses" (Ontario Regulation 180/06, under O. Reg. 97/04) established under the "Conservation Authorities Act" (R.S.O. 1980).

2.4 Aquatic Habitats

Assessment Report Map #6 – Surface Water Characteristics
Map Binder - Map Sleeve # 6

This map illustrates the three thermal aquatic habitat classifications (cold, cool and warm water) of known water bodies within the Lakehead Source Protection Area. Water bodies with unknown thermal classifications are also illustrated. The locations of surface water control structures, dams and electric power stations are indicated on the map and detailed in a table on the map. Historic and current stream flow gauges with known coordinates, located within the Lakehead Source Protection Area, are also identified on this map. The Ontario Benthos Biomonitoring Network does not have any data on record for the Lakehead Source Protection Area.

2.4.1 Fisheries

Within the Lakehead Source Protection Area, the Ontario Ministry of Natural Resources manages water bodies for fisheries while the Department of Fisheries and Oceans regulates the Federal "Fisheries Act".

Each fish species requires different habitats to carry out their life functions, and their habitat requirements vary with their life stage. Based on their temperature requirements, fish species can be grouped into three broad fish habitats: cold, cool and warm water. There is a certain amount of overlap among these broad community types as it is not uncommon to find some cold water species living in the same areas as cool water species or cool water species living in the same areas with warm water species. Waters with a temperature greater than 25 degrees Celsius are considered warm for fish habitat, temperatures between 18 to 25 degrees Celsius are cool waters and between 10 to 18 degrees Celsius are cold waters for fish habitat. Within the Lakehead Source Protection Area, a large proportion of the streams are cool or cold water which support populations of brook trout and/or rainbow trout. Some of the inland lakes also support populations of brook trout, rainbow trout and/or lake trout. Table 4 provides a listing of fish species and their water temperature requirements within the Lakehead Source Protection Area.

Approximately 815.86 square kilometres (81,585.68 hectares) is covered by lakes, rivers and streams, which represents 7.08 percent of the Lakehead Source Protection Area, some of which have been inventoried by the Ontario Ministry of Natural Resources. Appendix III contains a listing of known lakes, and Appendix IV contains a listing of known rivers and streams within the Lakehead Source Protection Area. Thermal water temperature classifications, where known, are included in each list.

Table 4: Fish Species of the Lakes Within the Lakehead Source Protection Area

Common Name	Scientific Name	Water Temperature Preference
Lake Sturgeon	*Acipenser fulvescens*	Cool
Largemouth Bass	*Micropterus salmoides*	Warm
Smallmouth Bass	*Micropterus dolomieui*	Warm
Rock Bass	*Ambloplites rupertris*	Cool
Walleye	*Sander vitreum*	Cool
Yellow Perch	*Perca flavescens*	Cool
Muskellunge	*Esox masquinogy*	Cool
Northern Pike	*Esox lucius*	Cool
Longnose Sucker	*Catostomus catostomus*	Cold
White Sucker	*Catostomus commersoni*	Cool
Black Crappie	*Pomoxis nigromaculatus*	Cool
Burbot	*Lota lota*	Cool
Lake Whitefish	*Coregonus clupeaformis*	Cold
Round Whitefish	*Prosopium cylindraceum*	Cold
Chinook Salmon	*Oncorhynchus tshawytscha*	Cold
Coho Salmon	*Oncorhynchus kisutch*	Cold
Lake Trout	*Salvelinus namaycush*	Cold
Brook Trout	*Salvelinus frontinalis*	Cold
Rainbow Trout	*Oncorhynchus mykiss*	Cold
Brown Trout	*Salmo trutta*	Cold
Smelt	*Osmerus mordax*	Cold
Carp	*Cuprinus carpio*	Warm
Lake Herring (Cisco) *	*Coregonus artedii*	Cold
American Brook Lamprey	*Lampetra lamottei*	Cool
Alewife	*Alosa psuedoharengus*	Cold

* found in Lake Superior only.

2.4.2 Aquatic Macro Invertebrates

The benthic zone is the deepest level in a body of water such as a lake or a river. It is inhabited mostly by organisms that tolerate cool temperatures and low oxygen levels, called benthos or benthic organisms. The profundal, limnetic and littoral zones of a waterbody can be found above the benthic zone. The aphotic zone is considered the benthic zone and there is no light other than bioluminescence found in this zone. Below the benthic level of water is the superficial layer of soil lining the waterbody. The nature of this soil layer has a great influence on the biological activity of the benthic zone. Examples of contact soil layers include sand bottoms, rock outcrops, coral and bay mud. Measuring the density and diversity of benthic invertebrates in streams and rivers can provide valuable clues when assessing the quality of surface water. Benthic invertebrates serve as an indicator to changes in water pollution over time and exhibit a wide range of sensitivity to various levels of environmental stress. The absence of sensitive benthic species or the dominance of pollution-tolerant species can indicate that water quality is degraded. EcoSuperior began collecting samples and data on benthic invertebrates in 2004 and again in 2008 in order to identify reference sites. Only four of their proposed sample sites fall within the Lakehead Source Protection Area. This data is preliminary and limited at this time and therefore was not used for the purposes of the “Assessment Report for the Lakehead Source Protection Area”. No other benthic sampling or monitoring information has been found to date.

2.4.3 Species and Habitats at Risk

In the Lakehead Source Protection Area, there is a transition from the northerly limits of the Great Lakes-St. Lawrence forest in the area south of the City of Thunder Bay, to the boreal forest in the northern area. Species and/or ecosystem complexity in the region is perceived to be diverse, and consequently species and habitats may be more variable across the Lakehead Source Protection Area. Vulnerability of habitats can vary, however there is scientific uncertainty regarding the “true” vulnerability of a species. Ecologically rare species may have adapted resilience and/or resistant characteristics, allowing their survival within natural disturbance cycles such as fire, storms, predator/prey relationships, or unnatural disturbance cycles including fragmentation on river systems due to dams. On the other hand, when a species, whether rare or common, becomes vulnerable by some disturbance and is unable to adequately adapt to these environmental changes, then the species will likely become threatened and/or endangered. A "Species at Risk" is any plant, animal, bird or aquatic species threatened by or vulnerable to extinction.

While several Species at Risk occur in and the potential habitats for these species are distributed throughout the Lakehead Source Protection Area, including the urban areas within the City of Thunder Bay, there is no evidence that any of these species or their habitats have a direct relationship to the source protection of Municipal Residential Drinking Water Systems. As a result, the Lakehead Source Protection Committee has chosen not to include detailed descriptions of the “Species at Risk” occurring in the Lakehead Source Protection Area. A complete list with detailed descriptions of the “Species at Risk” and invasive species occurring in the Lakehead Source Protection Area can be found in the report entitled “Watershed Characterization Report – A Draft Report for Consideration of the Lakehead Source Protection Committee” (Lakehead Region Conservation Authority, 2008).

2.5 Human Characterization

2.5.1 Municipal Plans

An Official Plan (OP) is a policy document prepared by a Municipality, which states in broad terms the Municipality's strategic vision for community development and land use. The primary role of the Official Plan is to establish a series of Municipal policies to manage physical change and the effects on the social, economic and natural environment within the Municipality. An Official Plan may delineate zones or areas requiring special policies, such as wetlands or other environmentally sensitive areas. A zoning by-law could also restrict activities in areas like wetlands, wellhead protection areas, intake protection zones and other vulnerable areas. These planning documents are necessary references when completing a watershed characterization.

Lakehead Rural Planning Board

The Lakehead Rural Planning Board is a regional planning board whose jurisdictional area is defined by the Ontario Ministry of Municipal Affairs and Housing as the five organized Townships/Municipalities (Neebing, Oliver Paipoonge, O`Connor, Gillies and Conmee) adjacent to the City of Thunder Bay; two Unincorporated Townships (Gorham, Ware) and a portion of another Unincorporated Area (Dawson Road Lots - Lots 1 - 20, Concession A and B - east of the Kaministiquia River). Planning Board members are responsible for providing input and making recommendations concerning local land-use planning matters, considering applications for the conveyance of land, reviewing local land-use planning documents and making recommendations regarding Amendments, interpreting and applying provincial policy and legislation relating to local land-use planning, and attending regular and special meetings of the Planning Board.

2.5.2 Settlement Areas

Settlement areas are the built-up areas of urban and rural Municipalities and the lands that have been designated for future development in an Official Plan. In some "built-out Municipalities" the settlement area coincides with the Municipal boundary, however most Municipalities have land within their boundaries that is not developed.

The total area of the Urban Residential, determined to be the City of Thunder Bay, is 33,416 hectares, which represents 2.9 percent of the total Lakehead Source Protection Area (1,152,600 hectares). In general, the majority of the land base in the Lakehead Source Protection Area is rural with a low population density. To calculate the rural residential area, all of the landbase of the organized Townships within the jurisdiction of the Lakehead Region Conservation Authority, excluding the area of the City of Thunder Bay, were measured and totalled. This area is 238,373 hectares, 20.7 percent of the Lakehead Source Protection Area. No data for the Unorganized Townships of Gorham, Ware and Dawson Road Lots was available and they were not included in the calculation. The majority of the population base is concentrated in urban areas within the City of Thunder Bay.

2.5.3 Land Use

Landfills

A landfill, also known as a waste disposal site or a dump, is a site for the disposal of solid waste materials. Landfills can be considered potential point sources of contamination. Depending upon the proximity of water wells and the direction of groundwater flow there can be impacts to the local groundwater regime. There are several landfills in the Lakehead Source Protection Area, including domestic and industrial (wood waste, ash and sludge). In the development of the Lakehead Source Protection Area Assessment Report, it was determined that none of these landfill sites have any direct impacts on the two Municipal Residential Drinking Water Systems within the Lakehead Source Protection Area.

Mining and Aggregate Extraction

Part of the early history of the Lakehead Source Protection Area included the acquisition and development of mining locations along the northern shoreline of Lake Superior. Traditional mining for minerals and precious metals has not been a significant activity in the Lakehead Source Protection Area since the early 1900's. Aggregate extraction has been consistently in demand since development within the Lakehead Source Protection Area began. Currently there is both provincial and federal legislation related to aggregate extraction and the protection of source water in place. In the development of the Lakehead Source Protection Area Assessment Report, it has been determined that neither mining nor aggregate extraction have any direct impacts on the two Municipal Residential Drinking Water Systems within the Lakehead Source Protection Area.

Oil / Petroleum

There are no processing plants or refineries located within the Lakehead Source Protection Area. Some petroleum products are transported via tanker ship through the Great Lakes to the Port of Thunder Bay and offloaded at one of two storage facilities located in the harbour on the shores of Lake Superior. Petroleum products are then delivered throughout the Lakehead Source Protection Area via transport truck and railway. The environmental hazard of petroleum to the water sources within the Lakehead Source Protection Area are limited to spills either at the storage facilities or a spill of a truck or railcar containing a petroleum product.

Natural Gas

The TransCanada Pipeline traverses the northern half of the Lakehead Source Protection Area in a west-east direction. Union Gas is a Duke Energy Company that provides natural gas distribution to three areas in Ontario including from the Manitoba border to North Bay. Union Gas is a direct customer of TransCanada and provides all of the natural gas distribution within the Lakehead Source Protection Area. In the development of the Lakehead Source Protection Area Assessment Report, it has been determined that natural gas distribution should not have any direct impacts on the two Municipal Residential Drinking Water Systems within the Lakehead Source Protection Area.

Ontario Power Generation

Ontario Power Generation (OPG) is an Ontario-based electricity generation company whose principal business is the generation and sale of electricity in Ontario. The Thunder Bay Generating Station is owned and operated by Ontario Power Generation. This generating station is located on the shore of Lake Superior in the City of Thunder Bay and has been in operation since 1963. It has two coal-fuelled generating units in service that together produce up to 326 megawatts (MW) of electricity. The station uses low sulphur lignite coal from Western Canada and low sulphur sub-bituminous coal from the United States. Currently, there are studies underway to determine the feasibility of using wood waste as biofuel, with the intent of replacing coal.

Ontario Power Generation's Northwest Plant Group operates eleven hydroelectric generating stations on five river systems in northwestern Ontario: the Aquasabon, English, Kaministiquia, Nipigon and Winnipeg rivers. These stations provide clean, low-cost, renewable and reliable sources of power to Ontarians year-round. Within the Lakehead Source Protection Area there are two hydroelectric generating stations operating on the Kaministiquia River, the Kakabeka Falls and Silver Falls Generating Stations.

Forestry

The forest operations occurring on Crown land within the Lakehead Source Protection Area are governed by the Ontario Ministry of Natural Resources. Forest management practices are bound by many provincial regulations to ensure environmentally sound and sustainable operations. The Ontario Ministry of Natural Resources, Northwest Region consists of 21 forest management units, all managed under long-term Sustainable Forest Licences. Each forest is licensed to a private sector company that is committed to ecologically based, sustainable forest management. In the Lakehead Source Protection Area there are four forest management units: the Black Sturgeon, Dog River-Matawin, Lakehead and Spruce River Forests.

Transportation

The City of Thunder Bay is situated in the centre of Canada and therefore is a major transportation hub providing access to both the eastern and western reaches of the country, as well as access to the United States. Thunder Bay is unique in terms of transportation services as it is one of the only cities in Canada that has a significant transportation system that combines land, water and air transportation systems.

Highway transportation is especially important in this part of the province where sparse population and long distances reduce the viability of other modes of passenger transportation. The Lakehead Source Protection Area has two primary highways, an organized network of secondary highways, Municipal roads and numerous gravel surfaced forest access roads.

Northern Ontario’s rail network consists of 7,000 kilometres of rail line that crosses the northern half of Ontario. The main flow of the Canadian Pacific Railway is east-west across Canada, with through traffic and local traffic originating and terminating in Thunder Bay. The main flow of Canadian National Railway rail traffic between eastern and western Canada is carried on the northern route between Winnipeg, Manitoba and Capreol, Ontario (north of Sudbury, Ontario).

The Thunder Bay International Airport is the third busiest airport in Ontario, servicing over a half million passengers annually and is adjacent to the Ontario Ministry of Natural Resources air and fire suppression base. Thunder Bay also houses the regional Ontario Ministry of Natural Resources air fleet, which services the needs of the Northwest Region Ontario Ministry of Natural Resources, including fire suppression.

Marine

The Port of Thunder Bay is at the head of the Great Lakes/St. Lawrence Seaway System, a dynamic navigable waterway that stretches 3,700 kilometres into the North American continent. A one-way voyage through the Great Lakes/St. Lawrence Seaway System, through 16 of the most efficient locks in the world, to Thunder Bay takes about five days. Most ships are approximately 222.5 metres in length, 23 metres in width with a loaded draft of almost eight metres. Both the Port of Thunder Bay and the Great Lakes/St. Lawrence Seaway System operate 24 hours a day, seven days a week, from the end of March through to December or January, depending on seasonal weather conditions.

The Port of Thunder Bay is designated as a Canada Port Authority, an international port. The Port of Thunder Bay handles grain from western Canada for export and is one of the largest grain-storage ports in the world. In addition, Port of Thunder Bay handles other bulk goods, such as coal and is the only potash load point on the Great Lakes. The Port of Thunder Bay has facilities for handling all types of cargo and is served by both the Canadian National and Canadian Pacific railways, as well as many major trucking companies. The numerous terminals and elevator sites located in the Port of Thunder Bay allow for quick and efficient turn-around time to the more than 400 ship visits the Port of Thunder Bay receives each year. Cargoes like grain, coal, potash, forest products, manufactured goods and dimensional cargoes are shipped throughout the world via the Port of Thunder Bay.

The Port of Thunder Bay extends 55 kilometres along the shoreline of Lake Superior and the Kaministiquia, McKellar, and Mission Rivers. The Port of Thunder Bay area constitutes a significant portion of the land area of the City of Thunder Bay, including in excess of 95 percent of the heavy industrial land described in the City of Thunder Bay's land use planning program and generates considerable revenue activities for the region. The Port of Thunder Bay encompasses 26 square kilometres of land area and 119 square kilometres of water area which represents over 17 percent of the total area of the City of Thunder Bay.

The Port of Thunder Bay is delineated by a breakwall that was constructed to protect the harbour from the destructive waves of Lake Superior. The breakwalls were constructed from rock quarried at Silver Harbour in the Municipality of Shuniah and also contain sections constructed of concrete.

Descriptions of the commodities handled through the Port of Thunder Bay are detailed below. Table 5 provides a summary of cargo statistics for the Port of Thunder Bay for 2007 and 2008.

Grain

The Port of Thunder Bay is Canada’s second largest grain handling port, with nine grain terminals and a total storage capacity of 1,400,000 tonnes. Private terminals are capable of handling a wide variety of western Canadian agricultural products. Loading rates at the terminals range from 1,000 to 3,400 tonnes per hour.

Grain accounts for about 70 percent of the Port of Thunder Bay’s overall throughput. Annual shipments of grain products are cleaned and handled through the grain terminals at Thunder Bay. Grains marketed both privately and through the Canadian Wheat Board move through the Port of Thunder Bay and Great Lakes/Seaway System to international markets. Wheat, durum, coarse grains, oilseeds, feed grains, peas and other pulse crops, as well as various grain by-products pass through the port handling facilities on an annual basis. The Port of Thunder Bay is a significant benefit to western Canadian agricultural producers. Over 75 percent of Manitoba’s wheat crop and a significant portion of the crops from Saskatchewan and Alberta are transported abroad via the Port of Thunder Bay.

Liquid Bulk Products

Bulk liquids such as petroleum products and calcium chloride account for about two percent of the Port of Thunder Bay’s annual shipped products. One petroleum company, Suncor, operates a terminal in the Port of Thunder Bay. The products received by this company are shipped to Thunder Bay for storage, with further distribution to service stations, manufacturing and pulp and paper industries via land transportation services. The General Chemical Company maintains a storage facility in the Port of Thunder Bay that receives calcium chloride shipped from Southern Ontario, which is off-loaded into storage tanks for distribution via land transport throughout Northwestern Ontario.

Dry Bulk Products

Commodities such as coal, potash, and other free-flowing mineral and agricultural products are considered dry bulk products and account for about 30 percent of the Port of Thunder Bay’s overall tonnage. Coal and potash are received in the Port of Thunder Bay via railway transport from Alberta, Saskatchewan and Manitoba and on-loaded to waiting ships that can take on loads of up to 30,000 tonnes. Thunder Bay Terminals Limited and Valley Camp Incorporated are the two facilities that handle over 2,000,000 tonnes of dry-bulk products each year. Other dry bulk products shipped into the Port of Thunder Bay and handled by these dry bulk handling companies, including Lafarge, include urea, sand, stone, salt, limestone, bark chips, uncleaned grain, grain by-products and steel.

Valley Camp Incorporated is a division of Synfuel Technologies, Limited Liability Company, and operates a free flowing dry-bulk transfer system. The Valley Camp Incorporated facility has two docks, one 550 metres in length and the other 201 metres in length that can accommodate vessels up to 304 metres in length. Valley Camp Incorporated has outside ground storage for over 2,000,000 tonnes of cargo and an annual throughput capacity for 10,000,000 tonnes of cargo. The site is also serviced by road, and the Canadian National Railway (CNR) and Canadian Pacific Railway (CPR). It is one of three ports in Canada that are serviced by both national railways.

General Cargo

About two percent of the Port of Thunder Bay's overall movement of goods comes from the category of product classified as general cargo. The following is a listing of the general cargoes that pass through the Port of Thunder Bay: lumber, newsprint, wood pulp, other products from the forest industry, manufactured goods, heavy equipment, machinery, bagged goods, steel, project cargoes, heavy lifts and heavy containers.

Keefer Terminal is a full-service transportation facility, owned by the Thunder Bay Port Authority, which has 750 meters of marine berths directly linked to rail and highway, is built on a 32 hectare site with approximately 50,000 square metres of secured covered storage and an additional 6.5 hectares of outside pad storage. The terminal was designed to reduce repeat handling of cargo.

Table 5: Cargo Statistics for the Port of Thunder Bay

Cargo Statistics for the Port of Thunder Bay		
	2007	**2008**
Total Vessels	431	415
Cumulative Totals for 2007 and 2008 in Metric Tonnes		
Type of Cargo	**Cumulative Totals 2007** (metric tonnes)	**Cumulative Totals 2008** (metric tonnes)
Grain	5,349,326	5,693,630
Coal	1,314,645	1,658,264
Potash	530,788	291,224
Dry Bulk	90,432	149,600
Liquid Bulk	155,554	212,083
General Cargo (includes forest products)	51,023	65,818
Total	**8,492,768**	**8,070,619**

Information Source: Thunder Bay Port Authority

Other businesses such as tug boat services, environmental services, oil spill recovery and response services, vessel brokering and stevedoring services operate in the Port of Thunder Bay. A Canada Coast Guard base, located adjacent to Keefer Terminal, includes a Marine Communications and Traffic Services Communication centre and Search and Rescue base. The waterfront of Thunder Bay supports a broad range of heavy industrial activity such as pulp and paper facilities, lumber mills and a wood preserving plant that relies upon water and/or rail service. The north commercial core of the City of Thunder Bay and associated Prince Arthur's Landing Marina Park are located in close proximity to the Port of Thunder Bay. The waterfront also provides space for tenants such as the Thunder Bay Generating Facility, marinas, private recreation clubs and associations (rowing, sailing, canoeing) and several open space recreational areas. Pleasure craft operating within the harbour adds to the total water-based activity within the Port.

2.6 Water Quality

2.6.1 Surface Water Quality

The Lakehead Source Protection Committee conducted a thorough search of studies and documentation for surface water quality information and only found the following water quality findings of tributaries within the Lakehead Source Protection Area, as detailed below. The following information has been extracted and summarized from information detailed in past studies carried out within the Lakehead Source Protection Area. As surface water quality studies in the past have not been related to residential drinking water sources but to the general health of contributing tributaries within the Lakehead Source Protection Area, surface water quality data is limited. Typically, past studies have been associated with fisheries habitat or pollution assessment which most often does not provide data that can be used for the assessment of raw drinking water quality for Municipal Residential Drinking Water Systems.

<u>Kaministiquia River</u>

As a direct reflection of the geology of the area, the water in the Kaministiquia River contains relatively high concentrations of organics, iron and turbidity. The alkalinity and hardness of the water ranges from moderate to low. Below Kakabeka Falls in the middle reaches of the river system, the water is characterized by high dissolved oxygen levels, low turbidity and colour, high transparency, high pH and moderate levels of nitrogen and phosphorus. Surface temperatures range from 19 to 25 degrees Celsius. Due to industrial development along the north side of the lower reaches of the river with wastewater discharges, the water quality and habitat have been considered degraded in the past.

Biochemical oxygen demand (BOD) is a measure of the quantity of oxygen used by microorganisms (aerobic bacteria) in the oxidation of organic matter. Oxygen consumed in the decomposition process robs other aquatic organisms of the oxygen they need to live. Biochemical oxygen demand is used in water quality management and assessment, ecology and environmental science. Biochemical oxygen demand is not an accurate quantitative test, although it could be considered as an indication of the quality of a water source. Biochemical oxygen demand can be used as a gauge of the effectiveness of wastewater treatment plants. At the mouth of the Kaministiquia River at Lake Superior, the water quality improves slightly because of the intermixing of cold well-oxygenated water from Lake Superior.

<u>Mosquito Creek</u>

The water in Mosquito Creek tends to be turbid and highly coloured. Continuous water sampling by the Ontario Ministry of Environment in the past revealed that total phosphorus concentrations are invariably over Provincial Water Quality Objectives (PWQO) throughout the Mosquito Creek watershed. Some extremely high phosphorus concentrations occurred near the mouth in the spring that at the time of testing were associated with large suspended solids loads. Annual geometric mean fecal coliform, total coliform and *Escherichia coli* (E. coli) levels generally increased downstream but remained below Provincial Water Quality Objectives levels. However, during spring, in part due to the seasonal Thunder Bay Correctional Centre lagoon discharges, exceedances of the Provincial Water Quality Objectives occurred with typically lower values occurring in the autumn months. The lagoons have also been found to be sources of ammonia, organic nitrogen, total phosphorus and suspended solids to Mosquito Creek. In the past, concerns have been expressed that the type of detergents used at the Thunder Bay Correctional Centre may unnecessarily contribute additional phosphorus loading to the stream. The level of treatment afforded by the lagoons would appear to be inadequate, given the level of in stream dilution available. Improvements to the Thunder Bay Correctional Centre sewage system were completed prior to the development of the Assessment Report, but water quality sampling results have not been available since the improvements.

Organic nitrogen levels are typically high throughout the Mosquito Creek watershed, while ammonia, nitrite and nitrate levels are low. The unionized fraction of the reported ammonia concentrations (conversion based on temperature and pH) do not approach the Provincial Water Quality Objectives level, which was established based on fish toxicity concerns. Total dissolved solids and chloride levels increase as one progresses downstream due to the dilution effect of waters flowing to the tributaries. The unnamed tributary draining the Mount Forest development (in the City of Thunder Bay) and Highway 61 has the highest chloride levels in the basin, with levels often exceeding 100 milligrams per litre. Sodium levels are also high in this tributary, suggesting the impact of road salt usage and increased shallow groundwater contributions. Dissolved oxygen levels in Mosquito Creek are often stressed, falling below four milligrams per litre in the middle reaches and headwaters during the summer. This can be attributed to biological decay and limited physical re-aeration due to the numerous areas of standing water at culverts and beaver dams. The standing water also contributes to the warming of the water. Contributing to Mosquito Creek is the runoff from the Nor'Wester mountain range. The Fort William Golf Course is located on Mosquito Creek and well within the drainage of the watershed. The runoff from the golf course due to irrigation and a subsoil of silty clay can contribute to the water quality in Mosquito Creek.

Cedar Creek

The geographic Township of Marks and Township of O'Connor landfill sites are both situated within the watershed of Cedar Creek. According to the available data to date, neither landfill has had any discernible effects on the water quality of Cedar Creek. The only previous water quality testing done in the watershed of Cedar Creek was in 1994 when the Ontario Ministry of Environment received an inquiry about the water quality of Cedar Creek immediately downstream of the two landfill sites. The results of this examination concluded the samples were within water quality and safety margins and the creek was considered unaffected by the landfills.

Other Surface Water Bodies

In 1973, the Ontario Ministry of Environment studied 43 lakes within an 80 kilometre radius of the City of Thunder Bay. Six parameters were incorporated in a ranking scheme in which a low level of biological productivity was considered an index of high water quality. Arrow Lake, located outside of the west boundary of the Lakehead Source Protection Area and Loch Lomond were of outstanding quality. None of the 43 lakes were shown to be critically impaired from a productivity standpoint. Since the mid-1960's, the Ontario Ministry of Natural Resources has instituted an extensive monitoring program called the "Sport Fisheries Fish Contaminant Monitoring Program". The principal trace contaminant in the Lakehead Source Protection Area is found to be methyl mercury, but traces of dichlorodiphenyltrichloroethane (DDT), mirex and polychlorinated biphenyls (PCB's) have also been detected in some species. Within the

Lakehead Source Protection Area, few lakes have been monitored but there have been no instances identified where it is recommended that no fish be eaten. At many sites, limited consumption of the large sizes of fish (45 centimetres and over) of various species is recommended to some degree.

Provincial (Stream) Water Quality Monitoring Network (PWQMN)

The Provincial Water Quality Monitoring Network collects surface water quality information from rivers and streams across Ontario. The main objective of the Provincial Water Quality Monitoring Network is to protect human health and aquatic ecosystems by providing reliable and current information on stream water quality, including tributaries to the Great Lakes, in support of source protection planning, nutrient management, performance measurement reporting, water quality standards review and setting, long-term trend monitoring, fisheries management, watershed management and planning, impact assessment, reviewing Permits to Take Water and Certificates of Approval for discharges and other approvals processes. The success of the Provincial Water Quality Monitoring Network is founded on the shared recognition of the benefits of cooperation and the free exchange of data. The Provincial Water Quality Monitoring Network also provides a strong foundation for implementing new monitoring strategies in response to new and emerging information needs.

The Ontario Ministry of Environment leads the design and operation of the Provincial Water Quality Monitoring Network in close cooperation with its partners which are typically Ontario's Conservation Authorities. The purpose of the Provincial Water Quality Monitoring Network is to document long-term ambient water quality trends to determine the general location and causes of water quality problems, and to measure the effectiveness of broad pollution control and watershed management programs including watershed-based source protection planning and nutrient management. The Provincial Water Quality Monitoring Network is the primary source of surface water quality data for Conservation Authorities. Partners collect water samples and deliver them to the Ontario Ministry of Environment where they are analyzed in the Ministry's laboratory. Currently, water quality is measured at over 400 locations in rivers and streams across Ontario, although only minimal coverage currently exists in Northern Ontario.

In the spring of 2008, the Lakehead Region Conservation Authority resumed sampling of five sites under the Provincial Water Quality Monitoring Network. Samples are collected approximately eight times per year from March/April to October/November during the ice free period. Samples are analyzed for chloride, dissolved nutrients, total nutrients, suspended solids, metals, hardness, dissolved oxygen content, pH, alkalinity and conductivity. The hardness product includes calcium and magnesium ion concentrations. Table 6 provides a summary of the current Provincial Water Quality Monitoring Network monitoring sites as of 2009 in the Lakehead Source Protection Area. As there were only 1.5 years of data and the records previous to 1995 could not be located at the time of the development of the Assessment Report, the Lakehead Source Protection Committee could not make any sound statements on raw water quality trends.

Table 6: Provincial Water Quality Monitoring Network Sample Sites in the Lakehead Source Protection Area (current as of 2008)

Station	Name	Location	Last Year of Historic Sampling	Year Sampling Resumed	Tertiary Watershed
01010400202	Current River	Highway 11/ 17, Thunder Bay Expressway	1995	2008	2AB
01010500102	McVicar Creek	Cumberland Street North, Thunder Bay	1995	2008	2AB
01010600202	McIntyre River	May Street, Thunder Bay	1995	2008	2AB
01010700202	Neebing River	Arthur Street West, West of Mapleward Road, Thunder Bay	1995	2008	2AB
01010800602	Slate River	Candy Mountain Road, Municipality of Oliver Paipoonge (Streamflow/Precipitation Gauge Site)	New station in 2008	2008	2AB

2.6.2 Groundwater Quality

During the "Lakehead Region Conservation Authority Thunder Bay Aquifer Characterization, Groundwater Management and Protection Study" ("Groundwater Study") carried out in 2005, the assigned consultant assessed the regional groundwater quality using the Ontario Ministry of Environment historic water quality database available at the time of the study. Data from a total of 253 wells within the Lakehead Source Protection Area were analysed and summarized. Of the 253 wells listed in this database, only two wells are designated as a Municipal Residential Drinking Water System and the rest are private systems. It should be noted that the water samples collected from the private systems are raw water samples while the water collected from the Municipal Residential Drinking Water Systems are treated drinking water samples. Ontario Drinking Water Standards (ODWS) were designed to set parameters on water quality related to treated drinking water. The raw water samples collected for the purposes of the "Groundwater Study" were tested and the results were analysed against the Ontario Drinking Water Standards. Any exceedances of the parameters set in the Ontario Drinking Water Standards on the raw water samples were indicated as poor groundwater quality in the study area.

The water chemistry data analyzed in the "Groundwater Study" was based on 253 wells located within the Lakehead Source Protection Area. The wells provided data on nitrate, sodium, chloride, iron, manganese and hardness. The results of the analysis performed by the consultant concluded that there was a considerable variation in water quality across the area represented by the 253 wells. In summary, spatial evaluation of the data did not show any significant trends in the location of wells and the parameter values. Ambient nitrate concentrations tended to be in the zero to two milligrams per litre range, which suggests minimal impacts from anthropogenic (man-induced) sources. The majority of the sodium concentrations were above the Ontario Drinking Water Standard of 200 milligrams per litre. Chloride concentrations illustrated a similar trend. Iron concentrations were variable throughout the "Groundwater Study" area; however an elevated iron concentration is common in many groundwater wells in Ontario. Manganese concentrations are similar to the iron concentrations in terms of number of exceedances. Hardness concentrations indicate that the water is very hard throughout the area where data was available. It is interesting to note that all sampled parameters exceeded the Ontario Drinking Water Standard for at least one parameter in each well. The parameters exceeded may be naturally occurring or man-made conditions affecting the quality of groundwater. Due to the nature of the geology and the concentrations of naturally occurring minerals in the Lakehead Source Protection Area, water quality samples often exceed Ontario Drinking Water Standards for mineral content. Table 7 provides a summary of the results of the consultant's analysis of groundwater quality parameters based on 253 wells where data was available.

Table 7: Ontario Treated Drinking Water Standards

Parameter	**Nitrate** (milligrams/litre)	**Sodium** (milligrams/litre)	**Chloride** (milligrams/litre)	**Iron** (milligrams/litre)	**Manganese** (milligrams/litre)	**Hardness** (milligrams/litre)
Ontario Drinking Water Standard Type	**Maximum Acceptable Concentration**	**Aesthetic Objective**	**Aesthetic Objective**	**Aesthetic Objective**	**Aesthetic Objective**	**Operational Guideline**
Ontario Drinking Water Standard Limit	10	200	250	0.3	0.05	80
Maximum	11.5	1,171	2,022	51.6	6.14	8,284
Minimum	0	0.2	0	0	0	5.5
Average	0.54	72.4	123.7	1.55	0.16	349.13
Standard Deviation	1.32	154.1	259.3	5.22	0.53	783.21
Percentage exceeding ODWS*	0.5%	60%	12.4%	35.2%	44.2%	91.5%

Source: Lakehead Region Conservation Authority Thunder Bay Aquifer Characterization, Groundwater Management and Protection Study, 2005.

Chloride

An Aesthetic Objective (AO) has been established by the Ministry of Environment for chloride at 250 milligrams per litre. At this concentration, chloride becomes detectable in drinking water by a salty taste. Chloride is found commonly in nature and is a part of various salts such as sodium chloride (NaCl) and potassium chloride (KCl). Chloride is non-toxic but its presence may also be indicative of the impact of road salts on groundwater. Data evaluated for the "Groundwater Study" area shows that the average chloride encountered in the study area was 124 milligrams per litre which is below the Aesthetic Objective. Only 12.4 percent of the samples exceeded the Aesthetic Objective. From the evaluation of their spatial distribution, these incidents of exceedence seem concentrated in the centre of the "Groundwater Study" area. There are some instances of linear bands along the major roadways in the centre of the City of Thunder Bay. The maximum measured value is 2,022 milligrams per litre and the large standard deviation of 259 indicates that there is a wide variation in this parameter across the area. The application of road salt is dependent on specific winter weather conditions in the Lakehead Source

Protection Area, so application is much more limited than areas in southern Ontario. As elevated sodium and chloride concentrations have been known to naturally occur in the groundwater in the Lakehead Source Protection Area, it therefore cannot automatically be assumed that the cause is a result of road salting.

<u>Nitrate</u>

A nitrate concentration of ten milligrams per litre is the Maximum Acceptable Concentration (MAC) for this parameter in drinking water. The Maximum Acceptable Concentration is defined for parameters that when present above a certain concentration, have known or suspected adverse health effects. Nitrates are a by-product of septic systems and may enter the groundwater if there are a high number of septic systems in an area. Nitrate in groundwater is known to be the cause of methemoglobinemia (Blue Baby Syndrome). Excess nitrogen in surface water bodies may also promote the growth of aquatic plants and algae. When these plants die back, they create a deficit in dissolved oxygen that may then lead to fish kills. Of the wells with coordinates sampled in the "Groundwater Study" area, only one exceeded the Ontario Drinking Water Standard for nitrate. Two wells exceeded a value of six milligrams per litre while the value for the other wells remained low. There is no apparent spatial trend in the distribution of nitrates across the "Groundwater Study" area, as each occurrence of elevated nitrate was concluded to be related to locally occurring conditions. Based on the concentrations of nitrates in the data provided, nitrate in the groundwater is not a significant problem at the present time.

<u>Iron</u>

Excessive levels of iron in groundwater may impart a brownish colour to laundry or plumbing fixtures as well as to the water itself and may result in a bitter taste in the water but is not known to be toxic. The precipitation of iron may also promote the growth of bacteria in water mains. The Aesthetic Objective for iron in drinking water has been set at 0.3 milligrams per litre as part of the Ontario Drinking Water Standard. Evaluation of the water quality data from the "Groundwater Study" area showed no clear spatial trend in the distribution of iron. Iron levels varied across the study area from a low of zero milligrams per litre to a high of 51.6 milligrams per litre. The average value for this parameter in the Lakehead Source Protection Area is 1.5 milligrams per litre and 35 percent of all samples exceeded the established Aesthetic Objective. Iron is usually present in groundwater as the result of mineral deposits and chemically reducing underground conditions. The absence of a spatial trend and the high variation in iron suggests that this parameter is a naturally occurring feature of groundwater in the aquifer, which is typical in groundwater in Ontario.

<u>Sodium</u>

As defined by the Ontario Drinking Water Standard, the Aesthetic Objective for sodium is 200 milligrams per litre. An Aesthetic Objective is established for a parameter that may impair the taste, odour or colour of water or which may interfere with good water quality control practices. Sodium at its Aesthetic Objective becomes detectable in drinking water by its salty taste. Sodium however, is not toxic and consumption in excess of ten milligrams per litre per day by normal adults does not result in any apparent health effects. Persons suffering from hypertension or congestive heart disease may require a sodium restricted diet and the intake of sodium in drinking water could become significant. To deal with this threat, the local Medical Officer of

Health should be notified if sodium levels exceed 20 milligrams per litre. The local Medical Officer of Health is then responsible for informing local physicians. The values for sodium showed large variation across the “Groundwater Study” area. Evaluation of the data showed that the Aesthetic Objective of 200 milligrams per litre for sodium is exceeded in 14 wells or 6.2 percent of the samples. The values reported also exceed 20 milligrams per litre in 60 percent of the cases. The average concentration in the sample set was 72 milligrams per litre, with the maximum concentration encountered being 1,170 milligrams per litre. The Rosslyn Village Subdivision Well Supply System has historically at times, shown levels above the 20 milligrams per litre level.

Manganese

An Aesthetic Objective has been established for manganese at 0.05 milligrams per litre. As with iron, manganese will stain laundry and fixtures black and at excessive concentrations it causes undesirable tastes in beverages. The precipitation of manganese also promotes the growth of bacteria in water mains. Manganese is not known to be toxic and is objectionable based only on its effect on the colour and taste of the water. Iron and manganese, when present in significant concentrations in groundwater, may present problems with bio-fouling of wells, pumps and water mains. Bio-fouling generally refers to the degradation of groundwater quality by bacteria and contributes to iron/manganese encrustation and corrosion of wells, pumps, distribution lines, and treatment systems. This process is very persistent, usually recurring and results in constrictions of the water supply system. No clear spatial trend was identified in the sample data for this parameter in the “Groundwater Study”. The average value for the samples was 0.16 milligrams per litre, which is above the established Aesthetic Objective. Approximately 44 percent of the wells sampled were above the Aesthetic Objective for this parameter. Manganese and iron are naturally occurring elements. Their effect on groundwater is largely due to the local geologic and hydrogeologic setting.

Hardness

Hardness is caused by dissolved calcium and magnesium and is expressed as the equivalent quantity of calcium carbonate in milligrams per litre. An Operational Guideline (OG) has been established for hardness at between 80 and 100 milligrams per litre as calcium carbonate, with hard water being above 100 milligrams per litre. When heated, hard water tends to form scale and will form a scum with regular soap. Hardness in excess of 200 milligrams per litre is considered to be poor but tolerable. Hardness in excess of 500 milligrams per litre is regarded as unacceptable for domestic purposes. Conversely, soft water (below 80 milligrams per litre) may result in accelerated corrosion of water pipes. Softening of water using a domestic softener increases the sodium content of drinking water. Data evaluated in the “Groundwater Study” shows that 88.9 percent of the wells sampled have a hardness that is above the Operational Guideline. Although there was no clearly defined spatial trend across the “Groundwater Study” area, water hardness ranged from a minimum of 5.5 milligrams per litre to a maximum of 8,284 milligrams per litre. The variability of hardness in the water suggests that this is a natural property of the groundwater. Based on the hardness data, it is reasonable to assume that individuals in the “Groundwater Study” area likely use water softeners as part of their individual water supplies. It should be noted that their use of softeners may add to the sodium content of drinking water. Naturally soft water occurred in only 8.5 percent of the samples.

Fluoride

The fluoride content of natural water supplies in Canada varies between 0.01 and 4.5 milligrams per litre. Ground water infiltration is suspected of being the major source of fluoride in surface water with high fluoride concentrations. Fluoride is a common mineral that is concentrated in rock formed from volcanic materials, and mineral particles that contain fluoride are common in some sedimentary rocks. Most of the elevated concentrations are associated with confined aquifers. Groundwater from confined aquifers usually has not had the opportunity to mix with recently recharged water high in dissolved oxygen. Therefore, the low oxygen environment and long resident time in confined aquifers allows fluoride to be naturally present in the aquifer geology to dissolve into the groundwater. Naturally occurring fluoride concentrations are found in well water samples in the Lakehead Source Protection Area. A fluoride concentration of 1.5 milligrams per litre is the Maximum Acceptable Concentration for this parameter in drinking water, as defined by the Ontario Drinking Water Standard. The Ontario Drinking Water Standard states that where water supplies contain naturally occurring fluoride at levels higher than 1.5 milligrams per litre but less than 2.4 milligrams per litre the Ontario Ministry of Health and Long Term Care recommends an approach through local boards of health to raise public and professional awareness to control excessive exposure to fluoride from other sources. Fluoride levels have been historically high in the Rosslyn Village Subdivision Well Supply System. It should be noted that the City of Thunder Bay and the Municipality of Oliver Paipoonge do not add fluoride to the drinking water during the treatment process.

Provincial Groundwater Monitoring Network (PGMN)

The Lakehead Region Conservation Authority entered into a partnership agreement with the Ministry of Environment on January 10, 2003 to participate in the Provincial Groundwater Monitoring Network Program. The Provincial Groundwater Monitoring Network consists of the installation of monitoring wells and subsequent collection of water quality and level data from program wells. The Provincial Groundwater Monitoring Network Program wells have been fitted with level logging devices that record the groundwater level every hour. The data is then downloaded and submitted to the Ministry of Environment for inclusion in the Provincial Groundwater Monitoring Information System database. All wells are sampled once per year for water quality analysis.

Eight program wells were installed from 2005 to 2007 within the Lakehead Source Protection Area in the following locations: East Gorham Fire Hall, Hazelwood Lake Conservation Area, Jackpine Community Centre, Kakabeka Falls Fire Hall, Murillo Fire Hall, Birch Beach, Dorion Fish Culture Station and Loon Lake. Sampling began in 2006 on the wells that were installed at that time with all the wells being sampled commencing in 2007.

As there were only a few years of data at the time of the development of the Assessment Report and there has been very limited data regarding groundwater quality and level data from the past, the Lakehead Source Protection Committee could not identify any groundwater quality trends from the data collected to date.

2.7 Managed Lands

Managed lands are lands to which nutrients (Agricultural Source Material, fertilizer, Non-Agricultural Source Material) are applied. It includes, but is not limited to cropland, fallow land, improved pasture, golf courses, sports fields and private and public lawns. For the purposes of the calculation of managed lands for the Assessment Report, the Lakehead Source Protection Committee included all managed lands that have the potential to have nutrients applied.

Managed lands can be broken into 2 subsets: agricultural managed land and non-agricultural managed land. Agricultural managed land includes areas of cropland, fallow and improved pasture that may receive nutrients. Non-agricultural managed land includes golf courses (turf), sports fields, lawns (turf) and other built-up grassed areas that may receive nutrients (primarily commercial fertilizer).

2.7.1 Managed Lands within the Lakehead Source Protection Area

The managed lands of primary concern within the Lakehead Source Protection Area are those located in the vicinity of the Rosslyn Village Subdivision Well Supply Wellhead Protection Areas. Within areas connected to the Rosslyn Village Subdivision Well Supply Wellhead Protection Area there are three properties which could be considered agricultural managed lands and several non-agricultural managed lands (lawns).

Agricultural Managed Lands

Although limited by terrain and soils, there are lands that are suitable for agriculture throughout the Lakehead Source Protection Area. The number of people involved in agriculture provide an important aspect of socioeconomic and food supply systems within the region. The Kaministiquia River and Slate River valleys are noted as the most significant areas in which agriculture is practiced within the Lakehead Source Protection Area, but agricultural land areas can be found scattered across the landbase where suitable soil and topography is found. Because the main agricultural activity is dairy farming, it is complemented by forage, grain and feed crop production in order to provide feed for the livestock. Apiaries often coincide with the large planted areas of feed or market produce crops and the apiary products are sold locally. Within the Lakehead Source Protection Area, there are significant amounts of fluid milk, potatoes, eggs, beef, pork, poultry, market garden produce, a Gouda cheese producer, and multiple greenhouse nurseries for horticultural products and forest tree seedling products.

The storage, handling and application of agricultural source material, non-agricultural source material, pesticides and fertilizers associated with agricultural activities can result in potential pathogen and chemical contamination to Municipal Residential Drinking Water Supplies.

The impacts from these activities were assessed by conducting site visits, using aerial photography and available Geographic Information System data. The information collected was used to produce maps that illustrate the percentage of managed lands and the location and density of livestock within the vulnerable areas. A summary of the percentage managed lands as they apply to the Rosslyn Village Subdivision Well Supply Wellhead Protection Areas is detailed in Table 8.

Table 8: Percentage of Managed Land

Type of Managed Land	Managed Area (hectares)	Vulnerable Area (hectares)	Percent Managed Lands
Wellhead Protection Area A Managed Lands	1.37	5.43	25.23
Wellhead Protection Areas B Managed Lands	2.57	4.89	52.56
Wellhead Protection Areas C Managed Lands	7.73	13.21	58.52
Wellhead Protection Areas D Managed Lands	15.59	24.34	64.01
Total Agricultural Lands	26.11	47.87	54.55
Total Non-Agricultural Lands	1.15	47.87	2.4
Total Managed Lands	27.26	47.87	56.96

The information on managed lands can be used as an indicator of watershed areas where intensive agricultural or other land management activities are conducted. A higher percentage of managed lands indicated a higher probability of agricultural activities taking place in an area. Field visits were conducted around the Rosslyn Village Subdivision Well Supply Wellhead Protection Area to confirm the presence of livestock on agricultural lands.

Livestock density is a measurement of the number of livestock expressed as Nutrient Units (NU) per unit area (acres) of managed lands. The main types of livestock identified within the managed land surrounding the Rosslyn Village Subdivision Well Supply Wellhead Protection Areas were horses and cattle. The 2006 Census of Agriculture has records of populations of cattle, horses, pigs, sheep, goats, llamas and poultry being farmed in and around the Lakehead Source Protection Area. The 2006 Census Data was the most detailed information available to Lakehead Source Protection Committee during the development of the Assessment Report. It is important to note, that the Census data is detailed for the entire District of Thunder Bay (103,706 square kilometers) which is significantly larger than the Lakehead Source Protection Area (11,526 square kilometers). Livestock density was determined for the Wellhead Protection Areas, Intake Protection Zones, Significant Groundwater Recharge Areas and Highly Vulnerable Aquifers. Detailed information on livestock numbers was determined during site visits to agricultural operations within the Wellhead Protection Areas. This information was coupled with parcel data to accurately determine livestock densities within the Wellhead Protection Areas. As there are no agricultural or non-agricultural managed lands within the Intake Protection Zones, no livestock densities were determined. A more general approach was taken for determining livestock density for Significant Groundwater Recharge Areas and Highly Vulnerable Aquifers:

i. Livestock numbers from Statistics Canada, 2006 Census of Agriculture, Farm Data and Farm Operator Data, were recorded and converted into nutrient units using technical direction from the Ontario Ministry of Environment as provided in the "Technical Bulletin on Managed Lands and Livestock Density".
ii. Next, using Municipal Property Assessment Corporation data, parcels that can be deemed managed lands were identified in the Geographic Information System environment. The total area for these parcels was calculated.

iii. Once the area was calculated, the nutrient units (as determined in Step i) were divided by the area (as determined in Step ii) to determine an average number of nutrient units for the entire Lakehead Source Protection Area.

iv. The final step was intersecting agricultural parcels with Significant Groundwater Recharge Areas and Highly Vulnerable Aquifers.

A summary of the livestock densities for the applicable properties within the Wellhead Protection Areas is detailed in Table 9.

Table 9: Livestock Densities

Property	Livestock Type	Nutrient Units	Area (Acres)	Livestock Density (Nutrient Unit per acre)	Potential for Nutrient Application Exceeding Crop Requirements
Potato Farm	None	0	52.18	0	**Low**
Cattle Barn	Cattle/horses	34	85.7	0.40	**Low**
Hobby Horse	Horses	3	14	0.21	**Low**

Appendix II provides additional details of livestock types and numbers, and the methodology used for determining livestock density within these vulnerable areas. The following maps detail the intersections between managed lands and Wellhead Protection Areas, Intake Protection Zones, Significant Groundwater Recharge Areas and Highly Vulnerable Aquifers, and provide an average livestock density throughout the vulnerable areas. The livestock density provided is much higher than the actual livestock density as a result of using livestock totals for the entire District of Thunder Bay, not just the Lakehead Source Protection Area. The Lakehead Source Protection Committee did not have data that could provide accurate livestock totals for the area within the District of Thunder Bay that represents the Lakehead Source Protection Area.

Assessment Report Map # 7A – Managed Lands
Map Binder - Map Sleeve # 7A

This map illustrates the agricultural and non-agricultural managed lands within the Rosslyn Village Subdivision Well Supply Wellhead Protection Areas. Only managed lands occurring in areas with a vulnerability score greater than 4, have been illustrated on the map.

Assessment Report Map # 7B – Managed Lands Percentage – Wellhead Protection Areas
Map Binder - Map Sleeve # 7B

This map illustrates percentage of managed lands (agricultural and non-agricultural managed lands) within the Rosslyn Village Subdivision Well Supply Wellhead Protection Areas. The map shows areas with less than 40 percent and areas between 40 and 80 percent managed lands, occurring in areas with a vulnerability score greater than four (4).

Assessment Report Map # 7C – Livestock Density – Wellhead Protection Areas
Map Binder - Map Sleeve # 7C

This map illustrates the livestock density within the Rosslyn Village Subdivision Well Supply Wellhead Protection Areas. Livestock density is a measurement of the number of livestock expressed as Nutrient Units (NU) per unit area (acres) of managed lands. The main types of livestock identified within the managed land surrounding the Rosslyn Village Subdivision Well Supply Wellhead Protection Areas were horses and cattle.

Assessment Report Map # 7D – Managed Lands – Significant Groundwater Recharge Areas
Map Binder - Map Sleeve # 7D

This map illustrates the agricultural and non-agricultural managed lands within Significant Groundwater Recharge Areas. Within the Lakehead Source Protection Area, all Significant Groundwater Recharge Areas have a vulnerability score of six (6), therefore all managed lands within Significant Groundwater Recharge Areas have been illustrated on the map.

Assessment Report Map # 7E – Managed Lands Percentage – Significant Groundwater Recharge Areas
Map Binder - Map Sleeve # 7E

This map illustrates percentage of managed lands (agricultural and non-agricultural managed lands) within Significant Groundwater Recharge Areas. The map shows areas with less than 40 percent and areas between 40 and 80 percent managed lands, occurring in areas with a vulnerability score of six (6).

Assessment Report Map # 7F – Livestock Density – Significant Groundwater Recharge Areas
Map Binder - Map Sleeve # 7F

This map illustrates the livestock density within Significant Groundwater Recharge Areas. Livestock density is a measurement of the number of livestock expressed as Nutrient Units (NU) per unit area (acres) of managed lands. There is a variety of livestock identified within the managed land surrounding the Significant Groundwater Recharge Areas.

Assessment Report Map # 7G – Managed Lands – Highly Vulnerable Aquifers
Map Binder - Map Sleeve # 7G

This map illustrates the agricultural and non-agricultural managed lands within Highly Vulnerable Aquifers. Within the Lakehead Source Protection Area, all Highly Vulnerable Aquifers have a vulnerability score of six (6), therefore all managed lands within Highly Vulnerable Aquifers have been illustrated on the map.

Assessment Report Map # 7H – Managed Lands Percentage – Highly Vulnerable Aquifers
Map Binder - Map Sleeve # 7H

This map illustrates percentage of managed lands (agricultural and non-agricultural managed lands) within Highly Vulnerable Aquifers. The map shows areas with less than 40 percent and areas between 40 and 80 percent managed lands, occurring in areas with a vulnerability score of six (6).

Assessment Report Map # 7I – Livestock Density – Highly Vulnerable Aquifers
Map Binder - Map Sleeve # 7I

This map illustrates the livestock density within Highly Vulnerable Aquifers. Livestock density is a measurement of the number of livestock expressed as Nutrient Units (NU) per unit area (acres) of managed lands. There is a variety of livestock identified within the managed land surrounding the Highly Vulnerable Aquifers.

2.8 Impervious Surfaces

Impervious surfaces, for the purposes of Source Protection Planning, are those impermeable surfaces where the potential for road salt to be applied exists. Examples of impervious surfaces are roadways, parking lots, paved areas, etc. Road salt is considered a threat to drinking water sources. In order to determine if there is a probability that road salt could pose either a low, moderate or significant threat to drinking water sources, a determination of the area of an impervious surface where road salt potentially can be applied must be made. The Lakehead Source Protection Committee determined the impervious surfaces for each of the Municipal Residential Drinking Water Systems by overlaying a one kilometre by one kilometre grid over the vulnerable area, with a node of the grid centred on the centroid of the Source Protection Area and then calculating the percentage of impervious surface area where the vulnerability scores for that area is less than the vulnerability score necessary for the application of road salt to be considered a significant, moderate or low threat in the "Table of Drinking Water Threats". The impervious surface areas were delineated using 20 centimetre resolution ortho-photography for both the Wellhead Protection Areas and the Intake Protection Zones. This was deemed a very accurate and reliable method for determining impervious surfaces within these areas.

For determination of impervious surfaces within Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas several assumptions were made:

1. Any provincially numbered highway has four lanes within the Thunder Bay city limits and two lanes once outside the city limits.
2. A lane of a roadway is 3.5 meters wide.
3. The City of Thunder Bay did not have available data on private parking lots within the city. Digitization of all impervious parking lot areas in Thunder Bay was not undertaken

at this time. These areas will not be included in the calculation of impervious areas for Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas.

Impervious surfaces for these areas were determined in a GIS environment by identifying road and highway centrelines and applying the above assumptions. This is believed to be the most accurate determination of the percentage impervious surfaces given the information available to the Lakehead Source Protection Committee.

The application of road salt is the land-use activity associated with impervious surfaces within vulnerable areas. The main perceived threat from impervious surfaces is chemical contamination from road salt being transported by precipitation runoff and snowmelt.

The Directors Technical Rules," Clean Water Act, 2006" requires that impervious surfaces be shown by percentage of impervious surface per square kilometre for areas where the vulnerability scoring could result in chemical contamination from storm water. Areas with a higher percentage of impervious surfaces have a greater likelihood that storm water will contain chemicals from road salt that will result in a drinking water threat.

Assessment Report Map #8A – Total Impervious Surface Area Map – Wellhead Protection Areas
Map Binder – Map Sleeve #8A

This map illustrates the percentage of impervious surfaces located in the Rosslyn Village Subdivision Wellhead Protection Areas where the vulnerability score for that area is high enough that the application of road salt could or would be considered a significant, moderate or low threat in the Table of Drinking Water Threats. The impervious surface areas were delineated using the 20 centimetre resolution ortho-photography. The percentage statistics are reported for each square of a one kilometre by one kilometre square grid placed over the Wellhead Protection Areas.

Assessment Report Map #8B – Total Impervious Surface Area Map – Intake Protection Zones
Map Binder – Map Sleeve #8B

This map illustrates the percentage of impervious surfaces located in the Intake Protection Zones for the Thunder Bay (Bare Point Road) Water Treatment Plant, where the vulnerability score for that area is high enough that the application of road salt could or would be considered a significant, moderate or low threat in the Table of Drinking Water Threats. The impervious surface areas were delineated using the 20 centimetre resolution ortho-photography. The percentage statistics are reported for each square of a one kilometre by one kilometre square grid placed over the Intake Protection Zones.

Assessment Report Map #8C – Total Impervious Surface Area Map – Significant Groundwater Recharge Areas
Map Binder – Map Sleeve #8C

This map illustrates the percentage of impervious surfaces located in Significant Groundwater Recharge Areas, where the vulnerability score for that area is high enough that the application of road salt could or would be considered a significant, moderate or low threat in the Table of Drinking Water Threats. The impervious surface areas were determined within Significant Groundwater Recharge Areas by using the Land Information Ontario Warehouse, Geographic Information System, roads data layer. The road centerlines as depicted in the roads layer were buffered with the average paved road width for the area to create a total surface area of impervious surfaces. The percentage statistics are reported for each square of a one kilometre by one kilometre square grid placed over the Significant Groundwater Recharge Areas.

Assessment Report Map #8D – Total Impervious Surface Area Map – Highly Vulnerable Aquifers
Map Binder – Map Sleeve #8D

This map illustrates the percentage of impervious surfaces located in Highly Vulnerable Aquifers where the vulnerability score for that area is high enough that the application of road salt could or would be considered a significant, moderate or low threat in the Table of Drinking Water Threats. The impervious surface areas were determined for Highly Vulnerable Aquifers by using the Land Information Ontario Warehouse, Geographic Information System, roads data layer. The road centerlines as depicted in the roads layer were buffered with the average paved road width for the area to create a total surface area of impervious surfaces. The percentage statistics are reported for each square of a one kilometre by one kilometre square grid placed over the Highly Vulnerable Aquifers.

3.0 Water Budget

The water budget chapter explains where water supply (quantity of water) and demand (uses of water) are within the watershed and provides an understanding of the pathways that water takes as it moves through a watershed. In order to determine this, a scientific analysis measures and determines the measurement of how much precipitation (rain and snow), runoff, evaporation and transpiration occurs within the watershed. The cycle of all of the contributions and demands on the water within the watershed form the hydrologic cycle. From 2006 to 2008, a consultant was hired by the Lakehead Region Conservation Authority to conduct a technical study and scientific analysis of a water budget and water quantity stress assessment. As draft work was completed on this technical study, a team of peer reviewers (local experts, Lakehead Region Conservation Authority staff and Ontario Ministry of Natural Resources staff) reviewed draft findings and provided technical expertise throughout the technical study. Prior to submission to the Lakehead Source Protection Committee, the report entitled "Lakehead Source Protection Area – Water Budget and Water Quantity Stress Assessment for the Consideration of the Lakehead Source Protection Committee" was reviewed by the peer review team and all agreed that the report met the technical requirements as outlined in the Ministry of Environment guidance document entitled "Assessment Report: Draft Guidance Module 7 Water Budget and Water Quantity Risk Assessment, March 30, 2007".

Water in a river/stream is the result of precipitation that has fallen on the watershed over time. Water resulting from precipitation gains entry to a creek following three main paths: by directly falling on a creek surface, by running over the land surface to streams/water bodies (surface runoff), or by infiltrating into the ground and later reappearing as groundwater discharge (springs or seeps) along the streams.

It is important to note that not all of the precipitation that falls on the watershed makes its way to the water system. A portion of the precipitation that falls to the ground returns to the atmosphere by evaporation from open water surfaces, including sublimation in the winter from snow covered surfaces, or is transferred by plants as transpiration. The other portion of this water infiltrates into the ground and may leave the watershed by discharge to streams/rivers or is used by plants (and other activities) in an adjacent watershed. The path that water follows in a watershed will determine to a great extent how the watershed responds to the water budget.

3.1 Conceptual Water Budget

A conceptual water budget analysis is used to provide an understanding and accounting of the movement and uses of water over time on, through and below the surface of the earth. In the Lakehead Source Protection Area, there are 21 watersheds (whole and partial) that drain into Lake Superior. Each subwatershed is analyzed in a similar fashion, addressing some or all of the following four main questions:

1. Where are the surface water and groundwater storages located?
2. How does the water move between those storages? What are the pathways through which the water travels?
3. What and where are the stresses on the water? Where are the takings and assimilative needs?

4. What are the trends, for example are water levels declining, increasing or remaining constant over time?

The water budget developed in each watershed accommodates some or all of the following considerations:

a) The amount of water within the various storage stages of the hydrologic cycle, including: precipitation; evapotranspiration; groundwater inflow and outflow; surface water inflow and outflow; change in storage; water withdrawals and returns.
b) A description of groundwater and surface water flow pathways and temporal (seasonal and annual) changes in water quantities within each storage stage of the hydrologic cycle.
c) Identification of Areas of key hydrologic processes (recharge and discharge areas) and availability of potential water sources (aquifers and unused surface water sources).
d) Support for predicted changes in the hydrologic cycle due to trends in climate, land use and additional takings.

The study of the water budget for the Lakehead Source Protection Area was undertaken for the following purposes and the information will be used for future watershed planning activities:

a) To provide an understanding and account of the movement of water on, through and below the surface of the earth and the effects of the uses of water over time.
b) To set quantitative hydrological targets (water allocation, recharge rates, etc.) within the context of subwatershed plans.
c) As a decision-making tool to evaluate, relative to established targets, the implications of existing and proposed land and water uses within (sub) watersheds.
d) To evaluate the cumulative effects of land and water uses within (sub) watersheds.
e) To provide a (sub) watershed-scale framework within which site-scale studies (hydrological evaluations, sewage treatment plans, water supply plans) can be undertaken.
f) To help make informed decisions regarding the design of environmental monitoring programs.
g) To assist in setting targets for water conservation.
h) To assist in establishing long-term water supply plans.
i) To identify data and knowledge gaps and to investigate climate change scenarios.

The hydrologic cycle is the cycle of water movement through the earth-ecologic-atmosphere system. Water vapour accumulates in the atmosphere by evaporation from surface water and transpiration from plants, forming clouds. When it condenses, it falls to the land surface as precipitation (rain and snow) and can be stored at the surface in lakes, ponds and marshes, etc. or at the subsurface as groundwater. From there it is evaporated (from the surface) or transpired (from the shallow subsurface or plants) to the atmosphere and repeats the cycle.

The hydrologic cycle begins with precipitation falling on the ground. The amount and rate of precipitation that actually arrives at the ground surface is controlled by the prevailing weather system that generated the precipitation on a regional scale. At the more localized scale, topography and land cover influence the actual precipitation amounts arriving at the ground surface.

This water (as rain or snowmelt) can have three pathways. It either runs off across the ground surface directly to a surface watercourse, infiltrates into the ground to recharge groundwater storage, or goes back to the atmosphere by evaporation, sublimation of snow or plant transpiration. The term "evapotranspiration" is used to couple the processes of evaporation, sublimation and transpiration (plant uptake) and is used throughout the report from this point forward. Losses due to transpiration include the temporary storage of the water as it moves through the plant body and then subsequently is released into the air.

The amount of water that actually infiltrates the ground surface is controlled by the rate of precipitation input (rainfall or snowmelt), soil type (clay, silt, sand or gravel), ground surface conditions (slope, frozen, cracking, etc.) and vegetative cover (pasture, forests, etc). In some areas, the surface topography has created large depressions, which require several metres of water to pond before overland flow occurs. Consequently, water in these depressions either infiltrates downward and contributes to groundwater and subsurface storage, or evaporates back to the atmosphere. The recharge to the groundwater system creates a groundwater pressure that causes it to flow slowly through the ground. In the Lakehead Source Protection Area, these pathways are localized and groundwater discharges over short distances back into the watercourses as baseflow. The travel time of groundwater flow is governed by the porosity and permeability of the soil or rock, the driving head or groundwater pressure and the geometry of the pathways.

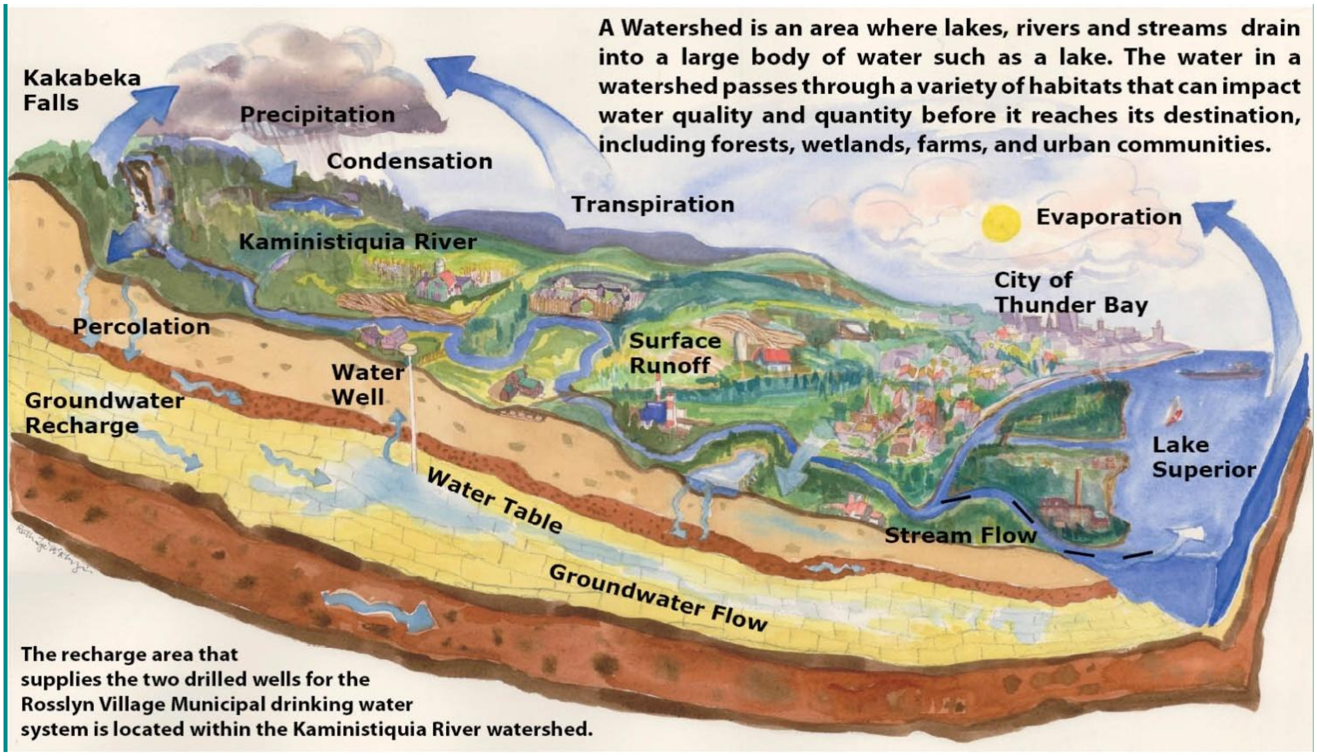
The level of water budgeting required in any specific watershed will depend on a number of factors, in particular water-taking (uses) or water-quantity stresses (over usage), or both. The objective of a water budget analysis is to provide a scientifically and technically sound basis for managing the quantity of existing and future sources of drinking water.

Surface runoff collects in stream channels that lead to larger channels or discharge to ponds, wetlands or lakes. While in these ponds or lakes, part of this water returns to the atmosphere by evaporation. It may also infiltrate into the ground or travel to downstream channels. The travel time of flow in these stream channels is governed by the length, slope, roughness and cross-sectional shape of these channels. If the flow is high and fast enough, water may overtop the channel banks, flooding the adjacent land area and subjecting it to further evaporation or infiltration.

Evapotranspiration is a function of multiple factors including temperature, wind, humidity and radiation. Potential evapotranspiration (PET) is the amount of water that could be evaporated and transpired if there was sufficient water available. Potential evapotranspiration can be measured indirectly from other climatic factors, but it also depends on the surface type, such as free water (for lakes and oceans), the soil type for bare soil and the species of vegetation.

Actual evapotranspiration (AET) is the actual amount of water evaporated to the atmosphere by evaporation and transpiration. In wet months, when precipitation exceeds potential evapotranspiration, actual evapotranspiration is equal to potential evapotranspiration. In dry months, when potential evapotranspiration exceeds precipitation, actual evapotranspiration is equal to precipitation plus the absolute value of the change in soil moisture storage (in these cases AET < PET). Due to the fact that seasonal vegetation and deciduous trees do not transpire and coniferous trees are dormant during the winter months (November through March) in the Lakehead Source Protection Area, noticeable evapotranspiration does not occur. Figure 3 provides an illustration of the conceptual representation of the hydrologic cycle as described in the previous text.

Figure 3: Conceptual Representation of the Hydrologic Cycle in a Portion of the Lakehead Source Protection Area



3.1.1 Physiography

Assessment Report Map #9 – Physiography
Map Binder - Map Sleeve # 9

This map illustrates the physiography of the Lakehead Source Protection Area. The data source for this map was Northern Ontario Engineering Geology Terrain Study (NOEGTS) surficial geology, point and line features. Standard NOEGTS symbology was used for this map. As this map is projected at the 1:250,000 scale, it lacks definitive and identifying details, so the characteristics of significant points of interest related to physiography are detailed in the text of the Assessment Report.

About one to two million years ago, the Lakehead Source Protection Area was covered by large mountains formed by ancient volcanoes, then the glacial period began in which gigantic glaciers spread across the Lake Superior region. The glaciers generally advanced in a southwesterly direction, stripping the bedrock of its former layers. The results were remainders of bedrock, as seen today, with varying grooved, scratched, smoothed, polished and in some areas, severely abraded surfaces. River valleys that run parallel to the direction of ice movement were gouged and deepened by the moving ice.

The last glacial period in the Lakehead Source Protection Area occurred approximately 10,000 to 12,000 years ago. As part of a much larger ice front that completely enveloped Canada, the Patrician Ice Mass moved into the area from a north and northwesterly direction. As the ice mass advanced and subsequently retreated it formed most of the land features which comprise the current landscape.

The Lakehead Source Protection Area is located within the James Bay Region of the Precambrian Shield. Within the James Bay Region, the two physiographic subdivisions, the Severn Upland and Port Arthur Hills, cover the Lakehead Source Protection Area. The Severn Upland has a vast, broadly rolling surface of crystalline Archean rocks that occupies most of northwestern Ontario. The southernmost boundary of the Severn Upland is bound by a line of Archean rock that runs from Whitefish Lake southwest of Thunder Bay, through Kakabeka Falls, Hazelwood Lake and eventually to the Black Sturgeon River northwest of Nipigon, past the eastern boundary of the Lakehead Source Protection Area. The northern part of the Lakehead Source Protection Area, within the Severn Upland, is dominated by the rolling surface of the Precambrian bedrock that is either exposed at the surface or covered with shallow overburden. The Port Arthur Hills, dominated by the Nor'Wester Mountains and Mount McKay, cover the southern portion of the Lakehead Source Protection Area. The western boundary of this area meets up with the eastern boundary of the Severn Upland, then extends to the eastern edge of the City of Thunder Bay, subparallel to the shore of Lake Superior. The Port Arthur Hills consist of Proterzoic sills and underlying metasediments.

When the ice melted towards the conclusion of Pleistocene time, the loose debris or morainal material consisting largely of a mixture of boulders, sand and clay, which had been picked up by the advancing ice sheet, was dumped haphazardly as glacial till. Unstratified end and ground moraines, drumlins and ablation tills mixed with glacial till occur throughout the Lakehead Source Protection Area. Stratified glacial deposits are also frequently encountered as proglacial outwash, glaciofluvial, glaciolacustrine and glaciomarine deposits. The City of Thunder Bay is located predominantly in an area dominated by the surficial material associated with the Kaministiquia River valley, immediately east of the Nor'Wester Mountains. Moraines mark significant ice margin positions in the glaciation history of the Lakehead Source Protection Area and form an arc across this area. Much of the Lakehead Source Protection Area is underlain by a mantle of ground moraine consisting of a non-stratified sediment silty-sandy till occurring at variable depths. The following are major moraines located in the Lakehead Source Protection Area.

<u>End Moraines</u>

Brule Creek Moraine

The Brule Creek Moraine represents a still-stand of the whole Patrician Ice Mass. The terminus of this moraine, which extends 300 kilometres to the northwest, is evident in the Lakehead Source Protection Area. It is flanked on the north by the Townships of Adrian and Sackville and to the south by the Townships of Aldine and Marks. Only the eastern portion of the Brule Creek

Moraine falls within the Lakehead Source Protection Area. This landform was modified by lake action and consists of shallow, bouldery sand material interspersed with bedrock outcrops.

Marks Moraine

Marks Moraine consists of silt and clay till, and was established by the westerly readvance of the Superior Ice Lobe at the same time as the Dog Lake Moraine. This moraine forms a disjointed arc commencing in Strange and Lybster Townships through Marks Township and then north easterly across Conmee, Ware and Gorham Townships and a portion of the City of Thunder Bay north of Dawson Road. It ranges from approximately 1.5 to five kilometres in width. The Marks Moraine and Dog Lake Moraine mark the extremities of temporary readvances by individual lobes of the Patrician Ice Mass.

Dog Lake Moraine

The Dog Lake Moraine was established by a readvance of the Dog Lake Ice Lobe from the northeast following the late-Wisconsinan glaciation. This moraine consists of a stony loam till with occasional boulders. The Dog Lake Moraine extends in a northwest southeast direction between the south shores of Dog Lake and Hazelwood Lake, crossing Fowler Township and portions of Gorham Township. The Dog Lake Moraine extends to the southeast until it intersects the MacKenzie and Marks Moraines at the present location of the Current River.

Interlobate Moraines

MacKenzie Moraine

The MacKenzie Interlobate Moraine was also formed between the Superior and Dog Lake ice lobes when the glacial Lake Kaministiquia was dammed in the angle of the Superior and Dog Lake Ice Lobes. The MacKenzie Moraine is an interlobate feature which trends easterly from the point where the Dog Lake and Marks Moraines merge. It crosses the south-central portion of the Township of Gorham and extends across the Geographic Township of MacGregor, and portions of the Geographic Township of McTavish, within the Municipality of Shuniah.

Intola Moraine

The Intola Moraine is an interlobate moraine with features that are consistent with ice stagnation conditions. This is a phenomenon from glacial times that is rarely recorded. The moraine is approximately 12 kilometres in length. Part of the moraine is designated as an Area of Natural and Scientific Interest (ANSI).

Besides moraines, glaciofluvial and glaciolacustrine deposits are evident as a result of glaciation. Glaciation brought about complete disorganization of the pre-existing drainage system and formed an intricate pattern of innumerable lakes. As the water levels of Lake Superior lowered, old shorelines became abandoned, more recent lake deposits became exposed at the surface and new shorelines were established. This produced a succession of terraces and abandoned beaches that were separated by abrupt escarpments or shore cliffs caused by the wave erosion. Glaciofluvial deposits, which include eskers, kames and out-wash deposits, were formed by large volumes of meltwater that emanated from and within the glacier. The glaciolacustrine deposits creating deltas and beaches were formed in conjunction with the large glacial lakes that later inundated most of the western Lakehead Source Protection Area. Typically, glaciofluvial and glaciolacustrine deposits contain valuable sand and gravel aggregate resources. Modern alluvial deposits, with a composition controlled by the underlying glacial material, are found in the local streambeds throughout the Lakehead Source Protection Area.

Eskers

Within the Lakehead Source Protection Area most eskers are short, rarely exceeding three to four kilometres in length. Notable esker deposits occur in the Townships of Strange, Fraleigh, Aldine, Adrian, Jacques and Geographic Townships of McIntyre, MacGregor and McTavish.

Kames

Kames (steep-sided hills of stratified glacial force) are widely distributed throughout the Lakehead Source Protection Area, but most are found in association with the end and interlobate moraines. A large kame complex occurs near the confluence of the Kaministiquia and Shebandowan Rivers.

Outwash Deposits

There are numerous outwash deposits (layers of gravel, sand and fine sediments deposited by glacial meltwater) found in association with the end and interlobate moraines within the Lakehead Source Protection Area.

Deltas

Deltas are common in the Townships of Fowler, Ware, Jacques, Gorham, Hartington, Devon and Dorion, Geographic Township of MacGregor, City of Thunder Bay and Municipality of Neebing. Deltas are associated with major watercourses most notably the Kaministiquia River delta.

Beaches

Within the Lakehead Source Protection Area, the most significant beach deposits are found in the Township of Devon, Geographic Township of McGregor, City of Thunder Bay and Municipality of Neebing.

Physiography of the Lake Superior Shoreline

Areas of dike lands, mesa lands, and cuesta lands extend from Pigeon River to the Kaministiquia River. Dike lands are characterized by resistant diabase dikes which form steep edges rising out of Lake Superior and by physiographic features such as Middle Falls, High Falls, Pigeon River Gorge and Mount Mollie Dykes. Mesas comprise the Nor'Wester Mountain range south of the City of Thunder Bay. Cuesta lands are typified by steep high cliffs with talus slopes.

The landscape between Loon Lake and Whitefish Lake is dominated by cuestas, mesas, and buttes resulting from the weathering and erosion of the flat-lying to gently dipping Animikie sediments and the diabase sheets that intrude them. Pie Island and the southwest trending Nor'Wester Mountain range are the highest of these mesas which are capped by diabase sills such as Mount McKay, which is the most northerly.

To the north of Mount McKay and the similar mesas and cuesta to the west, a broad, flat plain largely covered by drift extends northward to contact the granites and schists of the Archean period. These rise at a low angle from below the unconformity that separates them from Animikie to form the rugged topography of generally low elevation (274 – 427 metres above sea level) typical of most of northern Ontario.

At the base of the Nor'Wester Mountains, the land surface rises away from Lake Superior. Bluffs and steep palisades punctuate the topography along the shore of Lake Superior north of the City of Thunder Bay. The higher levels of ancient lakes have accentuated the protrusion of Precambrian sills and have cut shore cliffs in the metasediments.

The relatively flat plain lying to the west of the City of Thunder Bay is occupied by the valley, floodplain and delta of the Kaministiquia, Neebing and McIntyre Rivers. Between the river valleys, the landbase is covered by a thin layer of glacial drift, mostly boulder clay, swamp deposits and varved clays. Varved clays are exposed in the City of Thunder Bay on the Current River above the Lyon Boulevard Bridge and around the northeast end of the City of Thunder Bay. Like the lower reaches of the Kaministiquia River, the Whitefish River below Nolalu is entirely deposited drift which consists largely of stratified gravel and sand.

3.1.1.1 Topography

Assessment Report Map #10 - Topography
Map Binder - Map Sleeve # 10

> This map illustrates the topography of the Lakehead Source Protection Area. Note that the areas in the urban settled areas of the watershed, are areas with the lowest elevation while some areas farther from the shoreline of Lake Superior have elevations above 600 metres.

Glacial landform patterns are distinct and widespread because of the complex events that occurred during early post-glacial periods. The landscape of northwestern Ontario can be generally described as undulating, non-fractured bedrock dominant terrain, with the exception of the solidly broken topography along the Lake Superior coast and areas of stratified glacial deposits. Most of the landform features were created or modified by glacial movement or action. Organic deposits are usually occupying poorly drained bedrock depressions and lower landscape positions. The topography of the Lakehead Source Protection Area is extremely variable as a result of considerable glacial activity, post-glacial meltwater lake levels and river outwash activity.

The western portion of the Lakehead Source Protection Area is characterized by moderate to severely broken ground moraine with numerous occurrences of bedrock ridges and knobs. Precipitous ridges and mountainous terrain follow along the southern edge of the Lakehead Source Protection Area adjacent to the LaVerendrye Waterway and International border. This area within the Lakehead Source Protection Area, with the exception of the river plains, was relatively unaffected by post-glacial meltwater activity.

The lower central and south-central portions of the Lakehead Source Protection Area have predominantly flat to gently rolling topography. The areas of exception to this generalization are the Nor'Wester Mountains on the western shore of Lake Superior and the occasional mountainous features on the landscape. This is a result of post-glacial lake and river outwash activity in the Slate River and Kaministiquia River valleys.

The central portions of the Lakehead Source Protection Area are characterized by strongly broken hills and ridges composed of morainal material. The Marks and MacKenzie moraines form a series of highlands from Aldina Township to the Geographic Township of MacGregor. These highlands range in elevation from 366 to 488 metres above sea level with extremes of 640 metres above sea level in Aldina Township and Mount Baldy in the Municipality of Shuniah, which measures 566 metres above sea level. Benches and terraces containing water-worked sands, gravels and silty-clay deposits rise from Lake Superior to these highlands as a result of post-glacial lake levels. The northern reaches of the Lakehead Source Protection Area are of similar topography with the highest points reaching only 590 metres above sea level. Watercourses in the northern portion of the Lakehead Source Protection Area appear to reflect some of the major structural features in the underlying bedrock terrain and drain toward Lake Superior. All sub-watersheds within the Lakehead Source Protection Area drain southward, draining areas within both the bedrock dominated northern portion and the lowlands adjacent to Lake Superior.

The topography in the eastern portions of the Lakehead Source Protection Area is the most variable, especially in the Township of Dorion. The landscape is typified by the terrace-type formations extending north from Lake Superior to mountainous, steep-cliffed rock formations, bisected by river valleys and outwash plains, such as the Wolf River. This area is known for its gorges and canyons such as Ouimet Canyon, Cavern Lake Canyon and Cavern Lake Gorge.

3.1.2 Geology

Assessment Report Map #11 - Geology
Map Binder - Map Sleeve # 11

This map illustrates the geological characteristics of the Lakehead Source Protection Area. The map was constructed using information from the Ministry of Northern Development and Mines, Northern Ontario Engineering Geology Terrain Studies (NOEGTS) data. As this data was mapped at a scale of 1:1,000,000, it lacks definitive and identifying details, so the characteristics of significant points of interest related to physiography are detailed in the text of the Assessment Report. Northern Ontario Engineering Geology Terrain Studies maps were produced in the late 1970's and early 1980's by the Ontario Geological Survey to provide evaluations of near-surface geological conditions with the intent of determining the engineering capability of the terrain.

Assessment Report Map #11A– Quaternary Geology
Map Binder – Map Sleeve # 11A

This map illustrates quaternary geology formations for the study area of the original 2005 "The Lakehead Region Conservation Authority Thunder Bay Area Aquifer Characterization Groundwater Management and Protection Study", final report. It is a compilation of the quaternary geology data with the NOEGTS (Northern Ontario Engineering Geology Terrain Study) data that has been reclassified to match the quaternary geology classification as close as possible.

3.1.2.1 Bedrock Geology

Approximately 20,000 years ago the Laurentide Ice Sheet, of the Wisconsinan Glacial Advance, covered almost all of Canada. At its maximum, it is estimated that the Laurentide reached thicknesses of four thousand metres, but has been estimated to have only reached approximately 1,600 metres thick over parts of central Canada. The weight of the ice sheet compressed the land surface creating depressions. During deglaciation, the ice sheet retreated and the weight and pressure was relieved from the land surface, resulting in an isostatic adjustment (swelling) of the land. This rebound process continues today and to date there is an estimate of total rebound of one hundred metres near the northwestern Lake Superior shoreline.

The Lakehead Source Protection Area is underlain by ancient Precambrian rocks of the Canadian Shield, also referred to as the Southern Province. The rock formations of the Southern Province include the relatively flat lying Middle Precambrian, Kakabeka, Gunflint and Rove formations of the Animikie series plus the late Precambrian Sibley and Olser Series. Early Precambrian rocks exhibit radiometric ages of approximately 2.6 billion years and are represented by three east-west trend belts: Shebandowan Belt, a volcanic-plutonic complex; Quetico Belt, a sedimentary-plutonic complex; and Wabigoon Belt, a volcanic-plutonic complex. During the early Precambrian (Archean) time, the earth's crust was subjected to several periods of fracturing, mountain-building, volcanism and erosion. Greenstone belts were formed at this time and are separated by large expanses of banded gneiss and granitic rocks. Greenstone belts are zones of metamorphic, complexly folded volcanic or sedimentary rocks.

The Shebandowan and Wabigoon belts of greenstone are comprised of assemblages of metavolcanic and metasedimentary rocks which have been intruded by other rock of varied composition. Within these belts with metavolcanic rocks, base and precious metals like nickel, copper, platinum and palladium are found. The Quetico Belt is made up of metasedimentary rocks like gneiss and migmatite as well as granitic rocks of both magmatic and metamorphic origin.

The oldest rocks in the Lakehead Source Protection Area are Pre-Algoman volcanic and sedimentary rocks, which have been intruded by Algoman igneous rocks. Sedimentation and volcanism during the middle to late Precambrian (Proterozoic) times deposited thick sequences of relatively flat-lying sedimentary and volcanic rocks. The Animikie and Sibley Groups are middle Precambrian rocks, resting upon early Precambrian rocks which are primarily found in the south and southeastern portion of the Lakehead Source Protection Area. Middle and late Precambrian rocks have silver deposits and amethyst veins (Silver Mountain and Rabbit Mountain) and potential for uranium and base metals.

The Animikie Group contains Gunflint Formations and Rove Formations. Gunflint Formations are made up of taconite, algalchert, chert-carbonate, sandstone, shale, minor limestone, carbonates, conglomerates (shales) and small amounts of volcanic rock. Taconite makes up a very large part of the Gunflint Formation. Although found in very large deposits to the south in Minnesota, there are still numerous smaller occurrences in the Lakehead Source Protection Area. Taconite can be distinguished from other rock by its granular texture, which is present due to the innumerable granules or tiny rounded bodies consisting largely of iron-bearing minerals, most often greenalite. Rove Formations are made up of greywackes (rounded pebbles and sand cemented together), argillite, black shale and minor volcanic rocks. Typically, Rove Formations contain lower concentrations of iron and taconite than Gunflint Formations. In the Lakehead Source Protection Area, these rocks are overlain by a thick capping of non-permeable diabase, which averages about 60 metres thick. This formation, the eroded remnant of the sill that once extended over the entire region, is mostly located south of the Kaministiquia River. Mount McKay and Kakabeka Falls are two locations where this structure is visible to the general public.

The Sibley Group is sedimentary rock which overlies Animikie and Precambrian rocks. It is subdivided into Pass Lake, Rossport and Kama Hill Formations and underlies the extreme eastern part of the Lakehead Source Protection Area. The Pass Lake Formation comprises a discontinuous basal conglomerate and overlying sandstone that rests on Rove Formation shale. The Rossport Formation is mainly red, sand dolomite with a medial, fossiliferous chert-stromatolite unit, while the Kama Hill Formation is red to purple shale and siltstone. The Pass Lake Formation is also red in colour.

The most recent event in Proterozoic times, approximately 100 to 110 million years ago, was the Keweenawan intrusion of igneous material into the Gunflint Formation. This intrusion formed vertical diabase dikes and horizontal diabase sills. These sills and dikes are responsible for the prominent relief of the area. The dikes stick up as massive ridges trending north-easterly and the sills are formed as resistant caprocks which form the large mesa landforms, known as the Nor'Wester Mountains, of which Mount McKay is the best known. At this same time, the Great Lakes gabbro, containing nickel and copper deposits were intruded into the Rove Formation.

The oldest formations are Archean in age and consist of rocks intruded into the earth's crust. A portion of the geographic area, north of Highway 102 and west of Hilldale Road, is composed of these acid igneous and metamorphic rocks. Highly resistant granite, gneiss, quartz and feldspar rocks are the most common types found in this area and are visible in the numerous outcrops along Highway 102. Rocks of the Animikie Series compose the bedrock geology of the central portions of the Geographic Township of McIntyre (Highway 102 south to approximately John Street Road) and the majority of the north area of the City of Thunder Bay. This formation is known as the Lower Gunflint and consists primarily of metamorphic rock such as shale, schist and argillite-tuff, which are much less resistant than the igneous rock found in the more northerly areas of the Lakehead Source Protection Area.

Rocks of the Late Precambrian era are most common in the eastern portions of the Geographic Township of McIntyre, east of Hilldale Road. Large areas of intrusive igneous rocks dominate the landscape, making this area one of the most rugged. These outcrops are diabase sills and dikes, which have intruded between horizontal strata of other rock. This diabase, even though it is exposed in most areas, is highly resistant to weathering and erosion. As soils tend to be very shallow across the Lakehead Source Protection Area, outcrops of igneous and metamorphic bedrock are very common.

One of the most unusual rock outcrops in the Lakehead Source Protection Area is the area known as Hillcrest Park, located within the City of Thunder Bay. The escarpment contains outcrops of limestone which is an unusual occurrence in the Lakehead Source Protection Area. This limestone formation has an unusual and unique structure of fragmental rock, which is made up of angular and numerous small rounded pieces of chert, fused together by a matrix of coarsely crystalline iron-bearing carbonate. These fragmental rock layers are separated at close intervals by thin layers of chert, which are crudely parallel and persist for some distance. These layers will separate and rejoin in an irregular manner but do show evidence of an original sedimentary stratification. This escarpment is divided into two layers. The lower layer is an old beach left behind from the period when the Lake Superior basin was higher than the levels of today. The upper layer is made up of water-laid sand, creating the sedimentary rock layers, while the height of the escarpment was created by the wave action of the waters covering the lower terrace. The interest of this formation has attracted many geological scientists and rock hounds from throughout the world.

In various areas throughout the Lakehead Source Protection Area, there are multiple occurrences of silver-bearing quartz-calcite veins. These deposits are characterized by open cavities or vugs. The walls of these cavities are usually lined with well developed pyramidal and prismatic crystals of ordinary quartz and of the purple coloured variety of quartz, known as amethyst. The veins were often roughly tabular shaped veins with predominant occurrence of quartz, calcite and silver present as both argentite and native silver and variable amounts of other minerals such as barite, chalcopyrite, fluorite, galena, pyrite, pyrrhotite and sphalerite. Although the silver from these veins was mined until the early 1890’s, the quartz and especially the amethyst is still prized by rock hounds and tourists. Additional occurrences of these silver-bearing quartz-calcite veins occur along the shore of Lake Superior, outside the Lakehead Source Protection Area.

3.1.2.2 Surficial Geology

During the advance of the Laurentide Ice Sheet, subglacial till was deposited in the form of drumlins, drumlinoid ridges, crag and tail features and undifferentiated ground moraine, resulting in a structured topographic grain to the landscape. Approximately 20,000 years ago when the ice sheet began to recede, entrained materials within the ice melted out as ablation till. Meltwaters deposited sands and gravels within esker outwash systems and moraines. These moraines, found throughout Northwestern Ontario, are some of the most well developed and extensive interlobate, recessional and end moraine systems in North America. During the recession of the ice sheet, many temporary glacial lakes were formed. The finer-textured silts and clays suspended in the ice sheet were deposited into these lakes. Periodic readvances of local ice formations often accompanied the recession of the larger ice sheet. The combination of readvances and recession mixed and redirected former depositions and waterways, resulting in a complicated deposition of materials throughout northwestern Ontario. Other landform features not associated with glacial action that exist within the Lakehead Source Protection Area include organic accumulations, colluvial, aeolian and alluvial deposits.

Surficial deposits within the Lakehead Source Protection Area were deposited in the Late Wisconsin Age, by the retreating ice margin around 12,500 years ago. A readvance around

11,500 years ago by the Superior Lobe incorporated some lacustrine sediments that were deposited between the glacial advancements into subsequent till units. Due to the large occurrence of bedrock, many of the surficial deposits are relatively thin throughout the Lakehead Source Protection Area and are usually less than 14 metres thick, although there is some local variance in depth. In the area north of the Kaministiquia River, all watercourses contain bedrock cuts and are indicative of thin soil cover. There is some occurrence of moderately thick outwash gravels that can reach a thickness of up to 12 metres, but depths of 3 to 5 metres are more commonly found in the northern part of the Lakehead Source Protection Area. The maximum overburden thickness in the Lakehead Source Protection Area occurs at the mouth of the Kaministiquia River within the delta area, where a mixture of glacial deposits and lacustrine sediments are up to 50 metres thick.

Overburden types vary across the Lakehead Source Protection Area. A large area of till occurs directly west of the City of Thunder Bay and north of the Kaministiquia River and contains a significant proportion of fine-grained material that is subdivided into stony sand, clay and silt tills. Fine-grained material is also located in areas of former glacial meltwater lakes which ponded behind the Superior Ice Lobe that flooded to a depth of at least 280 metres above sea level. Earlier glacial retreat intervals left lacustrine deposits occurring up to elevations of 366 metres above sea level northwest of Kakabeka Falls.

The Kaministiquia River delta is a major surface feature within the Lakehead Source Protection Area. The delta extends for over 20 kilometres from the shore of Lake Superior to Kakabeka Falls and is divided into two distinct physiographic units, the deltaic upland and the lower deltaic plain. The Kaministiquia River delta is the most impressive and largest delta found along the shore of Lake Superior. The deltaic upland extends for 15 kilometres from Rosslyn to Kakabeka Falls, recording a rise in elevation from 230 metres above sea level to 260 metres above sea level. Gravel and sand form the core of the upland area with a wave-cut bluff forming the eastern face of this upland feature. The 24 kilometre long lower deltaic plain lies between the deltaic upland and Lake Superior. This is an extensive plain with a drop in surface elevation of 43 metres over its length but with no major topographic breaks in the general slope. The delta varies extensively in width from 6.5 kilometres to 21 kilometres wide. Fine-grained lacustrine deposits extend up the delta as far as Rosslyn Village. Glaciofluvial and deltaic sediments border the Kaministiquia River as far as ten kilometres from the shore of Lake Superior. These deposits are bordered on the south by the bedrock uplands of the Nor'Wester Mountains and on the north by older tills deposited by the Superior Ice Lobe. Table 10 provides a general summary of the bedrock and overburden formations found within the Lakehead Source Protection Area.

Table 10: Bedrock/Overburden of the Lakehead Source Protection Area Summary

	Description	Comments
Bedrock	Intrusive diabase sills and dikes.	Sills are cap rock to Nor'Wester Mountains and southern half of watershed.
	Archean Age: metavolcanics and metasediments.	Upper fractured and weathered portions and open structural zones may provide limited groundwater source.
	Archean granite.	Upper fractured and weathered portions and open structural zones may provide limited groundwater source.
	Animikie Group sediments (Rove and Gunflint Formations).	Upper fractured and weathered portions and open structural zones may provide limited groundwater source.
	Sibley Group sediments.	Upper fractured and weathered portions and open structural zones may provide limited groundwater source.
Overburden	Till and Dog Lake, MacKenzie, Intola, Brule Creek Moraines.	Groundwater sources possible in morainal material.
	Ground moraine.	Groundwater sources possible in ground morainal material.
	Deltaic, lacustrine and glaciolacustrine plains, beach ridges.	Groundwater sources possible.
	Ice-contact deposits.	Groundwater sources possible in ice-contact material.
	Recent alluvium.	Mainly found along and within the streambeds.

3.1.2.3 Soil Characteristics

The parent soils of the Lakehead Source Protection Area are glacial in origin, primarily having been deposited by the waters of glacial Lake Algonquin. Deep lacustrine deposits of clays and silts occur and are significant due to their relatively high biological productivity. Sandy and gravelly materials occur in outwash and beach deposits associated with ancient lakes. Eskers and moraines occur throughout the area and are porous, nutrient poor areas with low productivity, but provide the best sources of aggregate for construction.

Although the soils in the Lakehead Source Protection Area are generally classified as shallow, the soil texture and depth varies over the watershed due to modification by post glacial lake, stream and wind action. The soils are scattered and are often shallow deposits of drift over the bedrock formations previously described. Generally most areas have sufficient soil cover to sustain tree and shrub growth, but there are many areas of completely exposed bedrock. Throughout the entire Lakehead Source Protection Area the topography, drainage and climate determines the productive capacities of the soils. The major source of sand and gravel originates from glaciofluvial and morainal deposits. There are relatively limited areas within the Lakehead

Source Protection Area where the soil deposits are of sufficient depth or extent to permit agriculture.

Soil surveys in the Lakehead Source Protection Area have produced a generalized classification of five land types; clay lands, loamy lands, gravelly and sandy plains, thin soils over bedrock and deep organic soil deposits. These land types correspond to one of five soil type classifications: laminated lacustrine clays or glacial clays; deltaic sands, silts and glacial gritty silt tills; lacustrine stratified gravel and sand; weathered bedrock; and organic soils of bogs and swamps.

Thick units within overburden material of relatively coarse-grained structure such as sand and gravel are best for hosting groundwater aquifers. Such areas include glaciolacustrine beach gravels, areas of glaciolacustrine sands and bedrock depressions filled with thicker units of overburden. Measurements show that a mantle of thin overburden typically covers the remainder of the Lakehead Source Protection Area, typically ranging from zero to ten metres with up to 50 metres of overburden at the mouth of the Kaministiquia River and 20 to 25 metres within areas of the Whitefish River and Slate River valleys. Isolated areas of thicker overburden, ranging from 15 metres to 20 metres, occur at Cloud Bay and the Jarvis River. Another area of thick overburden is located within the Township of Dorion, reaching depths of more than 30 metres over a small area. Other areas with a measurable depth of overburden occur within the bedrock valleys across the Lakehead Source Protection Area.

Within the Lakehead Source Protection Area there are extensive but typically thin deposits of outwash sand that have been reworked by the action of glacial lakes. Evidence of this reworking is visible at elevations 56 metres above the present level of Lake Superior. Additional discontinuous glaciofluvial deposits are located north of the Kaministiquia River, adjacent to the present Lake Superior shoreline, while the remainder of the Lakehead Source Protection Area contains isolated occurrences of sand and gravel deposits. The nature of the bedrock underlying an overburden aquifer can also influence the quality and quantity of the water within the aquifer. Given the variable nature of the surficial material in the Lakehead Source Protection Area and the variability of the bedrock material itself, delineation of aquifer suitability in terms of water supply potential and water quality would require site-specific hydrogeological studies.

Clay deposits are found throughout the Lakehead Source Protection Area. In general, a large expanse of clay and silt deposits are located in the area south of the City of Thunder Bay extending to the international border. Much of this area supports agricultural activities. Soils suitable for agriculture are predominantly found in the Municipality of Oliver Paipoonge, the Township of O'Connor and the northerly part of the Municipality of Neebing. The better farms are located on soils adjacent to the Kaministiquia River and its tributary, the Slate River. Within the limits of the City of Thunder Bay, soils suitable for agriculture occur in the Geographic Townships of Neebing and McIntyre.

Assessment Report Map #12 A - Agriculture Soil Composition
Map Binder - Map Sleeve # 12 A

This map illustrates soil composition for a portion of the Lakehead Source Protection Area. The dataset used to compile this map is from the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). This dataset is a summary of soil composition as determined by the Ontario Ministry of

Agriculture, Food and Rural Affairs with the intent of identifying soils potentially suitable for agriculture activities.

Assessment Report Map #12 B - Forest Soil Composition
Map Binder - Map Sleeve # 12 B

This map illustrates forest soil composition from a perspective that supports natural plant life. The soils identified on the map represent the upper layers of the soil strata which provide nutrients to plant life and trees. Ecosite classification data from Forest Resource Inventory (FRI) was used to correlate vegetative cover with the soil type that corresponds to each vegetative type.

3.1.3 Surface Water

The flow of surface water can sustain a myriad of aquatic, stream bank and wetland communities. It can periodically cause flood and erosion hazards, which may impact aquatic life when surficial soils are washed into watercourses. These occurrences are directly linked to meteorological conditions, topography, soils and land use changes, channel and carrying capacities and surface water management practices. Surface water can also recharge groundwater supplies and can be a source of recreational and aesthetic pleasure to local residents. Surface water also has the ability to carry chemicals or pollutants that are applied to the land or added via sewers or outfalls, which travel with the flow of the water potentially causing the chemicals or pollutants to spread.

The Lakehead Source Protection Area drains to Lake Superior through major tributaries, such as the Kaministiquia, Neebing, Current and McIntyre Rivers and McVicar Creek. The Kaministiquia River and its tributaries form the most significant drainage system in the Lakehead Source Protection Area. The Kaministiquia and its tributaries, the Slate and Whitefish Rivers, drain a major portion of the area west of the City of Thunder Bay. Other major water systems in the Lakehead Source Protection Area include: the Cloud, McKenzie, Pearl, Wolf, Pine, Lomond and Pigeon Rivers; and Pennock, Mosquito and Whiskeyjack Creeks.

3.1.3.1 Watersheds and Water Bodies

Water budget studies are conducted on a watershed basis. For the purpose of this report, the entire watershed within the Lakehead Source Protection Area was studied along with the 21 whole or partial quaternary watersheds (18 whole and 3 partial). As described in Chapter 2 - "Watershed Characterization", Assessment Report Map # 1 – Lakehead Source Protection Area (Map Binder – Map Sleeve #1), illustrates the locations of the quaternary watersheds, while Table 1: "List of Quaternary Watersheds and Drainage Areas within the Lakehead Source Protection Area", summarizes the tertiary and quaternary watersheds and their drainage areas within the Lakehead Source Protection Area.

A lake is a sizable water body surrounded by land and fed by rivers, springs, or local precipitation. The broad geographical distribution of lakes across Canada is primarily the result of extensive glaciation in the past. Lakes can be classified on the basis of a variety of features, including their formation and their chemical or biological condition. Ponds are smaller bodies of still water located in natural hollows or that result from the building of dams, either by humans or beavers. Ponds are found throughout the Lakehead Source Protection Area and may exist seasonally or persist from year to year. Rivers and streams are bodies of fresh, flowing water. The water runs permanently or seasonally within a natural channel into another body of water such as a lake, sea or ocean. Rivers and streams are generally more oxygenated than lakes or ponds and they tend to contain organisms that are adapted to the swiftly moving waters.

Baseflow Separation

As the Lakehead Source Protection Area 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. Baseflow is defined as that portion of the total streamflow that occurs when there is no contribution from rainfall or runoff. In addition, any precipitation that does not run off, but infiltrates into the ground and later returns to the watercourse, would be referred to as 'baseflow'. Generally, infiltrated water that returns to the stream rapidly (for example; in less than 24 hours) is referred to as "subsurface flow" and sometimes as interflow which is usually considered as part of the storm flow. In agricultural watersheds that are drained by subsurface tiles, the flow in the tiles (tile flow) is considered part of the rapid subsurface flow (or slow storm flow). Water that infiltrates deeper into the ground and returns to the stream much later, for instance, in a period of greater than two days, would be considered the "baseflow".

Therefore, baseflow comprises the accumulated subsurface or groundwater discharge to the watercourses. This is important for the natural function of the ecosystem, providing clean water and sustaining streamflow and wetlands in dry periods. In particular, it provides the cold water that allows for thermal buffering in headwater streams, sustaining fish habitat. The accumulation of baseflow throughout the watershed sustains the river system and lakes in the Lakehead Source Protection Area.

Baseflow analyses were carried out using an automated baseflow separation program as described by Arnold, et al (1995). This program uses a digital filter technique and calculates baseflow from stream flow data. This filter method has proven to be comparable to other automated techniques in its ability to reproduce the results produced from graphical separation techniques. This method calculated baseflow, on average, of over 50 percent of the stream flow. On the other hand, values of 20 to 30 percent based upon surficial geology (soils information) considerations are given in Ontario Ministry of Natural Resources (OMNR) (1984) and Singer and Cheng (2002). Using the Kaministiquia River watershed example discussed in the section above, a value of 49 percent was derived (166 millimetres/337 millimetres = 0.49). Appendix III contains a listing of known named rivers and streams (with thermal property where known) in the Lakehead Source Protection Area. Appendix IV contains a listing of known named lakes (with thermal property where known) in the Lakehead Source Protection Area.

As there are thousands of lakes (over 5,600), rivers and creeks, many of which remain unnamed, within the Lakehead Source Protection Area, detailed data is intermittent for information such as flows, water levels and thermal classifications. The Lakehead Source Protection Committee has conducted a thorough search of all known data sources in order to reduce the amount of outstanding information and has included the most detailed data available. The Lakehead Source Protection Committee made all attempts to find detailed information on the tributaries detailed above. Some of the tributaries had much less information than others, most likely due to their remote locations. The following is a summary, listed in alphabetical order, of the main rivers and creeks of the Lakehead Source Protection Area including the thermal classification where known:

Blind Creek

Blind Creek is located in the Municipality of Shuniah within the Geographic Township of McGregor. The creek is approximately seven kilometres in length and has a watershed of approximately 12 square kilometres. The physical features of the watershed include forested and wetland areas interspersed with areas of rural residential areas. *Thermal Property Classification:* Unknown.

Blende River

The Blende River is located in the Geographic Townships of McTavish and McGregor in the Municipality of Shuniah. The area of the watershed is approximately 32 square kilometres. The River originates approximately one kilometre south of Highway 11/17, flowing southward for 6.6 kilometres and drains into Lake Superior. The average gradient of the river is 19.21 metres per kilometre. Five named waterbodies provide flow into the river system: Iron, Deception, Mirror, Picture and Blende Lakes. There are an additional four currently unnamed waterbodies that flow into the Blende River. *Thermal Property Classification:* Unknown.

Brule Creek (Tributary of the Kaministiquia River)

Two large tributaries form Brule Creek, which runs through the Township of Conmee. A northern tributary drains Thunder and Gold Lakes, while the southern tributary drains Stephens Lake. Both tributaries meander through forested land composed of shallow glacial drift overlying Precambrian rock. Several muskeg areas occur along both tributaries. After the streams converge, they enter an undulating clay plain which continues for ten kilometres to the Kaministiquia River. This system drains a basin approximately 57 square kilometres in size and the creek itself is approximately 17.6 kilometres in length. Eleven percent of this watershed is developed primarily for agricultural use. *Thermal Property Classification:* Cold Water.

Cedar Creek (Tributary of the Whitefish River)

The Cedar Creek watershed is located within the Townships of O'Connor, Conmee, Marks and Adrian, covering an area of approximately 94 square kilometres. The creek originates in the Township of Adrian and flows southeast into the Whitefish River, which merges with the Kaministiquia River for an overall length of approximately 63 kilometres and a moderate average slope of 0.60 percent. The watershed consists of nine sub-catchments (subwatersheds). Located within the Cedar Falls Conservation Area, Cedar Falls has a small waterfall with a series of four steps, each approximately 60 centimetres in height. The depth of the Cedar Creek is generally shallow, ranging from ten to 80 centimetres. *Thermal Property Classification:* Cold Water.

Cloud River

Cloud River falls 164 metres in elevation from its source at Cloud Lake to Lake Superior along a meandering course of 18.4 kilometres. The Cloud River, located in the Geographic Township of Crooks in the Municipality of Neebing, drains an area of approximately 80 square kilometres. The gradient is steep in the upper reaches (within the first 1.6 kilometres), then the river valley gradually widens until a flatter lowland area is reached. Most of the watershed consists of glacial drift overlying Precambrian rock, although an area of lacustrine clay extends from Cloud Bay, north along the river valley for approximately 6.4 kilometres. A major factor affecting the ultimate flood flows on the river is the storage provided by Cloud Lake. During a storm, the lake stores runoff from the upper 20 square kilometres of the basin and dissipates the storage over a length of time. The discharge does not contribute significantly to the peak flood flow downstream and no damage has been reported from flooding in the past. Most of the watershed is forested, with little settlement. *Thermal Property Classification:* Cold Water.

Coldwater Creek

Coldwater Creek has a watershed of approximately 138 square kilometres. The creek drains directly into Black Bay on Lake Superior. The waters of this creek are often silty and are considered fertile. Coldwater Creek is known for the rainbow trout populations spawning in the fall. Deep pools along the Creek often hold rainbow and brook trout. *Thermal Property Classification:* Cold Water.

Corbett Creek (Tributary of the Kaministiquia River)

Corbett Creek originates just south of Highway 102 near Mud Lake Road. It flows from north to south and drains into the Kaministiquia River below Kakabeka Falls approximately two kilometres downstream of the Village of Stanley. The Corbett Creek watershed lies in portions of the Municipality of Oliver Paipoonge and Unorganized Township of Ware. The drainage area of Corbett Creek and its six sub-catchments totals approximately 71 square kilometres with the majority located in the Geographic Township of Oliver. Corbett Creek has a moderate slope of 0.73 percent over its approximate 29 kilometre length. The upper and lower reaches generally have steeper gradients of about 1.5 percent. No serious flooding problems are known to have occurred on Corbett Creek but minor nuisance type flooding has occurred due to beaver activity which blocks upstream culverts. The peak flow of Corbett Creek at the confluence of the Kaministiquia River was calculated to be 15.7 cubic metres per second based on the Regional Storm. *Thermal Property Classification:* Cold Water.

Current River

The main branch of the Current River originates at Current Lake northeast of Thunder Bay. The Current River passes successively through Ray, Onion and Boulevard Lakes and falls over 304.8 metres in elevation over approximately 63 kilometres from its origin to where it drains at its outlet into Lake Superior. Over thirty tributaries feed into the Current River. Two of the main tributaries are the North Current River and Ferguson Creek. The lower branch of the river drops 274.3 metres over its approximate 38 kilometre length from its headwaters to the Kingfisher Lake area to north of Boulevard Lake where it joins the main branch. There is a dam with a small power generating station located at the east end of Boulevard Lake. From here, the Current

River, for approximately the last eight hundred metres in length, cascades steeply down to Lake Superior. The total watershed area is approximately 702 square kilometres. The river valley is in bedrock and the adjacent soils are very thin and undifferentiated. The major use of the Current River is recreational. The Current River has a history of severe floods that has resulted in damage to crossings, water control structures and loss of life. Historically, extreme flood flows have occurred in mid-April to mid-May due to precipitation coincident with snow melts. The presence of a large number of lakes along the river system tends to mitigate flood peaks by providing natural storage capacity. *Thermal Property Classification:* Cold Water.

Dog River

The Dog River is located to the northwest of Dog Lake and flows southeasterly into Dog Lake. The Dog River watershed is approximately 2330 kilometres in size. The water levels of Dog Lake are regulated by the Dog Lake Dam and Silver Falls Hydro Generating Station, at the south end of the lake. The outflow from Dog Lake feeds into the Kaministiquia River. Dog Lake has no known identified water quality issues in the lake and is known to support a healthy walleye population for sport fishing. *Thermal Property Classification:* Unknown.

Kaministiquia River

The Kaministiquia River is the largest tributary draining into the western side of Lake Superior. This watershed drainage area is approximately 7800 square kilometres. The Kaministiquia River is known as one of the first rivers in the province of Ontario to be used to produce electricity. Several large lakes and rivers feed into the Kaministiquia River. From the northern portion of the watershed, the Dog River feeds south into Dog Lake and then into the Kaministiquia River. From the northwest reaches of the watershed, Kashabowie Lake flows via the Kashabowie River into the Shebandowan Lake system. The Shebandowan River flows from the Shebandowan Lake system into the Kaministiquia River upstream of Kakabeka Falls. The Matawin and Wiegant Rivers drain into the Shebandowan River upstream from its confluence with the Kaministiquia River. There are Ontario Power Generation dams at Dog, Shebandowan, Greenwater and Kashabowie Lakes and Kakabeka Falls. Tributaries of the Kaministiquia River include the Shebandowan, Whitefish and Slate Rivers and Sunshine, Mosquito, Corbett, Oliver and Brule Creeks. The Kaministiquia River splits into three channels known as the Mission, McKellar and the Kaministiquia Rivers as it enters Lake Superior.

The Kaministiquia River begins just south of Dog Lake and makes its way generally southward to Kakabeka Falls. The Whitefish River flows into the Kaministiquia River in the vicinity of the Village of Stanley (south of Kakabeka Falls), at which point the river starts to flow eastward towards the City of Thunder Bay and Lake Superior. In the region between Kakabeka Falls and Rosslyn Village, the river flows across a distinct physiographic region described as the deltaic uplands, resulting in gentle meanders. Downstream of Rosslyn Village, the river is joined by its second largest tributary, the Slate River. Physiographically, the area from Rosslyn Village to Lake Superior is known as the lower deltaic plain. Upstream from Kakabeka Falls, the Kaministiquia River lies on the Precambrian shield, draining across exposed bedrock, glacial deposits and swamps. Geological features range from bedrock knobs and ridges, moraines, glacial outwash and lacustrine, alluvial and organic deposits. Typically, the soils in this area are deep, coarse loamy or sandy. At Kakabeka Falls and immediately downstream, the river is characterized by steep shale cliffs and open floodplains with large boulders providing in-stream cover. Soils ranging in composition from rubble/gravel to sand can be found. Fragmented shale is also common in this part of the river. Near Fort William Historical Park, the Kaministiquia River forms a deep meandering oxbow loop. Due to the slow moving water in this part of the river, the substrate is silt and usually consists of sand, mud and highly saturated organic soil.

In many areas, the Kaministiquia River is contained by steep banks that range from about two metres to over 18 metres in height while other areas along the banks are considered low lying. In its lower reaches, the erosion of alluvial deposits has formed many meanders, oxbow lakes and other features commonly associated with a "mature" river. Due to the natural meandering process, erosion of the river banks is continuing. In the past, the most critical bank erosion occurred at three points along the river in the urbanized area of Vickers Heights. Remedial actions have been put in place to rehabilitate the banks in these areas. In the areas where the banks are lower, high flows are experienced during the spring and early summer, resulting in some areas of the river experiencing nuisance flooding. The area known as the Pointe de Meuron peninsula, located ten kilometres upstream from Highway 61 and the site of Fort William Historical Park, is particularly vulnerable to flooding. *Thermal Property Classification:* Cold Water.

Kashabowie River (Tributary of the Kaministiquia River)

The Kashabowie River flows from Kashabowie Lake into upper Shebandowan Lake. The river is approximately 1.7 kilometres in length. Kashabowie Lake has a coldwater thermal property classification that supports lake trout fisheries. Walleye spawning occurs in the spring at the mouth of the river below the dam on Kashabowie Lake. *Thermal Property Classification:* Cold Water.

Matawin River (Tributary of the Kaministiquia River)

The Matawin River watershed area is approximately 903 square kilometres. There are an estimated 35 small lakes within the Matawin river watershed. There is a dam on the river that was constructed in the 1930's and was reconstructed in 1969. A 15 kilometre impoundment was created in the 1930's when a dam was constructed. Fish inventories carried out in the past have resulted in verification of established populations of predominantly yellow perch with white sucker, walleye and northern pike. The Matawin River joins the Shebandowan River upstream from where the Shebandowan River joins the Kaministiquia River. *Thermal Property Classification:* Unknown.

MacKenzie River

The MacKenzie River drains a basin of approximately 368 square kilometres. Most of this watershed is forested. The MacKenzie River flows for 56 kilometres with an average gradient of 4.6 metres per kilometre. The river flows over glacial drift overlaying bedrock before discharging into Lake Superior. *Thermal Property Classification:* Cold Water.

McIntyre River

The headwaters of the McIntyre River originate at Trout Lake. The drainage area of this watershed covers approximately 392 square kilometres. The river is approximately 47.5

kilometres in length and falls approximately 320 metres in elevation as it drains directly into Lake Superior. The McIntyre River meanders from north to south and receives water from at least eight tributaries along its course. The upper reaches of the river are located in undifferentiated soils overlying bedrock and then flow through flatter sand and gravel plains in the urban area within the limits of the City of Thunder Bay. These areas can experience stream bank erosion. The river enters Lake Superior as part of the Neebing-McIntyre Floodway. *Thermal Property Classification:* Cold Water.

McVicar Creek

The 42.2 square kilometre drainage basin of McVicar Creek lies entirely within the City of Thunder Bay. The elevation of the creek drops a total of 165 metres over its approximately 16.3 kilometre course. The upper reach passes through undifferentiated soil over-lying shaley bedrock, while the lower reaches consist of stratified sands and gravels. The close proximity of bedrock and the high urban development in the City, result in runoff from urban lands flowing into the river. Occasionally areas along the creek overflow the banks during periods of record rainfall in the spring or blockages of culverts. Relatively fast velocities along the lower sections of the creek are a major factor in stream bank erosion. *Thermal Property Classification:* Cold Water.

Mosquito Creek (Tributary of the Kaministiquia River)

The Mosquito Creek watershed encompasses an area of approximately 32 square kilometres within the City of Thunder Bay. Mosquito Creek originates in the area south of Highway 61 between Loch Lomond and McQuaig Lake and flows in a northeasterly direction, joining with the Kaministiquia River approximately nine kilometers upstream from Lake Superior. The terrain of the Mosquito Creek watershed is dominated by the presence of the Nor'Wester Mountains which form the height of land along the east and south limits of the watershed. Though the Nor'Wester Mountains form a dramatic terrain feature along the boundary of the watershed, the bulk of the area of the Mosquito Creek watershed consists of a low relief, glaciolacustrine lake plain composed of silt and clay deposits. The drainage network of tributaries comprising the headwaters of Mosquito Creek generally originate within the low, flat plain basin, from mountain runoff and seepage at the base of the Nor'Wester Mountains. Runoff from snowmelt is slowed as a result of the shadowing effect of the mountain. During high rainfall events, runoff is also eased somewhat by the nature of the overburden, which is talus debris on the mountain slopes overlapped by glacial lacustrine silt and clay material at the base of the mountains. In some of the less disturbed areas, wetlands or wet areas also appear to contribute to the base flow. Despite the attenuation provided by the local topography and surficial geology and the contributions provided by wet areas, Mosquito Creek is primarily a runoff dominated system. As a result, high flow conditions are closely linked to precipitation events. Overland runoff also has a direct impact on the water quality within the creek. More importantly, with respect to aquatic resources, segments of the creek, particularly the lower streams, dry up completely or form standing pools during dry weather conditions. The intermittent nature of portions of the watercourse limits the fisheries potential of the system. Beaver dams are evident in some areas of the creek. These dams restrict the flow of water and also serve as in-stream obstructions or partial obstructions, which restrict the movement of fish. Mosquito Creek supports a warm water fishery. As the substrate is generally sediment laden, species such as white sucker, darters and various minnow species are the only fish species found in the creek. Walleye and lake sturgeon have been reported at the mouth of the creek, at the Kaministiquia River, during their spawning periods. *Thermal Property Classification:* Warm Water.

Neebing River

The Neebing River flows from north to south at the edge of the limits of the City of Thunder Bay, then continues in a west to east direction through the City and empties into the Neebing-McIntyre Floodway just prior to Lake Superior, in the Thunder Bay harbour. The drainage area of this river is calculated to be approximately 235 square kilometres. The main branch of the Neebing is 39 kilometres long with an average gradient of 0.74 percent. The Neebing River has two large tributaries, Pennock Creek (approximately 20 kilometres long) and an unnamed northwest tributary. The main channel flows through undulating till plains of stratified sands and gravel and then through flat deltaic deposits which are imperfectly drained in numerous sections and contain deep peat bogs. The river falls only 15.3 metres in elevation in the last 13 kilometres and for the last 3.25 kilometres, the Neebing River is at the same level as Lake Superior. Along much of the river's banks are mature trees, some of which have large limbs overhanging or are submerged in the river, which are prone to collect debris and ice and can cause restrictions to water flow and navigation. Erosion of the riverbanks can be problematic, as much of the river's banks are made up of silty, fine to medium sands, ranging from loose to compact conditions. In areas where the banks are less stable, slumping and undercutting has occurred.

The Neebing-McIntyre Floodway was constructed from 1980–1984 to divert flows from the Neebing River at Ford Street in the City of Thunder Bay to the Neebing-McIntyre Floodway when flows in the Neebing River exceed ten cubic meters per second. The maximum design flow downstream of the diversion structure in the unaltered Neebing River is 26.9 cubic meters per second. The lower regions of the original Neebing and McIntyre rivers were abandoned. Since completion of the Neebing-McIntyre Floodway in 1984, flood protection to the Regional Storm Event is provided in this area of the City of Thunder Bay. *Thermal Property Classification:* Unknown.

Oliver Creek (Tributary of the Kaministiquia River)

Oliver Creek is a small 16 kilometre tributary of the Kaministiquia River that originates at Oliver and Pictured Lakes and drains a watershed area of approximately 48 square kilometres. Oliver Creek leaves Pictured Lake through a narrow valley consisting of shallow, undifferentiated soil with local lacustrine deposits in shallow depressions. In the middle reaches, the creek valley broadens into a rolling plain which becomes level near the Kaministiquia River. Soil types along the course of Oliver Creek change midway along its course. Lacustrine clays are found from the mouth to the midsection, then change to deltaic sands and silts up to and along the Kaministiquia River plain. In the areas containing lacustrine clays, above average runoff conditions are prevalent. *Thermal Property Classification:* Cold Water.

Pearl River

The Pearl River watershed is located predominantly in the Geographic Township of McTavish and partially in the Geographic Township of McGregor in the Municipality of Shuniah. The watershed drainage area for this river is approximately 114 square kilometres. The river drains into Lake Superior at Black Bay. There are 25 named lakes within this watershed drainage area which include: Loon, Knobel, Wideman, Dot Pond, Bisect, Hunter's, Johnnie's, Elbow, Upper Hunter's, Bass, Luck, Grassy, Big Trout, Pike, Cannon, Sward, Mountain, Pratt, Hilma, Bare, Little Hilma, Breezy, Big Pearl, Silver and Pearl Lakes. The watershed of the Pearl River can be characterized as mostly undeveloped, but Loon and Bass Lakes have significant residential/seasonal developments. There is very little available data about the physical characteristics of the watershed. *Thermal Property Classification:* Cold Water.

Pennock Creek (Tributary of the Neebing River)

Pennock Creek is the largest tributary of the Neebing River. The creek is 12 kilometres in length and has a drainage area estimated at approximately 52 square kilometres. Pennock Creek has an average stream gradient of 5.12 meters per kilometre. The watershed of Pennock Creek originates northeast of the Village of Murillo, and is located within the Municipality of Oliver Paipoonge and the City of Thunder Bay. The creek runs predominantly from west to east through wetlands, wooded areas, as well as active and abandoned agricultural lands and empties into the Neebing River on the west side of the City of Thunder Bay. Due north of Rosslyn Village, the creek divides into two branches, however the southern branch is barely visible due to the heavy undergrowth of the surrounding riparian area. The Arthur Bog lies within the Pennock Creek watershed boundary and has 1.2 - 2.4 metres of peat overlaying lacustrine silts and clays, conditions which result in poor drainage in this area. *Thermal Property Classification:* Unknown.

Pigeon River

The Pigeon River forms part of the United States-Canada border, west of Lake Superior, between the Province of Ontario and the State of Minnesota, which is the southern border of the Lakehead Source Protection Area. The Pigeon River flows in an easterly direction for approximately 80 kilometres until it drains into Lake Superior. In pre-industrial times the river was a waterway of great importance for voyageur transportation and fur trading between western Canada and the Great Lakes. In more recent years, it was used for transporting harvested logs, for the production of lumber, downstream to Lake Superior. Below South Fowl Lake, the Pigeon River alternates between navigable waters and cascades or waterfalls. As the river nears Lake Superior, the gradient increases, creating a spectacular gorge which includes two waterfalls, High Falls (approximately 37 metres in height) and Middle Falls (approximately 6 metres in height). The watershed for this river is located on both the Canadian and American sides of the border but only the portion within Canada was considered for this water budget analysis. *Thermal Property Classification:* Cold Water.

Pine River

The Pine River has a drainage area of approximately 404 square kilometres. The river has numerous tributaries and three large lakes (Crystal, Fallingsnow and Pine Lakes) contributing to its flow. The headwaters of the main branch originate near the intersection of the Township of Gillies, Unorganized Townships of Lybster and Fraleigh and Geographic Township of Pearson, located in the Municipality of Neebing. From its origin to Lake Superior, the river drops 291 metres along its 64 kilometre course. The Pine River meanders through swampy lowlands and is often bedrock-controlled. In many places, it widens to take the form of long narrow lakes. The gradient in the upper reaches is gentle (0.15 percent) and increases slightly in the lower reaches to 0.7 percent. Shallow till over bedrock is the prevalent soil type throughout this watershed, although lacustrine clay deposits are present in the middle reaches. Since the Crystal, Fallingsnow and Pine Lakes are located at the upper end of the tributary basin, the storage capacity of these lakes has little effect on the runoff into the river. Most of the watershed is forested. *Thermal Property Classification:* Cold Water.

Pitch Creek (Tributary of the Whitefish River)

Pitch Creek is located in the Township of O'Connor and is a tributary to the Whitefish River. No additional data on this creek was discovered during the development of the Assessment Report. *Thermal Property Classification:* Cold Water.

Shebandowan River

The Shebandowan River is the only outflow source for the Shebandowan Lake system which drains a watershed area of approximately 2908 square kilometres. The Shebandowan Lakes area overlies a greenstone belt. The substrates in the upper and middle basins of the Shebandowan Lakes consist of boulder, rocks or gravel. All of the three lakes in the system are underlain by acidic rock containing over 50 percent silica. The central portion of the Shebandowan Lakes has a high local relief with elevation exceeding 35 metres within 500 metres of the shoreline. The Shebandowan River is located at the eastern end of the lower basin of Shebandowan Lake. The Shebandowan River flows predominantly easterly into the Kaministiquia River upstream of Kakabeka Falls. Both the Matawin and Wiegant Rivers flow into the Shebandowan River, prior to it meeting the Kaministiquia River. Historically, the Shebandowan Lakes and River supported lake trout, northern pike and whitefish fisheries. The Shebandowan Lakes have a thermal property classification of cold water, but the thermal property classification for the Shebandowan River was not listed in the data sources. In 1940, the basin was stocked with walleye and smallmouth bass, which have established healthy populations since that time. Yellow perch and white suckers can also be found in the lakes, rivers and streams throughout this watershed. *Thermal Property Classification:* Unknown.

Slate River (A tributary of the Kaministiquia River)

The Slate River is 50 kilometres in length with a watershed drainage area of 183 square kilometres. The Slate River has numerous tributaries, but the two main tributaries are Otter and Newton Creeks. The main branch of the Slate River begins in the Geographic Township of Scoble, within the Municipality of Neebing (close to the intersection of Highway 608 and the boundary of the Township of Gillies) and flows eastward to a level plain area (along Highway 608) where several tributaries join the main river. After this flat area, the river drops quickly before changing course and flowing north, parallel to Highway 61. From here to the Kaministiquia River, the Slate River meanders with a steady gradient through gently rolling topography. Soils within this watershed are mostly composed of lacustrine clay deposits, although undifferentiated soils are found in the southwest portion of the basin. This results in rapid runoff. Concretion deposits are common in some areas along the Slate River. The agriculture community in this area uses the Slate River as a source of water for crop irrigation. *Thermal Property Classification:* Cold Water.

Tin Pail Creek (Tributary of the Whitefish River)

Tin Pail Creek is located in the Township of O'Connor and is a tributary to the Whitefish River. No additional data on this creek was discovered during the development of the Assessment Report. *Thermal Property Classification:* Unknown.

Welch Creek

Welch Creek is located in the Geographic Townships of McTavish and McGregor in the Municipality of Shuniah. Welch Creek meets Lake Superior at Moose Bay located at the south end of Superior Shores Road in a cottage development area. Welch Creek has a watershed area of approximately 45 square kilometres. Samick's, Mutt and Jeff lakes contribute flow to Welch Creek. The majority of Welch Creek is located within a mainly forested and inaccessible area except for a few residential areas found closer to Lake Superior. The Welch Creek watershed spans across the Trans Canada Highway (Highway 11/17) and the Union Energy Natural Gas Pipeline structure. Beaver damming and small areas of erosion have been reported on Welch Creek. *Thermal Property Classification:* Unknown.

Whitefish River (Tributary of the Kaministiquia River)

The Whitefish River, a major tributary of the Kaministiquia River, drains an area of approximately 587 square kilometres. This is a complex stream system with numerous tributaries which includes: Cedar, Pitch, Tin Pail and Whitewood Creeks. The lower reaches of the river are susceptible to flash flooding due to the narrow valley and poor water retention of the clay soils in this area. The Whitefish River originates in the unorganized Township of Jean, meandering in an easterly direction through mostly forested areas before joining the Kaministiquia River. The two largest communities along the river are the villages of Nolalu and Hymers. In 1977, an extreme flood event caused property damage in both of these villages. The Whitefish River watershed includes portions of the Geographic Townships of Jean, Strange, Fraleigh, Gillies, Scoble, O'Connor, Adrian and Paipoonge. *Thermal Property Classification:* Cold Water.

Whitewood Creek

Whitewood Creek is located in the Township of O'Connor and is a tributary to the Whitefish River. No additional data on this creek was discovered during the development of the Assessment Report. *Thermal Property Classification:* Cold Water.

Wiegant River (Tributary of the Shebandowan River)

The Wiegant River watershed is approximately 70 square kilometres and is located in the Unorganized Townships of Adrian and Horne. The river flows approximately 17 kilometres in a northwest, changing to a northerly direction from the head waters of Adrian Lake before draining into the Shebandowan River. As the Wiegant River flows north, for approximately the last 7 kilometres it is parallel to the Matawin River. No additional data on this river was discovered during the development of the Assessment Report. *Thermal Property Classification:* Unknown.

Wildgoose Creek

The Wildgoose Creek watershed covers approximately 14 square kilometres and is located within the Geographic Township of McGregor, in the Municipality of Shuniah. Wildgoose Creek originates approximately two kilometres north of Highway 11/17 and flows south to southwest into Lake Superior. The overall length of the water system is approximately nine kilometres. *Thermal Property Classification:* Cold Water.

Wolf River

The Wolf River originates in Upper Wolf Lake, generally flowing in a southerly direction and draining into Lake Superior in Black Bay. The watershed area for this river is estimated to be approximately 730 square kilometres. Approximately 64 kilometres in length, the river is fed by numerous lakes and streams along its course, including Venice, Anders, Hicky, Greenwich, Furcate, Wolf, Pringle, Wolfpup and Cavern Lakes. In its upper reaches, the river tends to be very steep creating hazardous slopes and sites with active erosion. Many of the areas along the river experience erosion at bends in the river where water flow has caused undercutting, slumping and bank instability. Dense vegetation, including mature trees and shrubs, covers the river banks. The lower portion of the river is gently sloping as it approaches Lake Superior. The majority of the Wolf River is contained within the Township of Dorion, with the balance in unorganized territory. Along the course of the river there are no significant wetlands larger than 40 hectares identified but some other small wetland areas are developing through natural succession in the oxbow lakes adjacent to the meandering portions of the river channel. Since 1972, there has been a stream flow gauge in operation near the crossing. A frequency analysis of peak annual instantaneous flows indicated a 1:100 year flood flow of 250 cubic metres per second. In 1985, fill line mapping was conducted for the lower reaches of Wolf River; however, in 1996 during a high water event, the Wolf River cut a new stream channel to meet Lake Superior approximately 815 metres south along the Lake Superior shoreline from the original confluence location. Hurkett Cove Provincially Significant Coastal Wetland lies within the watershed along the shoreline of the original confluence. Discussion with local residents and aerial photography reveal that the original confluence channel is subject to sedimentation and the increased growth of wetlands. As well, the extent of the coastal wetland is expanding further south to the new mouth of Wolf River. *Thermal Property Classification:* Cold Water.

<u>Streamflow Gauges</u>

The Assessment Report Map #6 – Surface Water Characteristics located in the Map Binder - Map Sleeve # 6 identifies the historic and current stream flow gauges with known coordinates, located within the Lakehead Source Protection Area.

In the development of the conceptual water budget, twenty-five streamflow gauges/hydrometric stations, which contained records of flow dating back from 1923 until the year 2003, were identified within the Lakehead Source Protection Area. Of these twenty-five, some measured stream flow continuously, some measured only water level and some were in operation for only a short period of time. Water levels in most of the rivers with stream gauges vary depending on the control dams, lakes and reservoirs. For the purposes of the water budget, fourteen of the twenty-five gauges/hydrometric stations have a period of record that match with corresponding precipitation records. The fourteen gauges that were used in the determination of the water budget are summarized in Table 11.

It should be noted that the Lakehead Region Conservation Authority continues to work in partnership with Environment Canada to maintain and operate the following streamflow and precipitation gauges: Corbett Creek, Current River, McIntyre River, McVicar Creek, Neebing River, Upper Neebing River, North Current River, Slate River and the Whitefish River.

Table 11: Summary of Continuous Streamflow Gauge Stations within the Lakehead Source Protection Area (data from 1970-1994)

Station Name	Station ID	Drainage Area[1] (square kilometres)	Latitude	Longitude	Period of Records	Number of Years	Mean Annual Flow Rate (cubic metres per second)	Maximum Annual Flow Rate (cubic metres per second)	Minimum Annual Flow Rate (cubic metres per second)
Pigeon River at Middle Falls	02AA001	1550	48°0'44"N	89°36'58"W	1924-1999	75	15.08	40.65	2.03
Kaministiquia River at Outlet of Dog Lake	02AB004	3760 (3397)	48°42'30"N	89°38'0"W	1923-1994	71	30.19	61.96	6.79
Kaministiquia River at Kaministiquia	02AB006	6475 (6455)	48°31'58"N	89°35'39"W	1926-2003	77	58.81	121.64	18.13
Neebing River near Thunder Bay Airport	02AB008	187 (205)	48°22'56"N	89°18'28"W	1953-2003	50	1.80	5.87	0.15
Shebandowan River at Sunshine	02AB009	2800 (2852)	48°33'20"N	89°40'55"W	1957-1994	37	24.09	60.45	4.67
Kaministiquia River at Kakabeka Falls Powerhouse	02AB010	6710 (6746)	48°24'56"N	89°37'51"W	1923-1994	71	54.46	121.71	16.73
Shebandowan River at Outlet of Shebandowan Lake	02AB011	Not Determined (1159)	48°37'11"N	90°3'42"W	1924-1994	70	6.14	21.41	0.24
Kashabowie River at Outlet of Kashabowie Lake	02AB013	526 (514)	48°39'25"N	90°25'3"W	1951-1994	43	3.87	11.09	0.21
North Current River near Thunder Bay	02AB014	111 (116)	48°30'4" N	89°10'47"W	1972-2003	31	1.22	3.58	0.20
Current River near Stepstone	02AB015	492 (499)	48°32'10"N	89°14'10"W	1972-1986	14	5.32	12.77	1.44
Current River at Stepstone	02AB021	392 (404)	48°33'45"N	89°14'27"W	1989-2003	14	3.92	7.78	1.77
McIntyre River at Thunder Bay	02AB016	145 (137)	48°25'7" N	89°15'55"W	1972-1986	14	4.01	1.26	0.15
McIntyre River above Thunder Bay	02AB020	90 (80)	48°28'57"N	89°19'31"W	1987-2003	16	2.36	0.82	0.14
Wolf River at Highway 17	02AC001	736 (716)	48°49'19"N	88°32'7"W	1971-2003	22	6.78	17.09	1.28

Note: 1. Drainage area is from HYDAT database; Drainage area in the parenthesis was calculated using ArcHydro and used for water budget analysis.

3.1.4 Surface Water Control Structures

<u>Dams</u>

The Ontario Ministry of Natural Resources is the regulating agency for dams throughout the Lakehead Source Protection Area. These dams regulate water flow for wildlife, wild rice habitat, prevention or reduction of flooding, and erosion control. In 1980, the Ontario Ministry of Natural Resources carried out an initiative to inventory all of the dams in the Thunder Bay District which are listed in Table 12.

In 2008, the Lakehead Region Conservation Authority, on behalf of the Ontario Ministry of Natural Resources, updated the dam listing with current operating dams as of 2008. Table 13 is a listing of these dams. Assessment Report Map #6 – Surface Water Characteristics (Map Binder - Map Sleeve # 6) displays the location of the dams listed in Table 13.

Table 12: Ontario Ministry of Natural Resources 1980 Listing of Dams within the Lakehead Source Protection Area

Dam Name	**River/Lake**	**Geographic Township**
Arrow Lake	Arrow Lake	Harwick
	Wolf Lake	Glen
	Shebandowan River	Conacher
Boulevard Lake Dam	Current River	Thunder Bay
Kakabeka Falls	Kaministiquia River	Oliver
Kakabeka Game Farm	Kaministiquia River	Oliver
	Farm Pond	Oliver
	Farm Pond	O'Connor
Lakehead University	McIntyre River	Thunder Bay
Loch Lomond	Loch Lomond	Blake
	Newton Creek	Scoble
	Little Pine River	Crooks
	Little Pine River	Neebing
	Pond	Neebing
	Twin Birch Creek	Sackville
	Serpent Creek	Sackville
	Serpent Creek	Aldina
	Little Whitefish River	Lismore
Matawin Dam	Matawin Dam	Laurie
	Shebandowan River	Blackwell
	Greenwich Creek	Unorganized
	Blende Lake	McTavish
	Sibley Creek	Sleeping Giant Provincial Park
	Green Water Creek	Haines
	Rudge Lake	Unorganized

Dam Name	River/Lake	Geographic Township
Onion Lake	Onion Lake	Gorham
	Barnum Lake	Unorganized
	McIntyre River	Gorham
	Two Island Lake	Jacques
Paquitt	Current River	Gorham
Ray Lake Dam	Ray Lake	Unorganized
	East Dog River	Unorganized
	Sunday Creek	Unorganized
Seine Lake	Seine Lake	Unorganized
	Matawin River	Unorganized
	Batwin Creek	Unorganized
South Fowl Lake	South Fowl Lake	Hartington
Strawberry Creek	Strawberry Creek	Ware
	Dog Lake	Fowler
Tree Nursery	Pennock Creek	Paipoonge
	Neebing River	Paipoonge
	Neebing River	Paipoonge

Information Source: Ontario Ministry of Natural Resources (1981)

Table 13: 2008 Listing of Dams in the Lakehead Source Protection Area

Dam Name	Owner	Purpose
Boulevard Lake Dam	City of Thunder Bay	Recreation
Carp River Dam	City of Thunder Bay	Former Municipal Water Supply
Dog Lake Dam	Ontario Power Generation	Control Dam
Greenwater Lake Dam	Ontario Power Generation	Control Dam
Hazelwood Lake Dam	Lakehead Region Conservation Authority	Recreation
Kakabeka Falls Dam	Ontario Power Generation	Control Dam
Kakabeka Falls Game Farm (2)	Private	Habitat
Kashabowie Lake Dam	Ontario Power Generation	Control Dam
Lakehead University Fishway	Lakehead University	Artificial Lake
Mabella Dam	Ontario Ministry of Natural Resources	Control Dam
Matawin River Dam	Ontario Ministry of Natural Resources	Control Dam
Neebing/McIntyre Diversion Structure	Lakehead Region Conservation Authority	Flood Control
Neebing River Weir	Lakehead Region Conservation Authority	Sea Lamprey Barrier
Pennock Creek Dam	Ontario Ministry of Natural Resources	Irrigation
Ray Lake Dam	Ontario Ministry of Natural Resources	Control Dam
Shebandowan Lake Dam	Ontario Power Generation	Control Dam
Wolf River Weir	Federal Department of Fisheries and Oceans	Sea Lamprey Barrier
Wolf River Dam	Ontario Ministry of Natural Resources	Fish Hatchery

Dams on the Current River

Boulevard Lake Dam

The Boulevard Lake Dam features 17 sluiceways with concrete weirs, 11 sluiceways containing 8 stop logs each and one fishway, for a total of 29 sluiceways. The associated waterpower facility is operated by The Power Producer under a lease from the City of Thunder Bay. Boulevard Lake is a man-made reservoir above the dam, approximately 44 hectares in size. The City of Thunder Bay has protocols in place stating that the water level within the reservoir is to be monitored by the staff at the Thunder Bay (Bare Point Road) Water Treatment Plant. It should be noted that the water levels of Boulevard Lake and the flows on the lower Current River have no impact on the availability of water at the intake for the Thunder Bay (Bare Point Road) Water Treatment Plant. The waterpower facility draws water from the north side of the dam and diverts a maximum of 3.9 cubic metres per second through a 1,200 millimetre pipe approximately 200 metres downstream to the generating station. The generating station uses a single vertical propeller turbine known as a Kaplan turbine. The minimum estimated flow over the Boulevard Lake Dam under extreme drought conditions could drop to 0.2-0.3 cubic metres per second. This flow is considered to be barely enough to provide flow through one sluiceway. Boulevard Lake is used extensively for recreational purposes in the summer. The Boulevard Lake Dam has an operating plan entitled “Boulevard Lake (Current River) Water Management Plan, March 2006”.

Hazelwood Lake Dam

This dam was originally constructed around 1905 and was intended for water control in the production of hydro-electric power at Boulevard Lake. In the late 1970’s, deterioration of the dam necessitated repairs to maintain desirable water levels. Completed in late 1980, the reconstruction was carried out by the Lakehead Region Conservation Authority and included the installation of an impervious membrane along the old dam and construction of a new spillway with a walkway above.

Onion Lake Dam

The dam at the outlet of Onion Lake was originally constructed to store water for the original hydro generating facilities at the Boulevard Lake Dam but was decommissioned (removed) in the fall of 2007.

Dams on the Kaministiquia River

Discharges into the Kaministiquia from the Shebandowan and Dog Lakes are regulated through the operation of control dams, several of which have aided in minimizing the effects of flooding. Control dams exist on Greenwater, Kashabowie, Shebandowan and Dog Lakes. These dams are regulated by the Ontario Ministry of Natural Resources but operated by Ontario Power Generation Corporation. The Shebandowan River basin portion of the Kaministiquia River watershed provides water storage with control dams at the outlets of Greenwater, Kashabowie and Shebandowan Lakes. The Mabella Dam, on the Shebandowan River, is not currently operated, but does alter flow. The outflow of the Shebandowan Lake Dam enters the

Shebandowan River approximately 15.3 kilometres south of the Silver Falls Generation Station. In the spring, the Shebandowan Lake Dam is closed to allow Shebandowan Lake to refill to the summer desirable level of 450.0 metres. The Kaministiquia River has an operating plan for the purposes of waterpower entitled “Water Management Plan for Waterpower for the Kaministiquia River System”. The control dams on Greenwater, Kashabowie, Shebandowan and Dog Lakes are owned by Ontario Power Generation and operated in accordance with the “Kaministiquia River System Water Management Plan, June 2005”. This Plan was approved under the “Lakes and Rivers Improvement Act” by the Ontario Ministry of Natural Resources. The “Kaministiquia River System Water Management Plan, June 2005” was developed through a formal multi-stakeholder planning process by Ontario Power Generation, in conjunction with the Ontario Ministry of Natural Resources, and in consultation with a public advisory committee and with public review. The “Kaministiquia River System Water Management Plan, June 2005” identifies how the hydroelectric facilities on the Kaministiquia River system manages water levels and flows to balance environmental, social and economic objectives. Figure 4 provides a schematic of the dams located in the Kaministiquia watershed.

Greenwater Lake Dam

Ontario Power Generation owns and operates this dam which was constructed on the south end of Greenwater Lake in 1923. It was rebuilt in 1943. Since 2005, the dam has been operated in accordance with the “Kaministiquia River System Water Management Plan, June 2005” requirements. It should be note that 1993 Agreement that established the previous operating regime has been superseded by the “Kaministiquia River System Water Management Plan, June 2005”.

Kashabowie Lake Dam

This dam is located on the south end of Kashabowie Lake at the outlet flowing into the Kashabowie River and upper Shebandowan Lake. Original construction of the dam, a single sluice and spill wall, took place in 1923 and was last reconstructed in 1984. The operation of this dam is in accordance with the flow and level limits set out in the “Kaministiquia River System Water Management Plan, June 2005”.

Mabella Dam

This dam is part of the Shebandowan River system and is located downstream of the Shebandowan Lake Dam. The structure consists of a single sluice flanked by two spill walls. The Canadian National Railway has ownership of the dam.

Matawin River Dam

The Matawin River Dam is owned and operated by Ontario Ministry of Natural Resources. This dam was first constructed in the 1930’s as a wooden structure to facilitate log drives, then reconstructed in 1969, as a 55 metre concrete structure to maintain the wetland and wildlife habitat that had developed behind the original dam. The dam currently operates as a weir and sluiceways have not been actively operated.

Shebandowan Lake Dam

The Shebandowan Lake Dam is located on the Shebandowan River at the east end of Shebandowan Lake and is currently owned by Ontario Power Generation. Originally built in 1923 to assist with log drives, it was reconstructed in 1956 as a timber crib design with five sluices. The operation of this dam is in accordance with the flow and level limits set out in the "Kaministiquia River System Water Management Plan, June 2005".

Other Dams

Lakehead University constructed two dams on the McIntyre River to impound water and create a small lake known as Lake Tamblyn. The first dam is a diversion dam located on the McIntyre River and the second is a dam/sluiceway located at the lake's outlet. The two dams work together to create the lake area of Lake Tamblyn.

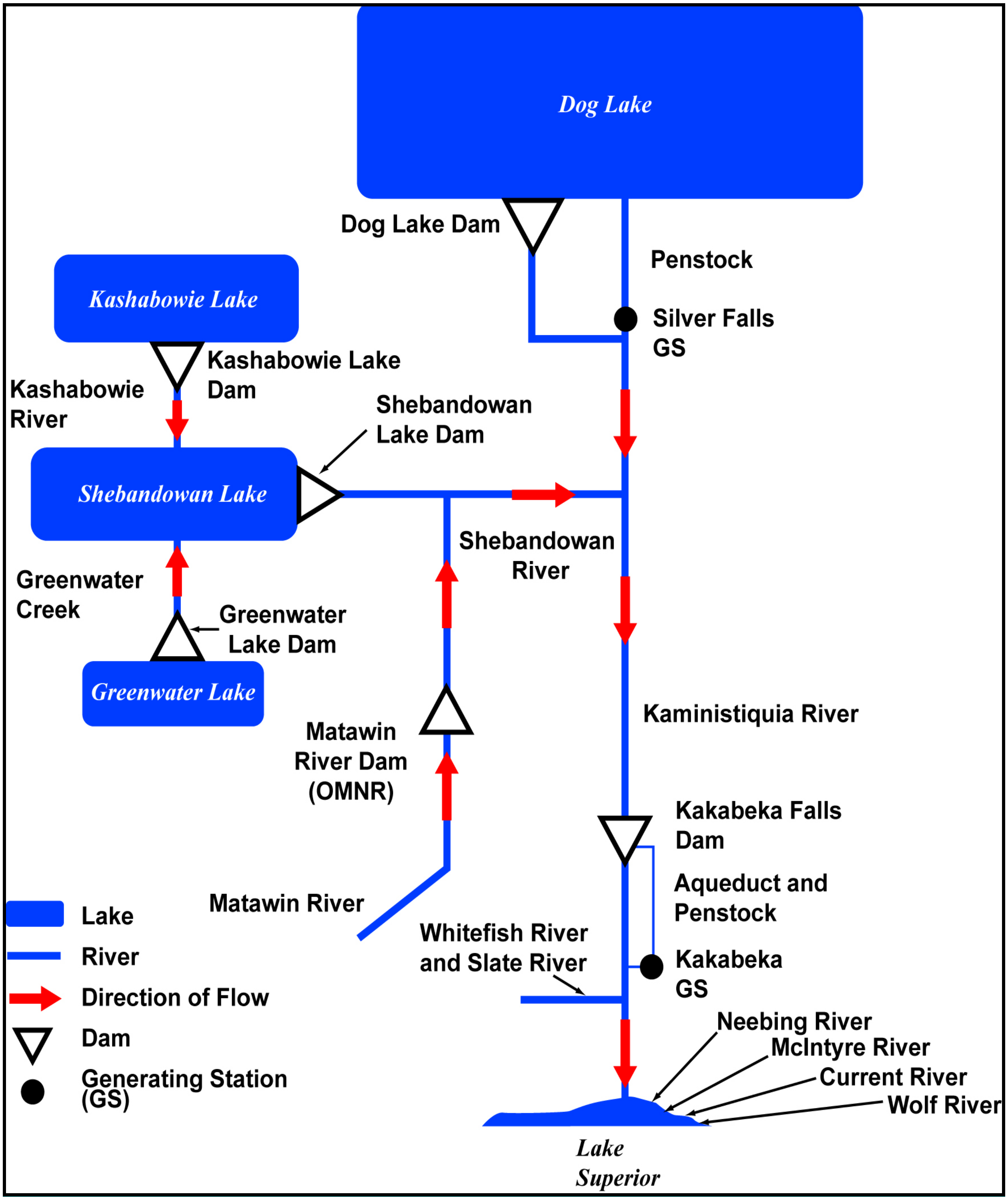
A small dam is located on Pennock Creek to the west of the City of Thunder Bay, at the Ontario Ministry of Natural Resources Science and Information Unit property.

A control dam regulates the natural discharge from Loch Lomond.

Dams are also located at Arrow Lake, Whitefish Lake, Pine River, Matawin River, Wolf Lake, Dog River and others.

The Neebing Weir in the City of Thunder Bay is a sea lamprey control structure and is owned by the Lakehead Region Conservation Authority.

Figure 4: Schematic of the Kaministiquia River System Drainage Basins and Control Structures



Neebing-McIntyre Floodway

In the past, repeated flooding by the Neebing and McIntyre Rivers resulted in damage and disruption in the central areas of the City of Thunder Bay. The development of the Neebing-McIntyre Floodway involved the re-routing of flood flows to alleviate the annual flooding problems in this part of the City. Construction of the floodway began in 1980 and was completed in 1984. The Floodway involved the construction of a diversion structure and floodway diversion channel from the Neebing River at Ford Street through the Chapples Golf Course to the widened and deepened McIntyre River near William Street. The diversion structure was designed to handle the maximum capacity which is determined by the Regional Storm event (19.3 centimetres of rainfall within 12 hours). When the water levels exceed the design capacity of the opening of the diversion structure, excess flows from the Neebing River are routed to the diversion channel draining into the McIntyre River. The McIntyre River flows east, into the Neebing-McIntyre Floodway, which outlets to Lake Superior south of Keefer Terminal. Since the construction of the floodway, there has been no further flooding in this part of the City of Thunder Bay. As a result, this area of the City has developed into the largest retail area in the City and in partnership with the City of Thunder Bay, over six kilometres of recreational trails have been constructed along the Floodway.

3.1.5 Groundwater Hydrogeology

Groundwater circulates as a component of the hydrologic cycle. Precipitation becomes surface water, soil moisture and groundwater. Groundwater circulates back to the surface and from the surface all water returns to the atmosphere through evaporation and transpiration. When precipitation falls on the land, part of the water runs off into the lakes and rivers. Recharge occurs when water from melting snow and rainfall seeps into the soil and percolates into the saturated zone. The area underground in which this occurs is referred to as a recharge area. When this water reappears above the ground it is called discharge. Groundwater may flow into streams, rivers, marshes, lakes and oceans, or it may discharge in the form of springs and flowing wells.

As the Lakehead Source Protection Area is largely characterized by shallow soils over bedrock, aquifers do not generally exist in these areas. In areas associated with glacial moraines or where overburden sand and glacial alluvial (gravel) deposits exist with significant depth, the potential for groundwater aquifers is greatly increased. The majority of thicker overburden material occurs in the general vicinity of the Kaministiquia River valley including the area immediately north of the valley and south of the Dog Lake Moraine, and Whitefish River and Slate River valleys. An isolated area of thick overburden occurs in the northeast part of the Lakehead Source Protection Area, in the Township of Dorion. In terms of potential water supply, the areas mentioned above offer the best opportunity for groundwater-based supply in the overburden. But as the remaining area has limited overburden, it is less likely to provide sufficient water yields.

Assessment Report Map # 13 – Overburden Thickness
Map Binder - Map Sleeve #13

This map illustrates an estimation of the thickness of the overburden in metres.

Groundwater recharge occurs through all surficial geology units, with the coarse-grained esker and outwash materials having the highest recharge rates. Groundwater discharge occurs mainly along the numerous lakes and streams. In general, groundwater recharge from direct infiltration of precipitation over the till and glaciolacustrine surface deposits is slower than that of the coarser deposits, but given the large surface exposure of the till and glaciolacustrine deposits, the volume of water supplied to the regional groundwater regime is significant.

An aquifer is an underground formation of permeable rock or loose material which can produce useful quantities of water when tapped by a well. Most of the aquifers of importance to the Lakehead Source Protection Area are contained in unconsolidated porous media such as sand and gravel. Unconfined aquifers are those that are bordered by the water table. Water table elevations range from 183 metres above sea level adjacent to Lake Superior to 618 metres above sea level in the western and northern part of the Lakehead Source Protection Area. Aquifers that lie beneath layers of impermeable materials are called confined aquifers (or artesian aquifers). An artesian well occurs when the water in an artesian aquifer rises higher than the top of the aquifer because of confining pressure. If the water level rises above the ground surface, a flowing artesian well occurs. The piezometric surface is the level to which the water in an artesian aquifer will rise. Steeper groundwater gradients occur where topographic changes are the greatest, for example in the area of the Nor'Wester Mountains. Bedrock valleys that host confined aquifers also influence the potentiometric contours and groundwater movement locally.

Regional aquifers in the overburden are difficult to characterize, as the majority of the overburden aquifers within the Lakehead Source Protection Area are associated with glacial landforms. Based on Ontario Ministry of Environment water well records, 91 percent of the wells in the Lakehead Source Protection Area are domestic wells and the rest are either industrial/commercial or not used (Burnside and AMEC, 2005). Well completion depths are highly variable with 75 percent of the wells completed at depths of 60 metres or less. Overburden wells dominate the Lakehead Source Protection Area, as extensive and/or discrete bedrock aquifers are not identified within the area. Moreover, most crystalline bedrock formations in the Lakehead Source Protection Area have very little inherent or primary porosity and are considered impermeable.

The Municipal Residential Drinking Water Supply System of Rosslyn Village in the Municipality of Oliver Paipoonge utilizes groundwater. This water supply system consists of two groundwater supply wells drilled in 1973, which as of January 2010 serviced 29 homes in Rosslyn Village. The source water for the system is a basal sand/gravel aquifer approximately five metres thick immediately above the bedrock, confined beneath approximately 35 metres of clay and silt rich material. Water is pumped from the two wells on an alternating basis to a single water treatment plant. Average daily actual water use is approximately 35 cubic metres per day, with maximum usage of approximately 50 cubic metres per day recorded (Burnside and AMEC, 2005).

Water Table

Assessment Report Map # 14 – Water Table Elevation
Map Binder - Map Sleeve #14

This map illustrates an estimation of the water table in metres above sea level using major and minor potentiometric surface contours (the theoretical surface to which water in an aquifer can rise by hydrostatic pressure).

The Ontario Ministry of Environment Water Well Information System (WWIS) data provided the depth of water for wells within the Lakehead Source Protection Area. At each well, the static water level that was recorded when the well was drilled was used to interpolate groundwater levels throughout the Lakehead Source Protection Area. Although static water levels may change over time, groundwater extractions have not changed dramatically and therefore the static water levels are considered acceptable for the purpose of mapping regional water table elevations. All wells completed to less than 15 metre depth were considered in this analysis. This was done to limit the misleading effects of deeper wells that may not measure the groundwater table, but actually a potentiometric head, as a deeper well in a recharge area will have a measured static level lower than the water table. The converse is true in a discharge area where the measured level will be higher than the actual water table. In general, a few reliable water wells records are available only in the central part of the Lakehead Source Protection Area. Because of sparse data over the northern portion of the Lakehead Source Protection Area where overburden is thin or discontinuous, a large number of data points were introduced using surficial water body features. It was assumed that the water table would coincide with the water levels in the surface water bodies and streambeds.

Generally, the water table follows the surface topography. The shallow groundwater flow system is entirely local, largely due to the presence of the many streams and lakes. Precipitation that is not taken up by evapotranspiration will either runoff to the local watercourses or recharge the water table (groundwater). Because of the low permeability of the bedrock, much of this recharge is deflected laterally through the relatively more permeable overburden. It discharges as baseflow in the local watercourses, which then flows out of the highlands in the north and south, draining to the tributaries of the Lakehead Source Protection Area and eventually into Lake Superior. The existence of numerous lakes is suggestive of shallow groundwater flow discharge into those water bodies. Water table elevations range from 183 metres above sea level at the shore of Lake Superior to 618 metres above sea level in the western part of the Lakehead Source Protection Area.

In general, groundwater flows from the northern uplands area toward Lake Superior or the east-west Kashabowie/Shebandowan/Kaministiquia River valley. It is unlikely that there is significant groundwater flow between major watersheds for the following reasons:

a) Locally, the shallow groundwater flow is influenced by the thickness and distribution of coarser sand and gravel units within the overburden and topographic highs in the surface of the underlying bedrock, with groundwater flow divides likely occurring along the bedrock highs.

b) Lateral groundwater movement will also occur in the shallow bedrock where fractures exist.

c) There are no appreciable deep groundwater flow systems on the regional scale, although some pathways are longer where the overburden is deepest.

Quantification of Groundwater Recharge

Recharge can be defined as the process by which water moves from the ground surface through the unsaturated zone to arrive at the water table. This provides the driving force that causes groundwater to flow and ultimately discharge as baseflow to wetlands, watercourses and lakes. It should be noted that not all water that infiltrates into the ground ends up as recharge as some is lost to plant uptake which is subsequently transpired by the plants.

Historically, groundwater recharge has been estimated by calculating the "missing" water from surface water calculations. Recharge needs to be estimated as the source and driving force for groundwater flow systems because the recharge of the water table is accomplished by the infiltration of precipitation and snowmelt that is not taken up again by plants or evaporation. In 1995, the Ontario Ministry of Environment and Energy (MOEE, 1995) established a method to estimate recharge based on topography, soils and plant cover. This method relied on applying a partitioning coefficient (F) to the annual surplus (S) to separate it into runoff (RO) and recharge (R) by the following relationships:

$$\mathbf{R = F \times S; \text{ and } RO = S - R}$$

Evapotranspiration is a large component of the water balance. This is a function of the vegetative cover as well as soil and climatic conditions. As described earlier, evapotranspiration includes the amount of moisture lost to the atmosphere through transpiration by plants and evaporation from the soil, tree canopy and other surfaces. Evapotranspiration can be affected by the removal of vegetation. This will result in a reduction of evapotranspiration losses, higher runoff and a smaller loss of soil moisture. The net result will favour the retention of groundwater. The mean annual water surplus (the difference between mean precipitation and evapotranspiration) is therefore derived.

The first step is to prepare a water budget for existing conditions from the meteorological data at each meteorological station. The average annual precipitation for the period of 1970 to 1994 was selected as it can be directly compared to the period of streamflow record. Using the method of Thornthwaite and Mather (1957), the actual evapotranspiration was calculated for each station. {This method is an empirical technique that quantifies monthly inflow (precipitation) and outflow (baseflow plus runoff = streamflow) for many watersheds, and thus calculates the actual evapotranspiration as the difference, which follows a predictable pattern}. This method uses precipitation, temperature, site latitude, surficial soil and vegetation cover to calculate the actual evapotranspiration. The surplus is determined by subtracting the actual evapotranspiration from the average annual precipitation. Soil moisture storage, used to buffer evapotranspirative losses, was assumed to be 100 millimetres based on the generally sandy soil type. The results of this analysis are presented in Table 14.

Table 14: Summary of Water Balance for the Selected Meteorological Stations (1970-1994)

Climate Station Name		Precipitation (millimetres per year)	Actual Evapotranspiration (millimetres per year)	Water Surplus (millimetres per year)
Stations Located Within the Lakehead Source Protection Area	Flint	805.3	505.5	299.8
	Thunder Bay	771.5	498.7	272.8
	Tranquillo Ridge	884.2	511.4	372.8
	Whitefish	907.7	524.2	383.5
Stations Located Outside the Lakehead Source Protection Area	Upsala	885.3	496.5	388.8
	Cameron Falls	851.1	501.0	350.1

The actual evapotranspiration ranges over a narrow band of approximately 496 to 524 millimetres per year, a much more narrow variation in comparison to precipitation which had a variance of 136 millimetres. The difference between the precipitation and the actual evapotranspiration is termed the surplus, which is available for runoff and infiltration (recharge).

Assessment Report Map # 15 – Surplus Distribution
Map Binder - Map Sleeve # 15

This map illustrates the difference between the precipitation and actual evapotranspiration which is termed surplus. The surplus ranges approximately between 273 and 388 millimetres per year and is greatest at the locations where the highest precipitation occurs.

The next step in determining recharge is to partition the surplus using the following methodology. The partitioning of the water surplus between runoff and infiltration depends on topography, soil texture, land cover type and available water in the watershed.

The MOEE (1995) method relies on calculating “infiltration factors” composed of the first three factors that are applied to the fourth factor, average annual water surplus. For the information of the reader, infiltration factors have been listed and calculated (MOEE, 1995) in Table 15.

Table 15: Infiltration Factors

Description of Area/Development Site	Value of Infiltration Factor
TOPOGRAPHY	
1. Flat and average slope not exceeding 0.6 metres per kilometre.	0.30
2. Rolling land, average slope of 2.8 metres to 3.8 metres per kilometre.	0.20
3. Hilly land, average slope of 28 metres to 47 metres per kilometre.	0.10
SOIL	
1. Tight impervious clay.	0.10
2. Medium combinations of clay and loam.	0.20
3. Open sandy loam.	0.40
COVER	
1. Cultivated lands.	0.10
2. Woodlands.	0.20

Source: Reproduced from MOEE (1995), "Technical Guidelines for the Preparation of Hydrogeological Studies for Land Development Applications".

For the purposes of the determination of the water budget for the Lakehead Source Protection Area, topographic factors were calculated based on actual slope. Application of the generalized infiltration factors recommended by MOEE (1995), were refined by developing a relationship between the infiltration factor and degree of slope. For the categories where slope ranges were given, the appropriate slope (in degrees) was calculated for the mid-point of the range. An infiltration factor, for example, of 0.4 means that 40 percent of the water surplus will infiltrate into the ground while the remaining 60 percent will become runoff. The method is applied on a long-term basis (annually) and is not related to individual precipitation events.

The soil factor is based on the geologic mapping for the area. Factors ranging between 0.1 for tight impervious soils or bedrock to 0.4 for permeable aeolian sands were selected and applied to the digital geologic map in a Geographic Information System (GIS) platform. Bedrock was assumed to be very tight and was assigned an infiltration factor of 0.1. Some rock is more susceptible to weathering (marginally) than others and was given an infiltration factor of 0.2.

The final factor in the MOEE (1995) methodology is based on land cover. In this case, there are two factors applied, based on whether or not the area is wooded or cultivated. Wooded areas were assigned an infiltration factor of 0.2, and cultivated areas (including lawns) were given an infiltration factor of 0.1. To estimate this factor, a grid of the Lakehead Source Protection Area was constructed in the Geographic Information System platform based on the vegetation coverage obtained from the Ontario Ministry of Natural Resources. That vegetation coverage is based on the interpretation of air photos during the development of the Ontario Base Mapping series. For all open water, the infiltration factor was set to 0, as all this water contributes to runoff.

The method is best described by a sample calculation. For a given 20 metre grid in the Geographic Information System platform, the slope is calculated. In this example, the slope is 2 degrees. The factor may be calculated using the equation below:

$$\mathbf{Y = 0.124 \times (2^{o})^{-0.267} = 0.103}$$

The slope factor is therefore 0.103, which is reasonable since it is relatively steep and the runoff is increased, meaning there is less opportunity for infiltration. Assuming that the bedrock is near the surface, but of the more weathered variety, a factor of 0.2 is used. This indicates that relatively more water will be captured by open fractures, leaking to depth. Finally, there is little vegetation except grasses and mosses on the slope, so retention of runoff is minimal and therefore a factor of 0.1 is selected. These are summed together to determine the partitioning coefficient of 0.103 + 0.2 + 0.1 = 0.403 for this example polygon.

The final step is to apply the partitioning coefficient to the surplus. We have assumed the square polygon in the grid lies in an area just south of Dog Lake. The surplus from Assessment Report Map # 15 – Surplus Distribution (Map Binder - Map Sleeve # 15) is about 320 millimetres per year. Therefore, infiltration equals 0.403 X 320 millimetres = 129 millimetres per year. This infiltration, which contributes to groundwater recharge, is shown on Assessment Report Map # 16 – Groundwater Recharge Distribution (Map Binder – Map Sleeve #16). The remaining water (191 millimetres per year in this case) is runoff, the difference between the surplus and the infiltration. Assessment Report Map # 17 – Runoff Distribution (Map Binder – Map Sleeve #17) shows the average annual runoff for the watershed of between 160 and 200 millimetres per year. In this example, the runoff is greater than the infiltration, which would be expected for a slope of 2 degrees or more.

Assessment Report Map # 16 – Groundwater Recharge Distribution
Map Binder – Map Sleeve #16

This map illustrates the groundwater distribution in the Lakehead Source Protection Area. Infiltration is the process of water moving from the ground surface vertically downward into the soil. The infiltration rate is determined by the quantity of water that enters the soil surface in a specified time interval and is often expressed in volume of water per unit of soil surface area per unit of time (e.g. centimetres per hour).

Assessment Report Map # 17 – Runoff Distribution
Map Binder – Map Sleeve #17

This map illustrates the average annual runoff distribution in the Lakehead Source Protection Area. Runoff is the portion of precipitation which is not absorbed by the ground surface and finds its way into surface stream channels and becomes the flow of water from the land to oceans or interior basins by overland flow and stream channels.

It is useful to examine the water budget on a watershed scale. Here we report the water balance as an example for the HYDAT catchment station (02AB006) of the Kaministiquia River Watershed, covering an area of 6,455 square kilometres. The following average values were obtained from the Geographic Information System (GIS) platform after interpolation. They are derived by multiplying their cell values by the cell areas, summed as a total volume, and then divided by the total area. The average precipitation for the watershed is approximately 846 millimetres per year, actual evapotranspiration is approximately 509 millimetres per year, and the surplus is approximately 337 millimetres per year. This surplus has been partitioned into runoff and recharge with a value of 166 millimetres per year and 171 millimetres per year, respectively. By way of comparison, the streamflow gauge on the Kaministiquia River at Kaministiquia estimates a total flow (including both runoff and baseflow) of 287.3 millimetres per year, which is about 85.3 percent of the surplus value of 337 millimetres per year at the same location. The close agreement (a plus or minus 15 percent difference) of these two independent methods provides some degree of confidence in the water balance.

3.1.6 Wells and Surface Water Intakes

The following is a summary of known information for wells and surface water intakes within the Lakehead Source Protection Area. The Lakehead Source Protection Committee made all attempts to locate detailed information about wells and surface water intakes within the Lakehead Source Protection Area. If additional information exists on either wells or surface water intakes, the Lakehead Source Protection Committee did not have access to it in the development of the Assessment Report.

Municipal Wells

There is only one Municipal well system within the Lakehead Source Protection Area. The hamlet of Rosslyn Village in the Municipality of Oliver Paipoonge has a Municipal Residential Drinking Water Supply System consisting of two groundwater supply wells. These wells were drilled in 1973 and as of January 2010 service 29 homes (in the past they have served up to 60) in the immediate area in the Village of Rosslyn. The source water for the system is a basal sand/gravel aquifer approximately five metres thick, confined by approximately 35 metres of clay and silt rich material above and bedrock beneath. Water is pumped from the two wells on an alternating basis to a single water treatment plant, where chlorine is added. Maximum usage of this system has been recorded at approximately 50 cubic metres per day.

Communal Wells

As the City of Thunder Bay does not support applications to permit the development of communal wells, there are no known communal well systems within the City of Thunder Bay. No information related to communal wells located in the remainder of the Lakehead Source Protection Area was located.

Private Groundwater Wells

For most residents beyond the areas serviced by the Thunder Bay (Bare Point Road) Water Treatment Plant in the City of Thunder Bay and the Rosslyn Village Subdivision Well Supply in

Rosslyn Village, private groundwater wells are the main source of residential water supplies. As there is a portion of the City of Thunder Bay that is not serviced by the Municipal Residential Drinking Water System, these residents must rely on their own private wells. Throughout the remainder of the Lakehead Source Protection Area residents are responsible for their own private well systems. There is evidence that there are both drilled and dug wells throughout the Lakehead Source Protection Area. The Lakehead Source Protection Committee was unable to locate any information during the development of this Assessment Report that would provide a complete inventory of private wells within the Lakehead Source Protection Area.

Surface Water Intakes

Prior to February 2008, the City of Thunder Bay operated two Municipal Residential Drinking Water Systems, each with their own water treatment plants. The northern part of the City of Thunder Bay received its water supply from the Thunder Bay (Bare Point Road) Water Treatment Plant which draws water from Lake Superior. The southern portion of the City of Thunder Bay received water from the Loch Lomond Water Treatment Plant, which drew its water from Loch Lomond. Loch Lomond was discontinued as a Municipal Residential Drinking Water System in February 2008 and removed from the Ontario Drinking Water Information System inventory listing in early 2009.

The Thunder Bay (Bare Point Road) Water Treatment Plant is a surface water system drawing water directly from Lake Superior. The water intake for the Thunder Bay (Bare Point Road) Water Treatment Plant is located approximately 840 metres off shore and 10.2 metres below the surface. The Thunder Bay (Bare Point Road) Water Treatment Plant supplies water to both industrial and residential users within approximately 92 percent of the geographic landbase of the City of Thunder Bay and has an operational capacity of 68 million litres per day.

The extension of Municipal Residential Drinking Water System delivery infrastructure beyond the limits of the City of Thunder Bay is generally not permitted and is only considered where the extension is necessary to support a development considered to be of benefit to the region. The Fort William First Nation and Whitewater residential subdivision and golf course located in the Municipality of Oliver Paipoonge, do receive Municipal Residential Drinking Water from the City of Thunder Bay,

There are no other Municipal surface water intakes located within the Lakehead Source Protection Area. In many areas within the watershed, residents residing at seasonal cottages draw their water off the lake for personal and residential use. These would be considered private surface water systems and are fairly common in many areas supporting cottages in the Lakehead Source Protection Area, but no definitive records of these systems were found during the development of the Assessment Report.

Point of Clarification

In order to complete water budget calculations and analysis, water taking and water input totals must be determined at a subwatershed level. As Loch Lomond was used as a Municipal Residential Drinking Water System prior to 2008, detailed data was available for this subwatershed which enabled the consultant to complete the required water budget calculations. During the period that the water budget analysis was undertaken (2006-2008), the City of Thunder Bay was actively in the process of decommissioning Loch Lomond as a Municipal Residential Drinking Water System. This process was successfully completed in February 2008.

Loch Lomond was included in the Assessment Report and the water budget analysis only as a source of reliable data related to a subwatershed within the Lakehead Source Protection Area. Loch Lomond was not considered a Municipal Residential Drinking Water System at the time of the water budget analysis or development of the Assessment Report, therefore information related to Loch Lomond only occurs when needed to meet the regulated data and calculation requirements for the water budget chapter of the Assessment Report.

3.1.7 Groundwater and Surface Water Interactions

Groundwater discharge can contribute significantly to surface water flow. In dry periods, the flow of some streams may be supplied entirely by groundwater. At all times of the year, in fact, the nature of underground formations has a profound effect on the volume of surface runoff. While the rate of discharge determines the volume of water moving from the saturated zone into streams, the rate of recharge determines the volume of water running over the surface. When it rains, for instance, the volume of water running into streams and rivers depends on how much rainfall the underground materials can absorb. When there is more water on the surface than can be absorbed into the groundwater zone, it runs off into streams and lakes. The residence time of groundwater (the length of time water spends in the groundwater portion of the hydrologic cycle) varies enormously. Water may spend as little as days or weeks underground or as much as ten thousand years or more. Residence times of tens, hundreds or even thousands of years are not unusual. By comparison, the average time it takes the water in rivers to completely replace itself is about two weeks.

General groundwater flow in the Lakehead Source Protection Area is towards Lake Superior. Localized flow in the major river valleys drains into tributaries that flow into Lake Superior. Groundwater recharge within sand and gravel deposits occurs through direct infiltration of precipitation and recharge from surface streams and wetlands. Groundwater discharge generally occurs along surface water features, with the discharge supplying the base flow to the streams. The northern portion of the Lakehead Source Protection Area is dotted with numerous lakes and water bodies, which is indicative of the impermeable nature of the surficial soils over the

Lakehead Source Protection Area, thus, the surface runoff in the Lakehead Source Protection Area is expected to be high.

Areas of potential groundwater discharge occurring near the City of Thunder Bay include the Slate River and Kaministiquia River valleys. Areas associated with sands and gravels are commonly known as discharge areas. Large bedrock valleys can influence the zones of groundwater flow, concentrating the areas of groundwater discharge. Smaller areas of groundwater discharge occur along local topographic lows and associated stream valleys, providing baseflow to the numerous streams in the northern part of the Lakehead Source Protection Area.

There is currently no additional data to support or determine groundwater and surface water interactions. As non-porous bedrock is very common in the Lakehead Source Protection Area, the Lakehead Source Protection Committee does not feel comfortable making assumptions on how groundwater drainage is affected by non-porous bedrock without additional scientific data. As a result, additional text and map products to describe groundwater and surface water interactions could not be included.

3.1.8 Water Use

The "Lakehead Region Conservation Area Groundwater Management and Protection Study Report" (Burnside and AMEC, 2005) identifies the basic water uses within the Lakehead Source Protection Area. These are summarized below and where data gaps were identified during that study, estimates have been provided. Table 16 provides a summary of water users in the Lakehead Source Protection Area.

Table 16: Water Users and Estimated Population in the Lakehead Source Protection Area

Water Users	Service Type	Population
City of Thunder Bay	Municipal and Private	109,016
Municipality of Oliver Paipoonge (including Rosslyn Village)	Municipal and Private	5,839
Municipality of Neebing	Private	2,049
Municipality of Shuniah	Private	2,466
Township of Conmee	Private	748
Township of O'Connor	Private	724
Township of Gillies	Private	522
Township of Dorion	Private	382
Fort William First Nation	Municipal and Private	599
Total Population in 2001		**122,345**

Source: Statistics Canada, 2001

Maximum allowable surface water takings based on the Ontario Ministry of Environment (MOE) Permit to Take Water database (only active permits shown) are presented in Table 17. Figure 5 provides the relative consumptive and non-consumptive surface water takings for power generation, Municipal, industrial and irrigation purposes from the Lakehead Source Protection Area based on Permits to Take Water. The bold and italicized values in Table 17 are non-consumptive surface water takings that include power generation, dams and reservoirs, totalling approximately 480 million cubic metres, most of which is returned to the source after use. Permitted total consumptive surface water takings is 210 million cubic metres per year, which in this case consists of three entities: permitted industrial volumes totalling approximately 161 million cubic metres per year, permitted irrigation volumes totalling approximately 21 million cubic metres per year and the permitted Municipal takings from Loch Lomond for the City of Thunder Bay is approximately 28 million cubic metres per year. It should be noted that as of February 2008, Loch Lomond was no longer used as a source of Municipal Residential Drinking Water. For the purposes of the water budget calculations, Loch Lomond was included as it was an inland surface water intake system and had appropriate data sets associated with it for the purposes of water budget calculations. Together, these account for approximately 31 percent of the total water taking and are probably lower based on the fact that water takings from the Ontario Ministry of Environment Permit To Take Water database do not report actual takings, just maximum permitted amounts. It should be noted that for the purposes of the analysis of the water budget, only those water takings with current Permits To Take Water (at the time the water budget analysis was completed in 2006-2008) for inland water systems were used. There were water takings with current Permits to Take Water along the shore of Lake Superior at this time, but as Lake Superior cannot be used for water budget calculations, these water takings were not included in the calculation of the water budget. Only the water takings with Permits To Take Water, used in the water budget analysis, are shown on the Assessment Report Map #18 – Permits to Take Water (Map Binder - Map Sleeve # 18).

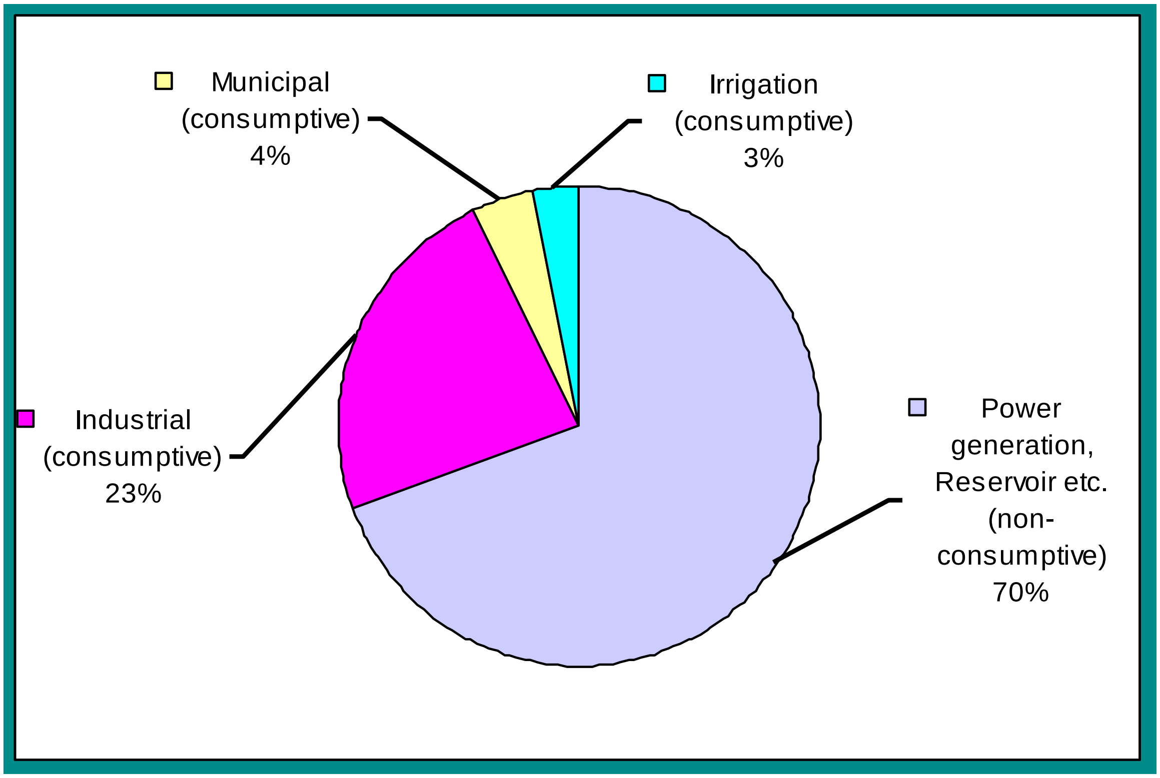
Assessment Report Map #18 – Permits To Take Water
Map Binder - Map Sleeve # 18

This map illustrates the locations of the Surface Water Takings According to the Ontario Ministry of Environment Permit To Take Water Database in 2007. Only active permits at the time the water budget analysis was completed in 2006-2008, are shown.

Table 17: Surface Water Takings According to Permit To Take Water Database in 2007 (only active permits)

Permit Number	Easting	Northing	Water Use	Source (River, Lake, Creek)	Takings (million cubic metres per year)
00-P-6024	318033	5359040	Field and Pasture Crops	Kaministiquia River	0.24
01-P-6047	309300	5431490	Pits and Quarries	Open Pit	10.95
01-P-6057	307850	5431495	Other - Industrial	Lac Des Illes	12.78
02-P-6057	321809	5356238	Field and Pasture Crops	Kaministiquia River	0.60
03-P-6040	309583	5362370	Aggregate Washing	Spring Few Tributary to Kaministiquia River	0.08
04-P-6027	336256	5360704	Other - Industrial	On-site Storage Ponds	1.08
3628-6BCQJR	335528	5358534	Other - Industrial	Mission River	0.10
67-P-511	331304	5361895	Dams and Reservoirs	Neebing River	***5.84***
70-P-429	332375	5365608	Dams and Reservoirs	McIntyre River	***0.02***
73-P-112	326816	5379309	Aggregate Washing	Pond on Tributary to McIntyre #1	0.64
73-P-112	326816	5379309	Aggregate Washing	Pond on Tributary to McIntyre #2	0.96
74-P-6015	328578	5360692	Golf Course Irrigation	Creek	0.10
75-P-6007	384101	5410724	Aquaculture	Wolf River	5.52
76-P-6011	382393	5410921	Aquaculture	Spring Creek	14.32
77-P-6001	334501	5359024	Power Production	Mission Island	***474.50***
82-P-6004	384069	5410868	Other - Industrial	Wolf River	6.69
84-P-6006	310703	5378970	Aggregate Washing	Strawberry Creek	2.39
86-P-6024	322497	5349921	Snowmaking	SW Quarter of Section 6	0.20
87-P-6015	329009	5357256	Manufacturing	Water Intake #1 Upstream Intake (Kraft)	78.84
91-P-6015	329000	5349213	Municipal	Loch Lomond	28.21
96-P-6013C	320606	5354884	Field and Pasture Crops	Slate River	0.20
97-P-6023	329001	5357254	Other - Industrial	Water Intake No. 2, Downstream Intake	52.56
97-P-6045	322500	5349912	Snowmaking	McQuaig Lake, Section 6	0.17
98-P-6094	319000	5355718	Field and Pasture Crops	Slate River	0.04
98-P-6893	321001	5356724	Field and Pasture Crops		0.05
Total					**690.36**
Non-consumptive (Power generation, Dams/Reservoirs)					***480.36***
Total Consumptive [Industrial, Municipal, Irrigation (Field and Pasture crops, aquaculture, etc.)]					**210.00**
Industrial					**160.74**
Municipal					**28.21**
Irrigation (Field and Pasture crops, Aquaculture, etc.)					**21.05**
Note: *Bold and italicized values represent non-consumptive uses.*					

Figure 5: Breakdown of Surface Water Takings from the Lakehead Source Protection Area According to Permit To Take Water Database



The largest demand for potable water is in the City of Thunder Bay, where water is supplied by the Thunder Bay (Bare Point Road) Water Treatment Plant and is drawn from Lake Superior through an intake pipe located approximately 840 metres offshore. Prior to and ceasing operation in February 2008, the Loch Lomond Water Treatment Plant also supplied potable water to some of the southern areas of the City of Thunder Bay. The Loch Lomond water supply was located south of the City of Thunder Bay limits, on Mount McKay. The water intake extended 220 metres into the lake (Lomond) and once supplied water by gravity distribution through the City's system. At the time the water budget analysis was conducted, the City of Thunder Bay Environment Division, stated that Bare Point (Lake Superior) supplied 92 million litres per day (33.6 million cubic metres per year) to a population of 109,016 (approximately 92 percent of the population of the City of Thunder Bay). The remaining eight percent of the population within the City of Thunder Bay, uses private wells to satisfy their personal water demand. Based on the Permit to Take Water database during the period from 2006 to 2008, the City was permitted to draw a maximum of 61 million cubic metres per year, but the City actually draws a little less than half of the allowed amount.

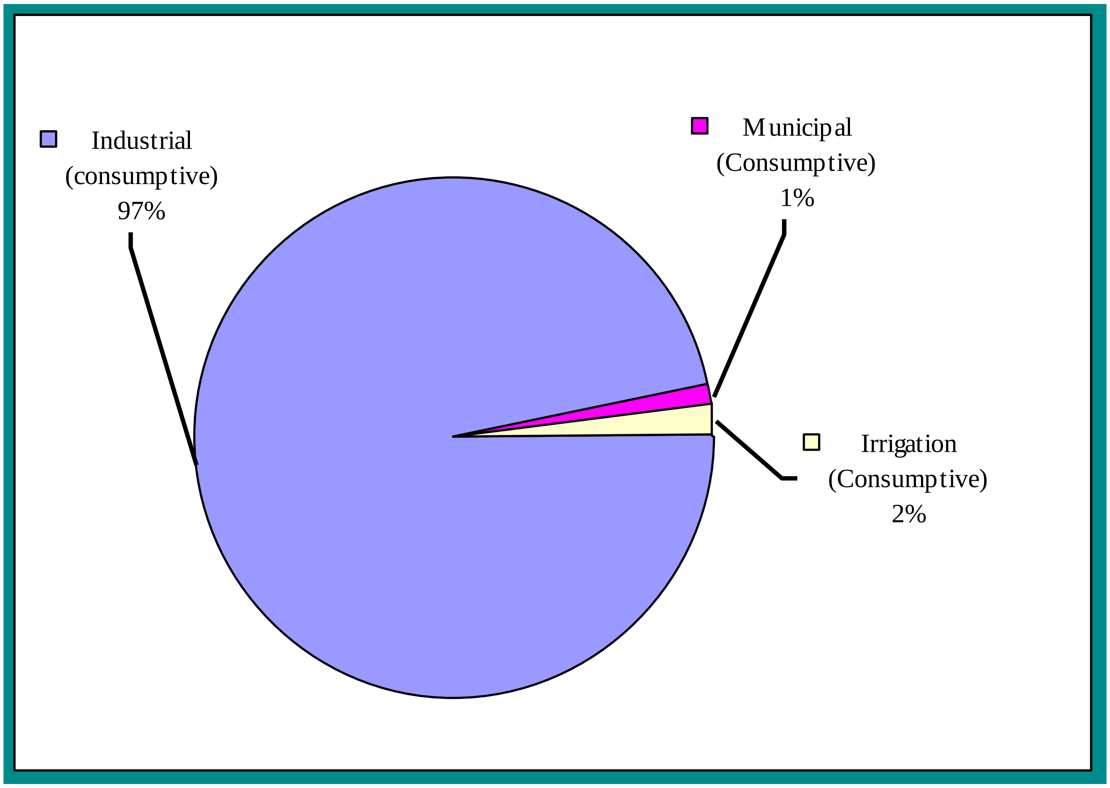
Maximum allowable groundwater takings based on the Permit To Take Water database are presented on Table 18. Figure 6 provides the relative consumptive groundwater takings for Municipal, industrial and irrigation purposes from the Lakehead Source Protection Area. Based on the Permit to Take Water database during the period from 2006 to 2008, the Rosslyn Village Subdivision Well Supply in Rosslyn Village, in the Municipality of Oliver Paipoonge, served about 29 homes which equalled an approximate population of 90 residents. The Rosslyn Village

Subdivision Well Supply was permitted to draw a maximum of 0.09 million cubic metres per year of water from two groundwater wells according to the Permit To Take Water database (Table 18). Based on Burnside and AMEC (2005), the average daily and maximum daily groundwater use for Rosslyn Village were 35 cubic metres per day and 50 cubic metres per day, respectively.

Table 18: Groundwater Takings According to Permit To Take Water Database (active permits during 2006-2008 only)

Permit Number	Easting	Northing	Water Use	Source (River, Lake, Creek)	Takings (million cubic metres per year)
3684-65WJW8	318409	5359730	Municipal (Oliver Paipoonge)	North Well	0.045
3684-65WJW8	318410	5359716	Municipal (Oliver Paipoonge)	South Well	0.045
01-P-6047	309300	5431490	Pits and Quarries	Open Pit	10.948
02-P-6021	366394	5358749	Campgrounds	Visitor Centre Well	0.051
02-P-6055C	320606	5354884	Field and Pasture Crops	Groundwater Pond	0.119
03-P-6021	335314	5377732	Communal	Wet Well	0.079
03-P-6021	335314	5377732	Communal	3 Wells	0.070
03-P-6043	324651	5355621	Snowmaking	Dug Reservoir	0.105
1373-6CSQ6P	320606	5354884	Fruit Orchards	Groundwater Storage Pond	0.119
92-P-6018	328501	5358424	Other - Industrial	Dug Well	0.097
Total					**11.68**
Other Industrial					**11.35**
Municipal					**0.09**
Irrigation					**0.24**

Figure 6: Breakdown of Groundwater Takings According to Permit To Take Water Database



In Municipal, non-Municipal and rural areas within the Lakehead Source Protection Area, where residents do not receive Municipal Residential Drinking Water services, private wells are used to draw groundwater for domestic water use. Within the limits of the City of Thunder Bay, eight percent of the population (8,721) that use private wells draw approximately 1.07 million cubic metres per year (based on the consumption rate of 335 litres per day per capita (MOE, 2007).

Within the surrounding Municipalities and townships, the primary source of water is groundwater from private wells. With a total population of 13,239 and based on the assumption that each resident uses 335 litres per day per capita, water demand is estimated at 1.62 million cubic metres per year. Analysis of the Ontario Ministry of Environment water well record data on wells in the area indicates that approximately 91 percent of the over 3,000 wells evaluated in the Burnside and AMEC, 2005 "Groundwater Study" are noted as being used for domestic purposes.

Because of shallow overburden and bedrock outcrops, the Lakehead Source Protection Area does not support any large-scale agricultural (irrigation and livestock) activities. The Permit to Take Water database was evaluated to estimate the proportion of agricultural water use derived from either surface or groundwater. The current database indicates that there is only one groundwater Permit to Take Water for agricultural use and that all agricultural demands are satisfied with surface water takings.

3.1.9 Land Cover

Assessment Report Map #5 – Land Cover
Map Binder - Map Sleeve # 5

This map illustrates land cover including wooded areas, wetlands, agriculture and Provincially Significant Wetlands within the Lakehead Source Protection Area. As there is no spatial data available related to riparian reserves for the Lakehead Source Protection Area, riparian reserves are not shown.

Land cover influences the distribution of surface runoff and infiltration to the subsurface. Projections of land cover and its type and area by watershed are presented in Table 19. As Assessment Report Map #5 – Land Cover (Map Binder - Map Sleeve # 5) and Table 19 illustrates, the vast majority, approximately 77 percent, of the Lakehead Source Protection Area is covered by forest. Generally, the watershed lies within two major forest regions, the Great Lakes-St. Lawrence Forest Region and the Boreal Forest Region. Although lakes, rivers and streams are densely distributed within the Lakehead Source Protection Area, these water bodies comprise, on average, only approximately seven percent of the land surface with wetlands that cover only approximately 4.75 percent. The Lakehead Source Protection Area supports a variety of trees, shrubs and herbaceous species including white birch, white and black spruce, poplar species and pine species (red, white, Jack pine).

Settlement and agriculture covers only approximately 2.5 percent of the Lakehead Source Protection Area which includes the urban areas of Thunder Bay, Municipalities of Oliver Paipoonge, Neebing, Shuniah and rural Townships of O'Connor, Conmee, Gillies and Dorion. Settlement and infrastructure are concentrated on these urban areas. Agriculture is limited within the Lakehead Source Protection Area and is mainly composed of food crops, hay, and cattle farms. Agricultural land cover primarily includes the land along the Slate, Neebing and the Kaministiquia Rivers.

The majority of the Lakehead Source Protection Area is unaltered in any significant way but available information shows that some physical and biological features have been altered as a result of human land use since pre-development conditions. Although pre-development conditions were not fully documented, significant alterations that affect water resources such as populated areas, dams, forestry and mine sites can be identified.

Generally speaking, the Lakehead Source Protection Area has an extensive forest, wetland and water cover (eight percent) and human settlement is less than two percent of the 11,526 square kilometre area, the highest density being observed in the Neebing and McIntyre River watersheds. Summarized in Table 19 is the land cover classification, produced by Gartner Lee Limited in 2008, using the digital analysis of spectral reflectance data recorded in Landsat-7 satellite images.

Table 19: Land Cover Types and their Percentages in the Lakehead Source Protection Area

Subwatershed	Percent Area Coverage					
	Open Water	Settlement	Mine/ Tailings	Forest	Wetlands	Agriculture
Kaministiquia River	3.5	4.3	0.0	86.4	0.3	5.6
Shebandowan River	13.4	0.6	0.1	83.7	3.1	0.0
Kashabowie River	21.8	0.0	0.0	76.1	2.6	0.0
Whitefish River	1.4	0.0	0.0	97.5	0.8	0.3
Slate River	1.1	0.9	0.0	77.2	0.1	20.8
Matawin River	8.4	0.0	0.0	88.3	5.4	0.0
Oskondaga - Swamp Rivers	0.8	1.3	0.0	95.6	3.4	0.0
Dog Lake	19.3	0.0	0.0	79.9	1.0	0.0
Dog River	9.1	0.0	0.4	86.1	6.6	0.0
Neebing River	0.5	17.8	0.0	77.7	0.6	3.4
McIntyre River - McVicar Creek	1.2	20.4	2.9	75.5	0.0	0.0
Current River	6.6	0.5	0.0	92.1	0.9	0.0
Wolf River	7.7	0.1	0.1	91.6	0.6	0.0
Lower Pigeon - Little Pine - Pine River	3.5	0.0	0.0	96.0	0.3	0.2
Cloud - Jarvis - Whiskeyjack - Lomond Rivers	8.4	0.8	0.0	90.7	0.2	0.0
Black Sturgeon R. - Little Squaw Creek - Squaw Creek	1.1	5.1	0.1	93.6	0.1	0.0
MacKenzie River	3.2	2.1	0.2	94.3	0.1	0.0
D'Arcy Lake - D'Arcy Creek - Pearl Lake – Big Pearl Lake - Welch Creek - Coldwater Creek	5.0	1.9	0.6	92.0	0.6	0.0
Portage Creek	4.7	2.6	0.0	92.6	0.0	0.0
Wildgoose Creek - Blind Creek - Blende River - Twinpine Creek	2.6	5.4	0.0	92.0	0.0	0.0
Lakehead Source Protection Area Average	**8.7**	**1.4**	**0.2**	**86.4**	**2.5**	**0.8**

3.1.10 Surface Water Intake and Wells without Permits To Take Water

During the development of the Assessment Report the Lakehead Source Protection Committee could not locate any information in respect to every surface water intake and well for which a Permit To Take Water has not been issued under the "Ontario Water Resources Act", the annual quantity of water taken and the purpose for which water is being taken, including whether water is being taken for a domestic use, agricultural use, commercial use, industrial use or any other specified use.

3.1.11 Aquatic Habitats Dependent upon Depth, Flow and Temperature

During the development of the Assessment Report, the Lakehead Source Protection Committee could not locate any information with respect to aquatic habitats dependent upon water depth, flow and temperature.

3.1.12 Trends Related to Water Budget Parameters

During the development of the Water Budget Report and the Assessment Report, the consultant and Lakehead Source Protection Committee, respectively, could not locate any information with respect to trends related to the water budget parameters in sections 3.1.3 to 3.1.11.

3.1.13 Climate

The climate in the Lakehead Source Protection Area is typical of a mid-latitude inland location with a Great Lakes moderating influence which is characterized as having warm wet summers, cold dry winters, a short growing season and usually reliable precipitation. The climate is categorized as "modified continental", meaning that the mean temperature difference between summer and winter is at least 30 degrees Celsius. Mean daily temperatures for January are minus 18.7 degrees Celsius and July are 18.5 degrees Celsius. The spring and fall periods are characterized by relatively cool temperatures during the day and evening and a greater occurrence of strong winds.

Topography has a pronounced effect on the local weather systems as well as the influence from Lake Superior. The height of land, at the westerly and northerly boundaries of the Lakehead Source Protection Area, tends to deflect storm centres from these directions, resulting in less intense areas of the storm passing over the settled areas closer to Lake Superior. In the outer reaches of the Lakehead Source Protection Area, the elevation ranges on average 470 metres above sea level, in height, with peaks up to approximately 640 metres above sea level, sloping down towards Lake Superior where the elevations average 184 metres above sea level. This change in altitude inland to the shore of Lake Superior has a pronounced effect on local weather conditions, as the down-slope effect, created by prevailing westerlies, tends to minimize cloud formation as well as diminish snow flurry activity in the winter in proximity to the Thunder Bay Airport weather station.

The influence of Lake Superior on the local climate is restricted to a zone approximately 16 kilometres inland from the shoreline with the prevailing winds in this area off shore (easterly). The climate in this area which affects the City of Thunder Bay is characterized by extremes in temperature, low humidity and moderate winds, characteristic of a mid-latitude inland location. The constant influence of several air masses, including moist subtropical air, dry arctic air and dry continental air masses, makes the area susceptible to extreme and rapid variations in the weather throughout the year. These variations are especially prevalent during the summer months when cyclonic storms mix warm humid air with dry cool air from Lake Superior, resulting in moderate to severe thunderstorms. There is an enhanced effect when storms approach the Lakehead Source Protection Area close to the shore of Lake Superior and the approaching weather systems filled with warmer inland air clashes with cold air over Lake Superior. An occasional east to southeast breeze off Lake Superior will produce a low overcast cloud over the area but this layer rarely extends farther than 32 to 40 kilometres inland. This same off-lake circulation results in a few cases of snow flurries during the early winter but snowfall amounts from these are not as heavy or as frequent as in localities on the south shore of Lake Superior. By mid-January, the bay known as Thunder Bay is usually entirely ice-covered, therefore the inland zone around the City of Thunder Bay is no longer affected by open water influences resulting in a substantial decrease in lake effect snow flurry activity. The influence of Lake Superior has a slight cooling effect in the summer and slight warming effect in the winter on the inland temperatures away from the City of Thunder Bay.

The summer period in the Lakehead Source Protection Area is approximately 97 days in length extending from the beginning of June to the beginning of September (beginning of summer is defined as the day the maximum daily temperature rises above 18.3 degrees Celsius). The summer months are normally characterized by cool evenings. Daylight hours in the summer peak at 16 hours. The Lakehead Source Protection Area summer climate is sometimes considered more comfortable during the summer months than more southerly Ontario areas because of lower humidity with cool nights. Fall lasts about sixty days, extending into early November. The winter season lasts approximately six months, extending from mid-November through to May. The first day of winter is taken as the first day with snowfall 2.5 centimetres or more. The winter months in the Lakehead Source Protection Area are characterized by relatively cold temperatures and although daylight hours in the winter time are as short as 8.4 hours, a relatively high incidence of sunshine is recorded.

The south part of the Lakehead Source Protection Area lies in the Rainy River-Thunder Bay region and the north part in the Height of Land climatic region (Chapman and Thomas, 1968). Given that this region is in the southern part of Northern Ontario, it is about eight degrees warmer than beside Hudson Bay to the north. The average annual temperature is about two degrees warmer at the south edge of the Lakehead Source Protection Area compared to its north edge. Frost-free days vary across the Lakehead Source Protection Area with approximately 100 days near Thunder Bay and only approximately 70 days to the northwest. From a moisture point of view, this region has ten to 30 percent lower precipitation in comparison to other Northern Ontario regions to the east and experiences a correspondingly lower surplus. These relatively cooler and drier conditions are understandable given the fact that the region is upwind of large water bodies. The western inland edge of the Lakehead Source Protection Area, on average is cooler and drier than the other regions within the Lakehead Source Protection Area.

Within the Lakehead Source Protection Area, there is an obvious north to south trend in the mean annual air temperature, with the northern area on average being cooler than the southern area. For example, Cameron Falls, located 100 kilometres northeast of Thunder Bay, is 0.7 degrees Celsius cooler than Thunder Bay. Upsala, which is the furthest north and most inland weather station, is the coolest (on average) being 1.7 degrees Celsius cooler than Thunder Bay. The spatial distribution of mean rainfall and snowfall amounts in the Lakehead Source Protection Area tends to be related to the distance from Lake Superior as well as to the relative topography of the area. The average annual precipitation throughout the Lakehead Source Protection Area ranges from 696 millimetres to 823 millimetres with approximately 70 percent of the measurement being identified as rain. In general, the highest total precipitation is associated with the highest topography and longest distance north of Lake Superior as recorded in Table 20.

Historically there were two weather stations present within the Lakehead Source Protection Area; the Thunder Bay Airport and Kakabeka Falls. These two stations were situated only 29 kilometres apart, but comparison of historic temperature data from the stations illustrates the moderating effect of Lake Superior on the average temperatures. Minimum temperatures in Thunder Bay are about three degrees Celsius warmer on an annual basis than at Kakabeka Falls. The inland areas of the Lakehead Source Protection Area receive most of their snow in November, while the area within the 16 kilometre zone of influence from Lake Superior receives most of its snow in January. The weather station in Kakabeka Falls was decommissioned many years ago and review of the records from this station concludes that when it was operating data collection and recording was sporadic. The only continuous weather records for the entire Lakehead Source Protection Area are from the Thunder Bay Airport location. Over the past 120 years, climate observations comprising maximum and minimum daily air temperature and daily precipitation (as rainfall and snowfall) totals have taken place within and around the Lakehead Source Protection Area at 49 meteorological stations. These measurements, however, have been made over different time periods. Only two of these meteorological stations (Cameron Falls and Upsala, both of which are located outside of the Lakehead Source Protection Area) meet the World Meteorological Organization standards. At a few of these locations, there are recording rain gauge (tipping-bucket) measurements and in others, snow depth on the ground snow course measurements. At other stations, snow course measurements have been made on a twice monthly schedule during the winter months. For the most part, these climate observations have been carried out by a number of agencies, including: Environment Canada's Atmospheric Environment Service (AES), the Ontario Ministry of Natural Resources (OMNR), Lakehead Region Conservation Authority (LRCA), Ontario Power Generation (OPG), some mining companies and regional Municipalities.

Using a data fill-in technique to account for missing values in the record, developed by Schroeter et al., (2000), daily meteorological data was processed for six selected stations in and around the Lakehead Source Protection Area for the period 1970-1994. This period was chosen to keep consistency with HYDAT data for estimating water balance for the same interval. Table 20 provides a summary of mean annual values for air temperature, rainfall, snowfall and total precipitation at six selected climate stations at and in the vicinity of the Lakehead Source Protection Area, are grouped according to geographical location and then listed in a north to south orientation within each group.

Table 20: Climate Summary for Selected Stations at and in the Vicinity of the Lakehead Source Protection Area (Data of 1970-1994)

	Climate Station Name	Climate Station Identification Number	Mean Annual Air Temperature (degrees Celsius)	Mean Annual Rainfall Depth (millimetres)	Mean Annual Snowfall Depth (centimetres)	Mean Annual Total Precipitation Depth (millimetres)
Stations Located Within the Lakehead Source Protection Area	Flint	6042MJ7	2.19	588.3	217.1	805.3
	Thunder Bay	6048261	2.52	573.8	197.7	771.5
	Whitefish	6049466	1.74	603.9	303.7	907.7
	Tranquillo Ridge	6048864	2.56	629.1	255.1	884.2
Stations Located North of the Lakehead Source Protection Area	Upsala*	6049095	0.78	601.3	249.8	851.1
	Cameron Falls	6041110	1.80	643.8	241.5	885.3
Note: *This station is situated 30 km to the northwest of the northern boundary of the Lakehead Source Protection Area.						

The average precipitation (arithmetic average) for all six of the climate stations is 851 millimetres per year. Assessment Report Map #19 - Mean Annual Precipitation and Climate Stations (Map Binder - Map Sleeve # 19) displays the total precipitation across the Lakehead Source Protection Area, contoured using an inverse distance weighting formulation. Within the Lakehead Source Protection Area, the contours range from 775 millimetres per year at Thunder Bay Airport in the east, increasing towards the southwest to a value of 900 millimetres per year near Whitefish Lake. The average precipitation inland to the north of the Lakehead Source Protection Area is 850 to 885 millimetres per year. Variations in climatic data between watershed meteorological stations result from differences in elevation, the rain shadow effect of topography, the moderating effect of large water bodies and the moderating effect of large urbanized areas. As these variances cannot be illustrated on the map at a 1:250,000 scale, precipitation depths are shown as general ranges.

Assessment Report Map #19 - Mean Annual Precipitation and Climate Stations
Map Binder - Map Sleeve # 19

The mean annual precipitation depths in millimetres are illustrated on the map with gradient shading. Note that the variance in mean annual total precipitation depths as you move from east to west and south to north across the Lakehead Source Protection Area. The climate stations from which data was utilized in the determination of the water budget are also indicated on the map.

Dominant weather modifiers in the Lakehead Source Protection Area include:

a) The modifying effect of Lake Superior.
b) The rain shadow effect of the Height of Land (Atlantic/Arctic watershed division) in the northern part of the Lakehead Source Protection Area, which is an area of great local variation resulting in a difference in total precipitation over the entire watershed area.
c) The rain shadow effect of the Height of Land, west of Thunder Bay resulting in higher precipitation at Tranquillo Ridge and in Whitefish, than that at the Thunder Bay Airport.
d) The rain shadow and temperature inversions which occur between the Height of Land and the shore of Lake Superior.
e) The urban heat island effect that occurs over urban Thunder Bay.
f) On-shore winds from Lake Superior at the Thunder Bay Airport.
g) The down-slope effect created by prevailing westerlies, which tends to minimize cloud formation over the airport weather office.

For discussion purposes, 55 year (1950-2005) mean values of air temperature and precipitation (as rainfall and snowfall) for the Thunder Bay Airport climate station are summarized in Table 21 (this is not the period selected for the water balance, but is used here as it provides representative conditions on average for a longer period). This particular station was selected for discussion because it has the longest period of record and is still in operation. Table 21 illustrates that the mean annual total precipitation is about 728.5 millimetres, of which 27 percent (assuming 199 centimetres of snow = 199 millimetres of water) appears as snowfall and 73 percent as rainfall (or 529 millimetres). Note that for the purpose of this conceptual water budget, the consultant has assumed a 10:1 ratio for the depth of snow to the equivalent depth of water. Snow water equivalent is a term that refers to the total millimetres of water contained in the snowfall, assuming it were melted and had fallen as rain. In reality, the ratio is somewhat less, however such a detailed assessment is beyond the scope of this conceptual exercise. The highest average monthly snowfall amounts occur in December and January (41 and 46 centimetres, respectively). The total precipitation is distributed such that May through October are the wettest months, likely due to the presence of the many upwind lakes. December, January and February are the three driest months, because ice cover removes the upwind lakes as a source of moisture. The lowest average monthly precipitation (30.6 millimetres) occurs in February, whereas the highest precipitation without snowfall occurs in either July (79.7 millimetres) or August (80.2 millimetres).

Table 21: Summary of Climate Data for Thunder Bay Airport (1950-2005)

Month	Average Maximum Daily Temperature (degrees Celsius)	Average Minimum Daily Temperature (degrees Celsius)	Average Daily Temperature (degrees Celsius)	Mean Total Rainfall (millimetres)	Mean Total Snowfall (centimetres)	Mean Total Precipitation (millimetres)
January	-8.8	-21.0	-14.9	1.2	46.6	47.8
February	-5.3	-18.6	-12.0	2.3	28.3	30.6
March	0.2	-11.8	-5.8	13.3	28.7	42.0
April	8.6	-3.2	2.7	34.1	16.7	50.8
May	15.7	2.2	9.0	68.6	2.6	71.2
June	20.8	7.5	14.2	79.5	0.0	79.5
July	24.3	11.0	17.6	79.7	0.0	79.7
August	23.2	10.2	16.7	80.2	0.0	80.2
September	17.6	5.6	11.6	79.4	0.3	79.7
October	10.8	0.0	5.4	58.8	4.8	63.6
November	1.9	-7.1	-2.6	27.9	30.4	58.3
December	-5.4	-16.5	-10.7	4.1	41.0	45.1
Annual Mean or Total	**8.6**	**-3.5**	**2.6**	**529.1**	**199.4**	**728.5**

The daily average temperature ranges from minus 14.9 degrees Celsius in January to an average of 17.6 degrees Celsius in July, with an annual mean daily temperature of 2.6 degrees Celsius (Table 21). Extreme temperatures as high as 40 degrees Celsius can occur in summer and as low as minus 41 degrees Celsius in winter.

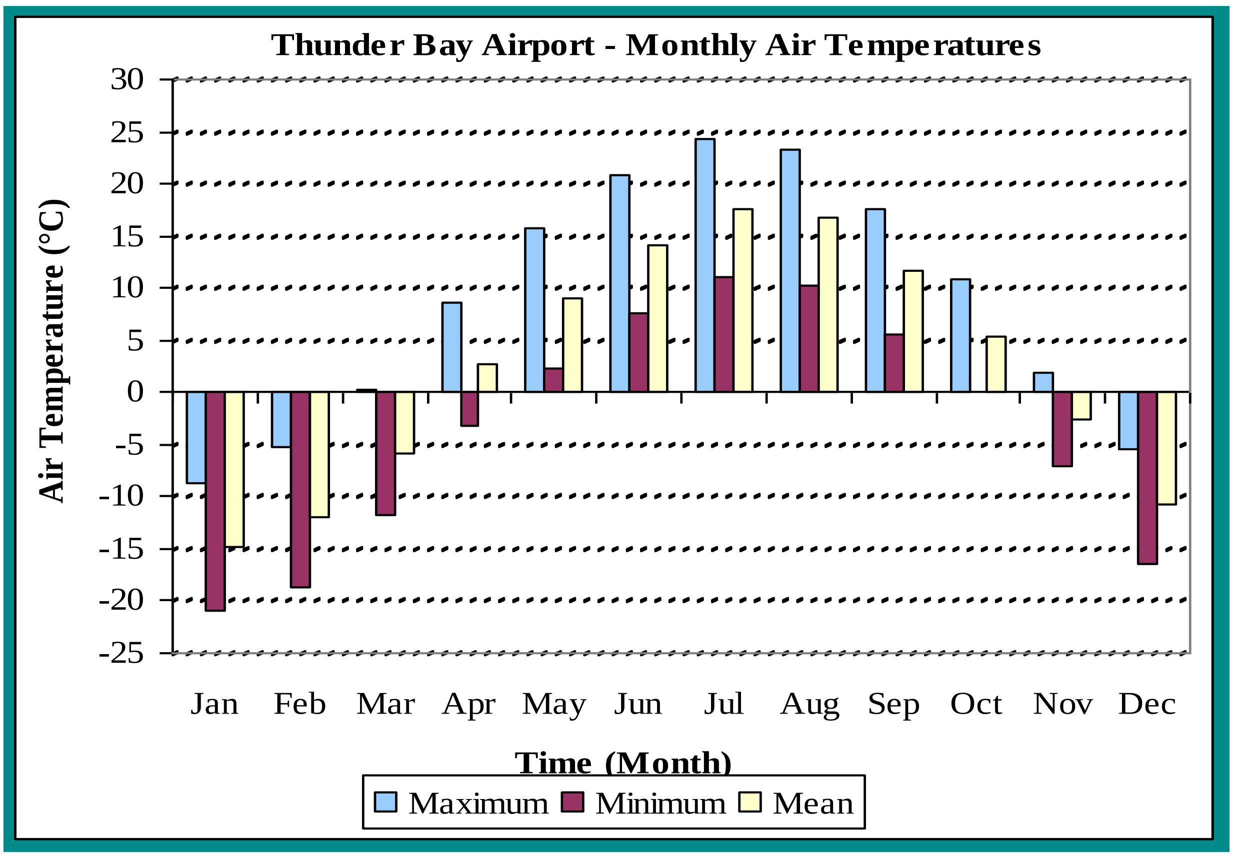
Monthly water balance calculations for evapotranspiration at the six meteorological stations show that actual evapotranspiration is greater than the total precipitation input for June, July and August, relying in part on soil moisture uptake. Therefore, during the summer period there is a net deficit in the water balance. The loss of recharge and continued plant uptake causes water tables to drop during this period.

In the following sections, the Thunder Bay Airport meteorological station is relied upon to discuss trends. For the purposes of the water budget calculations, undertaken later in this chapter, spatially distributed climate data between the six meteorological stations within and in the vicinity of the Lakehead Source Protection Area have been used. Assessment Report Map #19 - Mean Annual Precipitation and Climate Stations (Map Binder - Map Sleeve # 19) shows that the precipitation distribution determined by the Inverse Distance Weighted (IDW) interpolation technique is more heavily weighted to the measured values closest to the location than those further away. This technique is described in detail in the report entitled "Lakehead Source Protection Area Water Budget and Water Quantity Stress Assessment – A Draft Report for Consideration of the Lakehead Source Protection Committee" (Gartner Lee Limited, 2008).

Temperature Trends

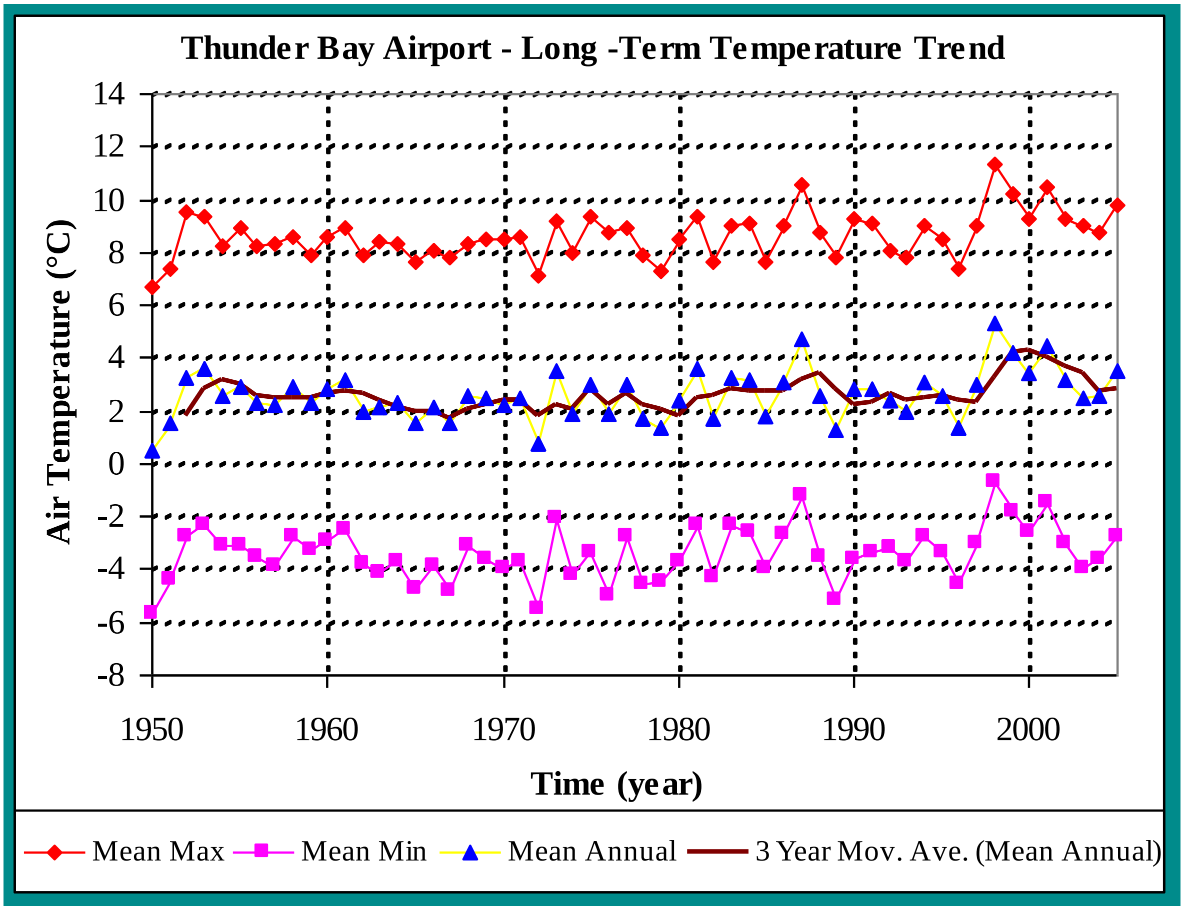
The temperatures within the Lakehead Source Protection Area vary with yearly climatic cycles and geographic location. Based on historical data at the Thunder Bay Airport location for the period 1950 to 2005, the highest air temperatures (above nine degrees Celsius) occur between mid-May and mid-October and start to significantly decrease in late October, when the lowest air temperatures (less than minus five degrees Celsius) occur regularly between November and February. Typically, summer average daily high temperatures (by month) are 14.2 to 17.6 degrees Celsius. Winter average daily temperatures are in the range of minus 2.6 to minus 14.9 degrees Celsius (see Table 21). Figure 7 shows the monthly distribution of average daily, average maximum and average minimum air temperatures at the Thunder Bay Airport climate station.

Figure 7: Average Daily Temperature (by month) at Thunder Bay Airport (1950 to 2005 normals)



The time-series of average annual air temperatures for the 1950 to 2005 period are plotted in Figure 8 along with a three-year moving average trend line, representing the average annual temperature. It suggests that there has been a mild warming trend, which has also been noticed in most locations throughout Canada but does not indicate a significant variation from the long-term average. Nonetheless, the years from 1998 to 2002 have been above average.

Figure 8: Time-Series of Mean Annual Temperatures at Thunder Bay Airport for 1950 to 2005



Of the 55 years shown in Figure 8, the highest mean daily temperature of 5.3 degrees Celsius occurred in 1998, while the lowest mean daily temperature of 0.5 degrees Celsius occurred in 1950. The absolute highest maximum daily temperature of 40.3 degrees Celsius occurred on July 7, 1983, where the lowest minimum daily temperature of minus 41 degrees Celsius occurred on January 30, 1951 (not shown on Figure 8).

Precipitation Trends

Precipitation, like temperature, varies with yearly climatic cycles, geographic location, and elevation. Figure 9 gives the mean monthly distribution of precipitation occurring at the Thunder Bay Airport climate station for the period 1950 to 2005. It is important to understand that this climate station is used because it has the longest and most complete period of record. However it is acknowledged that this station falls within the approximately 16 kilometre extent of lake effects from Lake Superior. (Temperatures are very much warmer nearer the lake in winter, which affects precipitation patterns.) Precipitation data from the former Kakabeka Falls climate station (now decommissioned) may be more representative for the Lakehead Source Protection Area, as it does not exhibit the influence of Lake Superior in its readings. However, the period of record for Kakabeka Falls is too short to be reliably used here.

Figure 9: Mean Monthly Precipitation at Thunder Bay Airport for 1950 to 2005

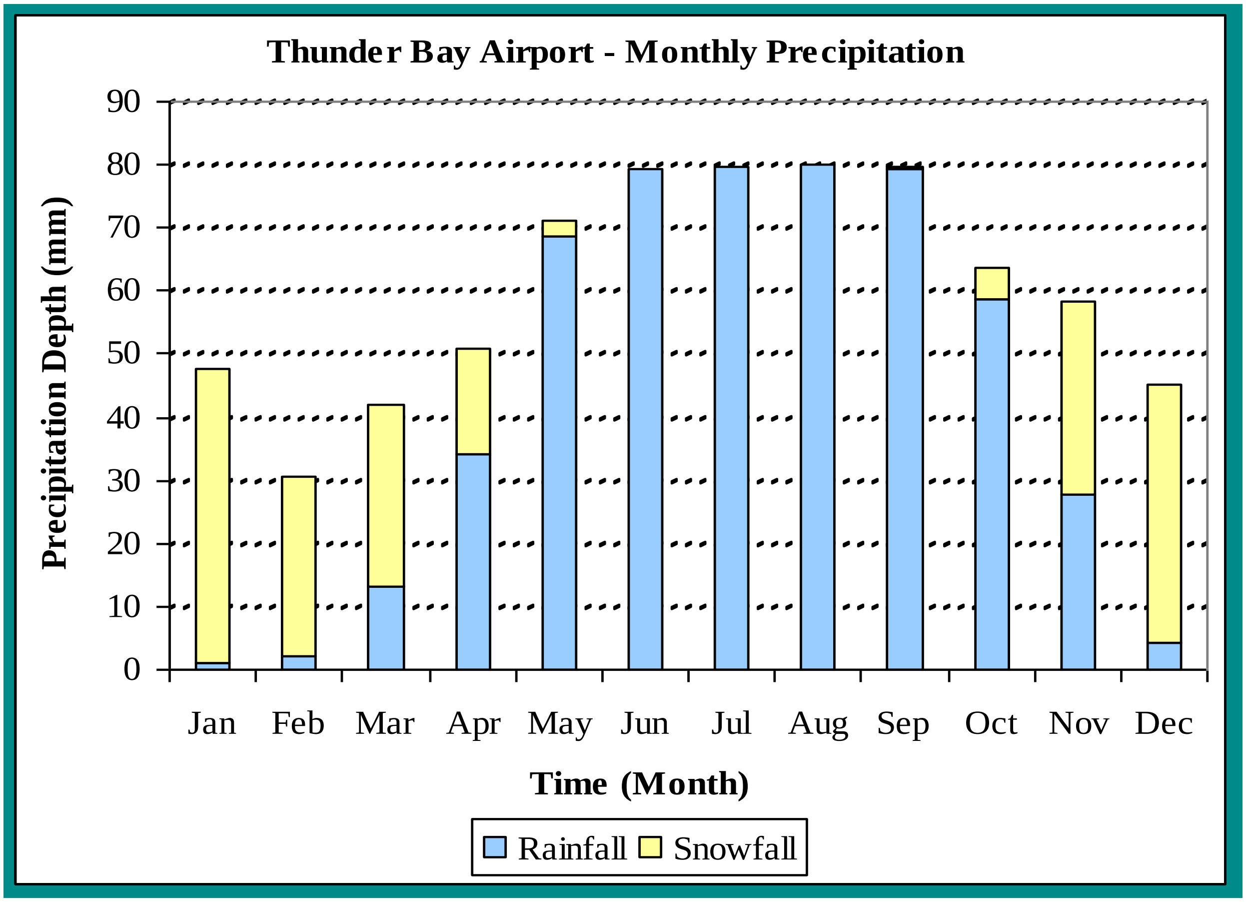
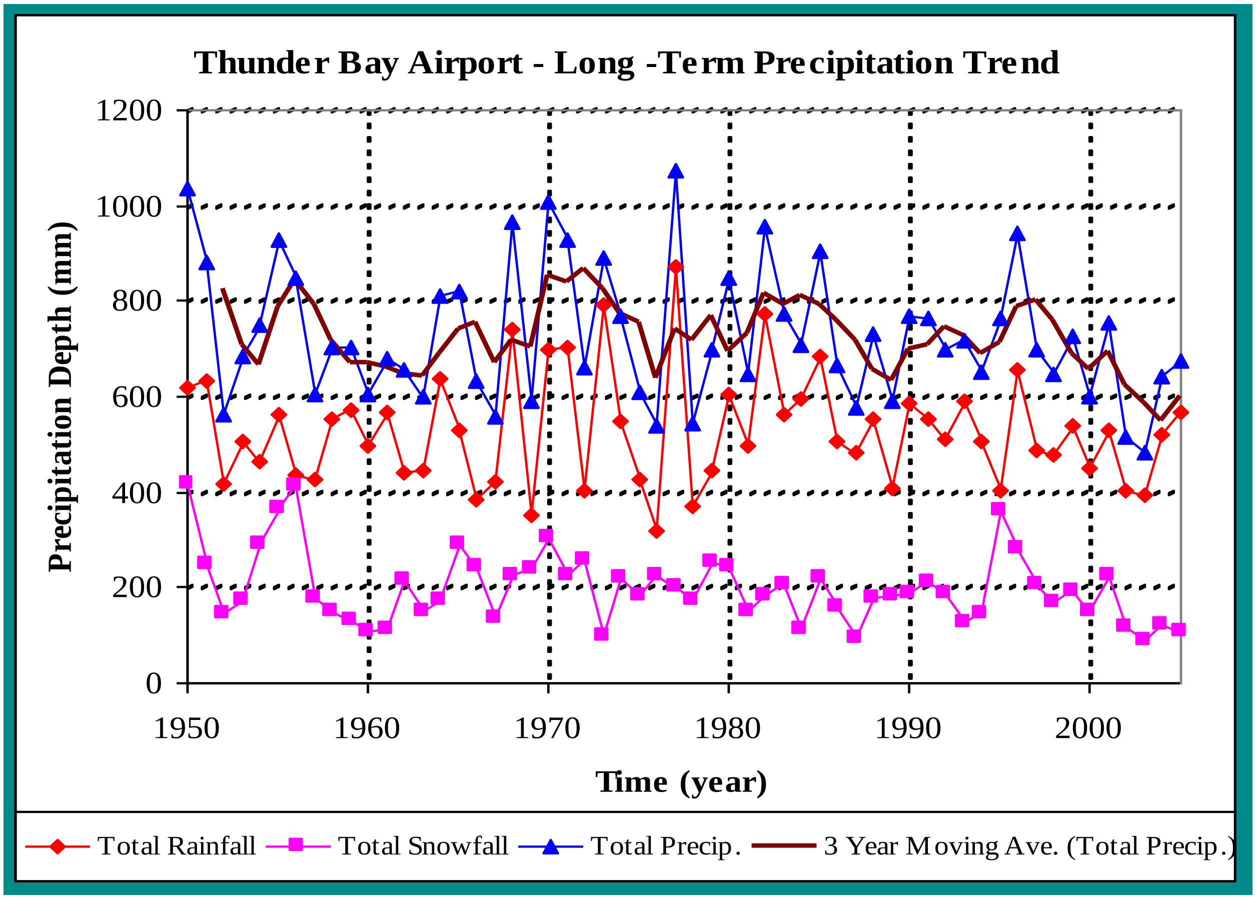


Figure 9 is presented as a stacked histogram graph so that the contributions from rainfall and snowfall can be illustrated concurrently (snowfall is given in equivalent millimetres of water). From Figure 9, we see that the maximum precipitation occurs in the summer months when all of it appears as rainfall. (The high summer rains have much to do with the proximity of Lake Superior at this particular meteorological station.) In winter, most of the total precipitation falls as snowfall in the Lakehead Source Protection Area. Snowfall can occur as early as October, and extend throughout April in small quantities. In some years, there has been snowfall observed in early May.

Figure 10 illustrates the annual time-series of total precipitation, rainfall and snowfall occurring at Thunder Bay Airport from 1950 to 2005. In general, there has been a constant trend in the precipitation totals since the early 1950's. From Figure 10, it appears that the wettest period in terms of total precipitation occurred in the early and late 1970's, whereas the driest periods took place during the early 1960's and early 2000's. The highest annual total precipitation of 1,072 millimetres occurred in 1977, whereas the lowest total of 483 millimetres occurred in 2003. In terms of mean annual rainfall totals, the highest total of 872 millimetres also occurred in 1977, whereas the lowest amount of 317 millimetres occurred in 1976. The highest total snowfall of 416 centimetres (which equals 416 millimetres equivalent water) occurred in 1950, whereas the lowest total of 90 centimetres occurred in 2003.

The greatest twenty four hour rainfall total of 131.1 millimetres took place on July 8, 1977 and the highest twenty four hour snowfall total of 61.5 centimetres took place on January 18, 1996.

Figure 10: Time-Series of Annual Precipitation at Thunder Bay Airport for 1950 to 2005



Snow Courses

The Lakehead Region Conservation Authority monitors three snow course survey locations within the Lakehead Source Protection Area as detailed in Table 22. The location of the snow course stations are shown on Assessment Report Map #19 - Mean Annual Precipitation and Climate Stations (Map Binder - Map Sleeve # 19). Snow course data for the purposes of the water budget analysis was used for the period between 1974 and 2006. The Lakehead Region Conservation Authority continues to collect this data on an annual basis and has data up to and including the 2009/2010 winter season.

Table 22: Lakehead Region Conservation Authority Snow Course Data

Station	Data Record Available	Source	Easting	Northing	Elevation (metres above sea level)
Current River - 1401	1974-2006	LRCA	336,539	5,384,171	438.6
Pennock Creek - 1601	1974-2006	LRCA	319,173	5,361,296	221.5
McVicar Creek - 1501	1974-2006	LRCA	334,784	5,368,865	232.2

Figure 11 shows the temporal distribution of snow water equivalent at three snow courses for a high snow winter (1995-1996). Snow water equivalent is a term that refers to the total millimetres of water contained in the snowfall, assuming it were melted and had fallen as rain.

The maximum snow water equivalent tends to occur in early March. However, Figure 12 provides similar information for a low snow winter (2002-2003) when the maximum snow water equivalent also tends to take place in early to mid-March. During the spring freshet most of the runoff is generated by the melting snowpack because the frozen ground inhibits infiltration. Freshet is the term most commonly used to describe a spring thaw resulting from snow and ice melt in rivers located in the northern latitudes of North America, particularly Canada, where rivers are frozen each winter and thaw during the spring.

Figure 11: Temporal Distribution of Snow Water Equivalent for a High Snow Year (1995 to 1996)

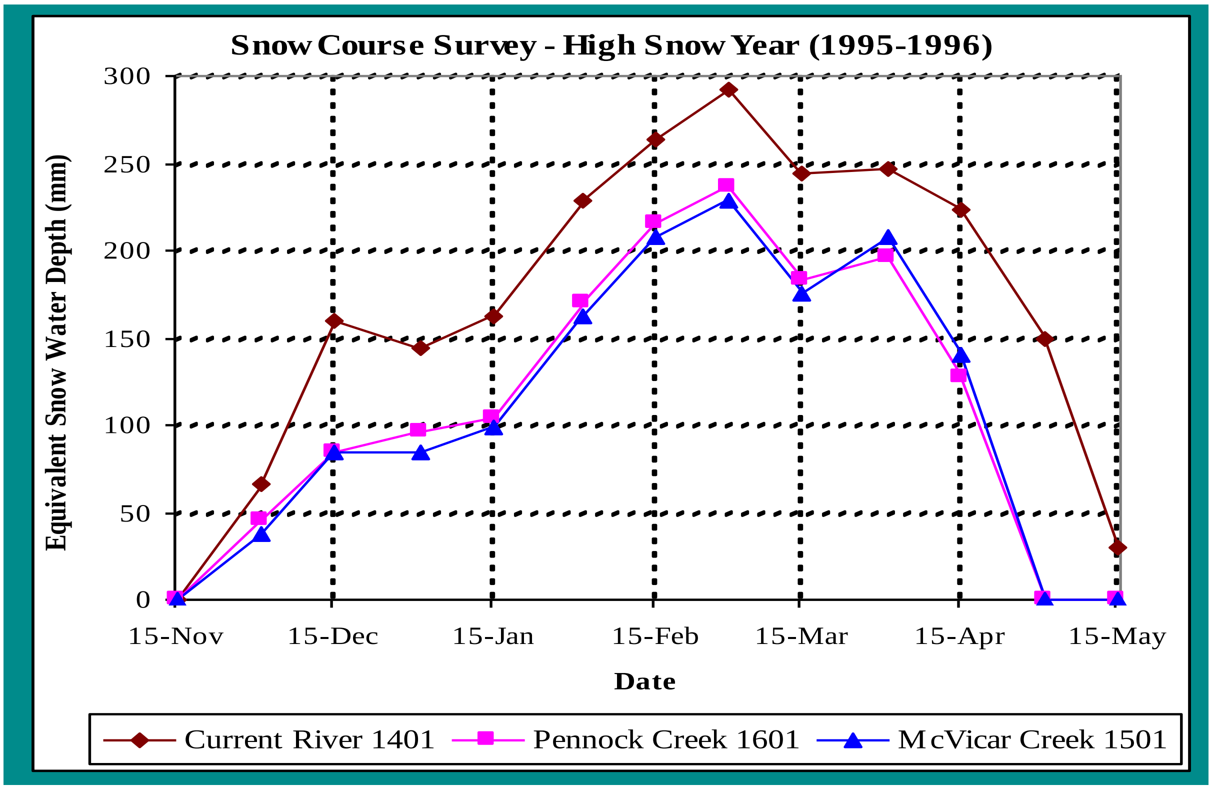
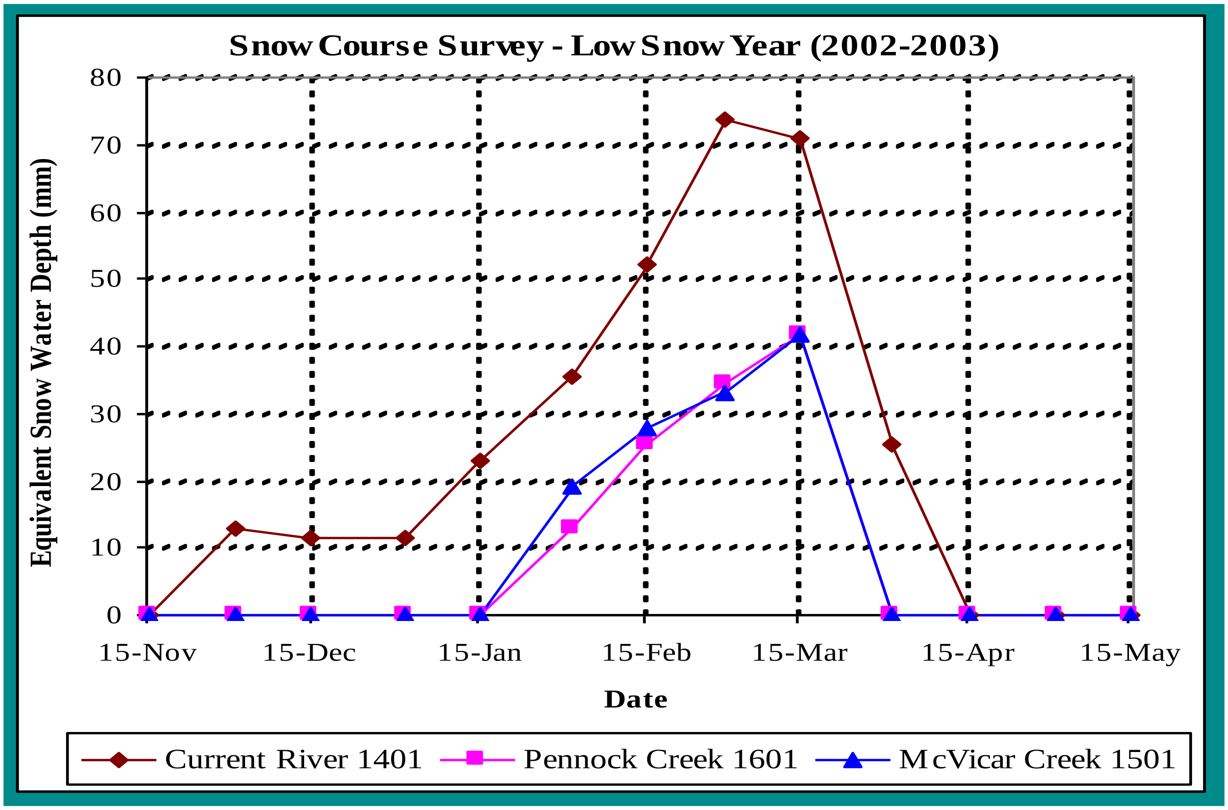


Figure 12: Temporal Distribution of Snow Water Equivalent for a Low Snow Year (2002 to 2003)

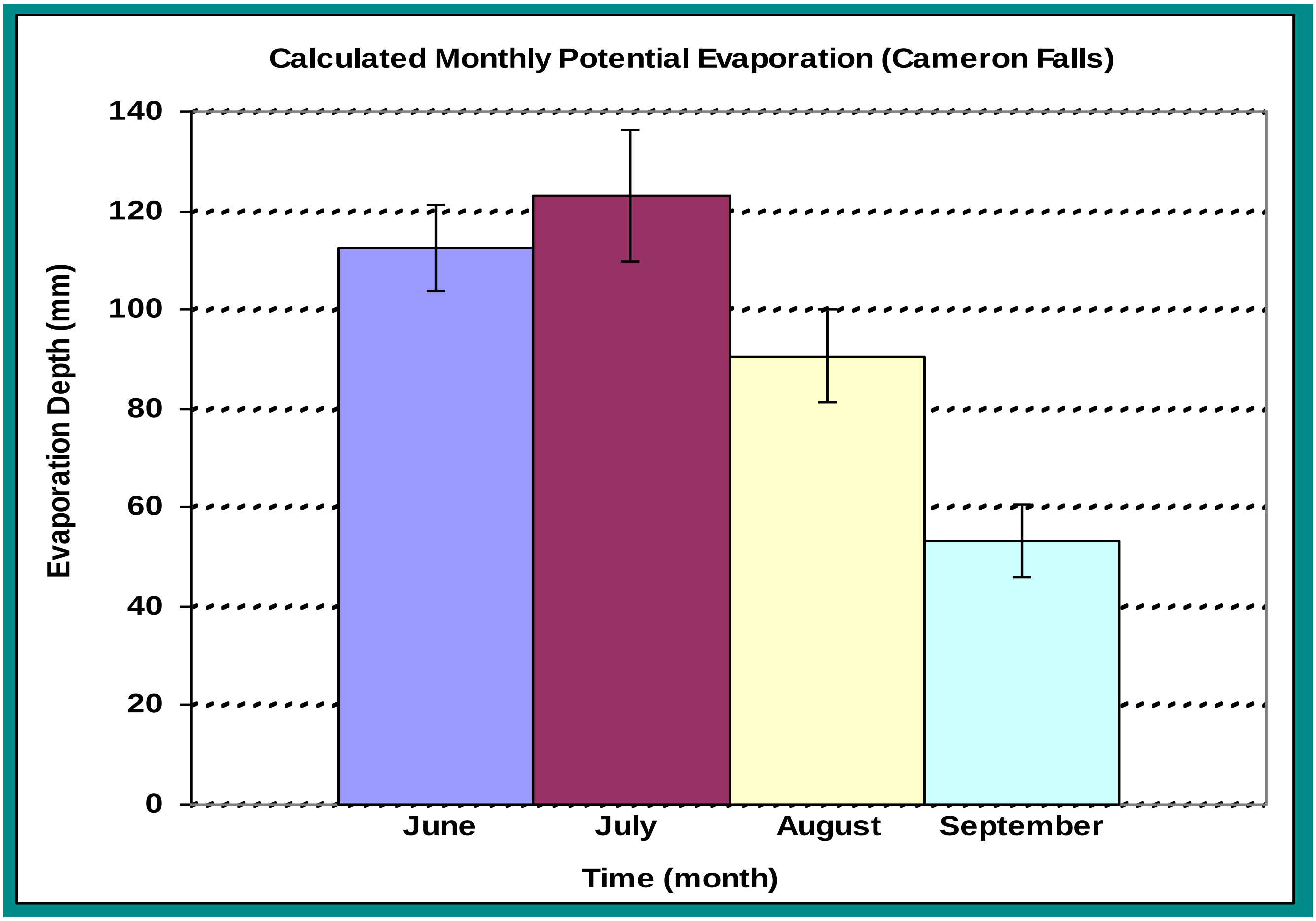


<u>Evaporation and Potential Evapotranspiration</u>

None of the climate stations in the general vicinity of the Lakehead Source Protection Area, as listed in Table 20, have been equipped with pan evaporation measurement equipment that would permit estimates of lake evaporation. Calculated lake evaporation amounts may be used to provide estimates of the available evaporation/evapotranspiration potential in an area. Historically, the closest available evaporation measurements for Northern Ontario have been made by Environment Canada, for different regions of Canada using a "Class A" evaporation pan and calculated lake evaporation (which is always less than pan evaporation) in Cameron Falls, close to the northeastern boundary of the Lakehead Source Protection Area. Although these measurements have not occurred within the Lakehead Source Protection Area, they are sufficiently close enough to provide some indication of the pattern of evaporation potential that can occur within the Lakehead Source Protection Area. Typically, the annual total potential (or lake) evaporation ranges between 570 to 650 millimetres. Given the fact that the Lakehead Source Protection Area is further south, one would expect these values to be higher (annual total estimated lake evaporation in Cameron Falls is 379.4 millimetres) because the sun is at a higher angle of incidence throughout the year.

Figure 13 shows the distribution of mean monthly potential evaporation for Cameron Falls, as taken from the 1951-1980 climate normals. Range bars represent the standard deviation calculated from the monthly lake evaporation totals for the available data during the 1951-1980 period. The highest potential amount occurs in July. When these values (approximately 120 millimetres) are compared with the precipitation amounts (approximately 80 millimetres) given in Table 20 it is evident that the potential evaporation amounts are higher than the precipitation totals. In order to satisfy the deficit between the potential evaporation and precipitation totals, water is drawn from soil-water storage below the land surface, if available.

Figure 13: Mean Monthly Potential Evaporation at Cameron Falls (1951 to 1980 normals)



3.2 Water Budget on a Watershed Basis

Spatial Scale

As indicated previously in the water budget chapter, the Lakehead Source Protection Area consists of a large number of surface water river systems which all ultimately drain to Lake Superior. Groundwater flow is localized towards surface water systems. In the Lakehead Source Protection Area, it is assumed that the surface drainage watershed or subwatershed boundaries correspond to the groundwater flow divides. Given the shallow nature of the groundwater systems, this is a reliable assumption. The Lakehead Source Protection Area 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. In total, twenty-one independent quaternary watersheds (Table 1) are identified within the Lakehead Source

Protection Area. There are 13 usable HYDAT stations within the Lakehead Source Protection Area 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.

Groundwater takings for Municipal drinking water from the Rosslyn Village Subdivision Well Supply consist of two wells operating alternately to supply 29 homes (current as of January 2010), equating to an estimated 90 residents. Groundwater is also the source of private domestic water supplies in the Rosslyn Village area, and other surrounding townships and Municipalities in the Lakehead Source Protection Area that have no access to Municipal Residential Drinking Water service. Approximately 22,000 residents use groundwater from individual private wells within the 11,526 square kilometres of the Lakehead Source Protection Area. There were approximately 3,000 private wells listed in the Ontario Ministry of Environment (MOE) water well database. 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.

The City of Thunder Bay obtains its water supply from Lake Superior, at a volume of approximately 33.6 million cubic metres per year for a population of approximately 109,016. Within the boundary of the City of Thunder Bay, approximately eight percent of the residents use private groundwater wells for their personal water use. The treated wastewater is discharged into Lake Superior via the lower reach of the Kaministiquia River.

Annual Temporal Scale

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

Period 1 occurs from approximately mid-November to the late part of March. Precipitation is generally in the form of snow with the thickness of the snowpack increasing. The temperature is generally below freezing. 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. With the rise in temperature to above freezing, most precipitation is in the form of rain. Melting of the snowpack often leads to high streamflow and flooding. This is enhanced by the fact that the ground is still frozen in March and early April, therefore the snowmelt cannot infiltrate. As suggested by a rise in the water table during this period (April/May), percolating water exceeds the saturation limit of the soil, resulting in significant streamflow runoff. Evapotranspiration is not significant during this period, because the temperature is still low and plant growth is minimal. As the ground thaws, this period becomes a rapid transition from little to no groundwater recharge to significant groundwater recharge.

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 (saturation point) of the soil is exceeded. Limited groundwater recharge can occur during periods of soil moisture deficit when runoff through such features as fractures and ditches, dry kettles or swales reaches the water table. However, during this period 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 is in the form of rain and some snow. The growing season is finished, transpiration is low and evaporation declines as the 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. As the frost sets into the ground, the December period more closely resembles Period 1 in the Lakehead Source Protection Area.

Water availability within the various components of the hydrologic cycle also varies on longer than seasonal scales. For example, there are periodically two to three year periods of above or below average precipitation. The vertical position of the water table can vary by two metres over a year, but can vary by another two metres from year to year, depending upon the availability of recharge from precipitation. To be representative of average conditions, the climatic information used for water budgeting purposes in the Lakehead Source Protection Area has been taken over a 25 year period. 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.

<u>Water Budget Approach</u>

The following approach has been used in initiating the water budget analyses for the Lakehead Source Protection Area watershed:

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, groundwater levels and streamflow conditions.
3. The period of 1970 to 1994 is the period where complete streamflow and precipitation records are coincident.

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 Source Protection Area 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). As a result 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).
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:

$$\mathbf{P + Sw_{in} + Gw_{in} + ANTH_{in} = ET + Sw_{out} + Gw_{out} + ANTH_{out} + \Delta S} \qquad \textit{Equation (1)}$$

Where:	**P**	=	Precipitation.
	$\mathbf{Sw_{in}}$	=	Surface water inflow into the system from outside.
	$\mathbf{Gw_{in}}$	=	Groundwater inflow into the system from outside.
	$\mathbf{ANTH_{in}}$	=	Anthropogenic or human inputs.
	ET	=	Evapotranspiration losses.
	$\mathbf{Sw_{out}}$	=	Surface water outflow from the system.
	$\mathbf{Gw_{out}}$	=	Groundwater outflow from the system.
	$\mathbf{ANTH_{in}}$	=	Anthropogenic or human removals.
	$\mathbf{\Delta S}$	=	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 occurs from open waterways, forest 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:

$$\mathbf{P = AET + S} \qquad \textit{Equation (2)}$$

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:

$$\mathbf{S = RO + R} \qquad \textit{Equation (3)}$$

Therefore Equation (2) can be restated as:

$$\mathbf{P = AET + RO + R} \qquad \textit{Equation (4)}$$

For the preliminary estimation of the water balance components (i.e. actual evapotranspiration, surface runoff and recharge for equation (4) above), the climatic data as determined in Table 20 was used for the periods 1970-1994 for all stations.

In terms of Drinking Water Source Protection Planning, objectives of the water budget exercise include determining the available water in watercourses and the ground, the amount of water being used for anthropogenic purposes and water lost through evapotranspiration from watercourse basins. 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**) and are 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.

3.2.1 Lakehead Source Protection Area Water Budget Calculations

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

Individual monthly 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 Source Protection Area (or watershed) was determined from the mean of the interpolated values over the area of interest. The mean was calculated as described, 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 which were summed and then divided by the entire area to obtain an average value for the entire area of interest.

Precipitation

Assessment Report Map # 19 – Mean Annual Precipitation and Climate Stations
Map Binder – Map Sleeve #19

Illustrated by gradient shading on the map are the mean annual precipitation depths in millimetres. Note the variance in mean annual total precipitation depths as you move from east to west and south to north across the Lakehead Source Protection Area. The climate stations from which data was utilized in the determination of the water budget are also indicated on the map.

As previously discussed and detailed in Table 20, the climate data for six stations within and surrounding the Lakehead Source Protection Area were calculated for the period 1970 to 1994. The mean annual precipitation for each of these six stations was calculated for that time period to agree with the time frame for streamflow records available in the Lakehead Source Protection Area.

The point observations of mean annual precipitation for the six climatic stations were entered into the Geographic Information System (GIS) database and the mean annual precipitation was interpolated with the Inverse Distance Weighted (IDW) formulation technique (as previously mentioned) over the entire Lakehead Source Protection Area. The interpolated annual precipitation is presented in Assessment Report Map # 19 – Mean Annual Precipitation and Climate Stations (Map Binder – Map Sleeve #19). Table 23 presents annual average precipitation estimated by this method for the different watersheds (above specific stream gauges) in the Lakehead Source Protection Area. Among the six selected meteorological stations, precipitation ranges from 771 millimetres per year to 908 millimetres per year averaging to an annual precipitation of 850.8 millimetres per year. A weighted interpolated annual area average for the entire Lakehead Source Protection Area is approximately 843 millimetres per year, which is used in the following analyses.

Table 23 was compiled for the twelve watersheds with gauges and consistent periods of record (1970-1994). A water budget was not completed for gauge stations 02AA001 and 02AB011 because of lack of information and flow measurement inaccuracy.

Table 23: Summary of Water Budget on Subwatershed Basis

Catchment Name	Area (square kilometres)	Average Annual Precipitation (millimetres)	Average Annual Actual ET (millimetres)	Average Annual Surplus (millimetres)	Average Annual Runoff (millimetres)	Average Annual Recharge (millimetres)	Annual Streamflow (millimetres)	Baseflow (millimetres)[1]
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.

Evapotranspiration

Assessment Report Map # 20 – Evapotranspiration
Map Binder – Map Sleeve #20

Illustrated by profile lines on the map, are the mean annual actual evapotranspiration values in millimetres. Note the variance in mean annual actual evapotranspiration as you move from southwest to northeast across the Lakehead Source Protection Area. The climate stations from which data was utilized in the determination of the water are also indicated on the map.

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 actual evapotranspiration by considering soil moisture storage. Based on the application of this method, actual evapotranspiration estimated for the six stations ranges from 496 millimetres to 524 millimetres per year, with an arithmetic average of 506 millimetres per year annually. An area weighted mean annual actual evapotranspiration total of 508 millimetres is derived and used in Table 23. The interpolated annual actual evapotranspiration is illustrated on Assessment Report Map # 20 – Evapotranspiration (Map Binder – Map Sleeve #20).

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 23, with the annual mean streamflow variances from 237.6 millimetres to 336.3 millimetres. The mean annual water balance for the entire Lakehead Source Protection Area is summarized in Table 24. The average streamflow for the entire Lakehead Source Protection Area was calculated by using the flow rate of each individual watershed, divided by the corresponding watershed area, all of which were summed and then multiplied by the total area of the watershed using a pro rata basis.

Summary of the Lakehead Source Protection Area Water Budget

Table 24 below provides a summary of the integrated water budget for the entire Lakehead Source Protection Area. The description column of the table provides some insight as to assumptions and limitations of the analysis.

Table 24: Summary of the Conceptual Water Budget of the Lakehead Source Protection Area (Total Drainage Area: 11,526 square kilometres)

Parameters	Annual Depth (millimetres)	Annual Volume (million cubic metres per year)	Description
Precipitation	842.8	9,714	Interpolated and area averaged annual mean precipitation. Precipitation calculated by arithmetic average of the six stations is 850.8 millimetres.
Actual Evapotranspiration (AET)	508.0	5,855	Interpolated and area averaged annual average actual evapotranspiration. (Arithmetic average of actual evapotranspiration calculated using Thornthwaite and Mather (1957) is 506.2 millimetres per year).
Surplus	334.8	3,859	Spatially distributed average value. (Arithmetic average value is 344.6 millimetres per year).
Recharge	167.8	1,934	Determined in GIS platform.
Runoff	167.0	1,925	Determined in GIS platform.
Mean Streamflow	290.6	3,350	Area weighted mean annual streamflow.
Maximum Streamflow	748.4	8,626	Area weighted maximum annual streamflow.
Minimum Streamflow	62.3	718	Area weighted minimum annual streamflow.
Consumptive Surface Water Takings	5.3	61.2	According to Permit to Take Water (PTTW) Database. Provided in Table 18. See also Table 17.
Non-consumptive Surface Water Takings	54.6	629	Total surface water takings minus the consumptive surface water takings.
Consumptive Groundwater Takings	0.32	3.75	According to the Permit To Take Water (PTTW) database provided in Table 18 and including water takings from private wells for about 22,000 people consuming water at a rate of 335 litres per day per capita.
Non-consumptive Groundwater Takings	0.69	7.93	Total groundwater water takings minus the consumptive groundwater takings.

A total of 9,714 million cubic metres per year falls as precipitation, of which 5,855 million cubic metres per year, is returned to the atmosphere by evapotranspiration (approximately 60 percent). This leaves 3,859 million cubic metres per year as a surplus, available for runoff or recharge. By way of comparison, the average streamflow out of the watershed is 3,350 million cubic metres per year, which is made up of both runoff and baseflow. There is about a 13 percent 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 million cubic metres per year is partitioned between runoff and recharge as about 50 percent of the surplus (1,925 million cubic metres per year) directly runs off, whereas the remaining 1,934 million cubic metres per year 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 million cubic metres per year is 702 million cubic metres per year, of which 637 million cubic metres per year is comprised of non-consumptive uses (Surface Water: 629 million cubic metres per year; Ground Water: 8.0 million cubic metres per year; see also Table 24 for details). 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 25 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 million cubic metres per year, which is only about nine percent of the values reflected in the Permit To Take Water database. Note that the Permit To Take Water database only records maximum usage, not actual usage. Similarly, the actual consumptive groundwater demand from the watershed is about 3.75 million cubic metres per year, which is approximately 32 percent of the peak takings listed in the Permit to Take Water database.

Table 25: Consumptive Surface Water and Groundwater Use/Demand in the Lakehead Source Protection Area

Water Use	Water Takings (million cubic metres per year)	Consumptive Factor	Consumptive Use (million cubic metres per year)
Surface Water			
Total Surface Water Takings according to Permit To Take Water.	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 prior to 2008).	10.22	0.2	2.04
Permitted Takings: Agriculture (Irrigation, Livestock).	21.05	0.9	18.95
Total Consumptive Surface Water Use/Demand			**61.17**
Groundwater			
Total Groundwater Takings according to Permit To Take Water.	11.68		
Permitted Takings: Other - Industrial.	11.35	0.25	2.84
Permitted Takings: Municipal Water Supply.	0.09	0.20	0.02
Permitted Takings: Agriculture (Irrigation, Livestock).	0.24	0.90	0.22
Water Takings: Private wells.	2.69	0.25	0.67
Total Consumptive Groundwater Use/Demand			**3.75**

In calculating the actual consumptive water takings provided in Table 25, the following assumptions were made:

a) Consumptive water loss for power generation is zero which means that all of the water drawn from the watershed is returned to the watershed.
b) Consumptive water loss for industrial water use is 25 percent and the rest is returned to the watershed through drains.
c) Consumptive water loss for Municipal water use is 20 percent (except as noted in Table 24) and the rest is returned to the watershed through residential septic tanks.
d) Consumptive water loss for irrigation water use is 90 percent through evapotranspiration, etc. and the rest is returned to the watershed through infiltration into the ground or runoff to the ditches.

Prior to February 2008 and when the water budget study was conducted, the consumptive use (including Thunder Bay's withdrawal from Loch Lomond) was about 65 million cubic metres per year (Surface Water: 61.17 million cubic metres per year; Groundwater: 3.75 million cubic metres per year: see also Table 29 for details) or 1.68 percent of the surplus. The total use (consumptive and non-consumptive) is about 18 percent of the surplus. After February 2008, the withdrawal from Loch Lomond dropped to zero.

Water Use Percentage

As per the Ontario Ministry of Environment (MOE), 2007: Assessment Report: Draft Guidance Module 7 Water budget and Water Quantity Risk Assessment, March 30, 2007, the percentage of water used in the watershed region was also calculated. Table 24 gives the summary of the conceptual water budget of the Lakehead Source Protection Area. Streamflow volumes are compared to the water use to estimate the "Percent of Water Use" for Lakehead Source Protection Area and these are presented in Table 26.

Table 26: Streamflow Volume versus Surface Water Use Scenarios

Streamflow	Volume (million cubic metres per year)	Water Use [1] (million cubic metres per year)	Percent 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 23)

Table 26 shows that on average, consumptive surface water demand is 1.83 percent over the entire Lakehead Source Protection Area and is used for different purposes, including drinking water. These values are based on the Permit To Take Water database for surface water takings and include only the actual water takings from Loch Lomond, prior to February 2008, as reported in Table 17. Since February 2008, these takings have dropped to zero. Surface water takings from Lake Superior are not considered in this calculation as the water is not taken directly from the watershed. These consumptive water demands are also compared to the minimum and maximum streamflow 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 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 Source Protection Area 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 Lakehead Source Protection Area is relatively small (only 1.83 percent). Even with the worst case scenario of a minimum streamflow volume of 718 million cubic metres per year, the water use is still only approximately 8.5 percent of the water available.

Table 27 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 millimetres, determined within the Geographic Information System and multiplied by the area where most of the wells are concentrated. This area is estimated to be about 4,395 square kilometres. According to the Permit To Take Water database and based on the assumption that approximately 22,000 people use 335 litres per day per capita, the total consumptive groundwater demand in the entire Lakehead Source Protection Area is about 3.75 million cubic metres per year, which represents less than one percent of recharged water in the selected portion of the Lakehead Source Protection Area. As these are just estimated values, further detailed studies on the delineation of the actual recharge area are required in order to more accurately compare groundwater recharge with groundwater use.

Table 27: Groundwater Recharge versus Groundwater Use Scenarios

Parameters	**Amount**
Recharge Area (square kilometres)	4,395
Recharge Rate (millimetres per year)	167.8
Total Groundwater Recharge (million cubic metres per year)	737.5
Consumptive Groundwater Use (million cubic metres per year)	3.75
Percent Consumptive Groundwater Use	0.51

In conclusion of the conceptual water budget, from a water quantity perspective, the amount of water moving through the watershed greatly outweighs present and future anticipated uses, the quantity is reliable. 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.

3.3 Tier 1 Water Budget and Water Quantity Stress Assessment

<u>Introduction</u>

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, water movement within the watershed is understood and the sustainability of Ontario'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 and/or water quality stresses.

The Ontario Ministry of Environment 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 slope. The estimates of the components are performed using either simple numerical analysis or, where necessary, Geographic Information System techniques to assist with this process. For the watersheds of the Lakehead Source Protection Area, which contain a few small communities, two Municipal Residential 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 Source Protection Area, 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 Source Protection Area 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 Source Protection Area was estimated from the Ontario Ministry of the Environment Permit To Take Water database for both surface water and groundwater (see Assessment Report Map #18 – Permits To Take Water; Map Binder - Map Sleeve # 18). The surface water supply was determined from the available streamflow data (1970-1994). The Municipal groundwater supply for the Rosslyn Village Subdivision Well Supply was calculated using data from the "Groundwater Study Report".

Assessment Report Map # 21 – Loch Lomond Watershed
Map Binder – Map Sleeve #21

This map illustrates the watershed area that drains into Loch Lomond.

Assessment Report Map # 22 – Rosslyn Village Wellhead Supply Recharge Map Binder – Map Sleeve #22

This map details the zone of influence for recharge to the aquifer that supplies the Rosslyn Village Subdivision Well Supply, Municipal Residential Drinking Water System.

A Tier 1 analysis must be completed on a subwatershed basis. As there was suitable data available for the Loch Lomond watershed and Rosslyn Village Subdivision Well Supply Recharge Area, these subwatershed/catchment areas were used in the Tier 1 analysis.

At the time this water quantity stress assessment was conducted, the Loch Lomond water supply plant was still in operation. As Loch Lomond had a surface water intake (see Assessment Report Map # 21 – Loch Lomond Watershed; Map Binder – Map Sleeve #21) and there was ample data for conducting an assessment, a water quantity stress assessment was carried out on Loch Lomond. A water quantity stress assessment was conducted for the Rosslyn Village Subdivision Well Supply, Municipal water wells (see Assessment Report Map # 22 – Rosslyn Village Subdivision Well Supply Recharge; Map Binder – Map Sleeve #22) to determine if there are any concerns regarding the sustainability of the Municipal drinking water supply for 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.

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 Source Protection Area "Conceptual Water Budget Understanding" phase using climate data (1970-1994). The recharge was estimated using the Geographic Information System techniques previously mentioned in this chapter.

3.3.1 Water Supply Estimation

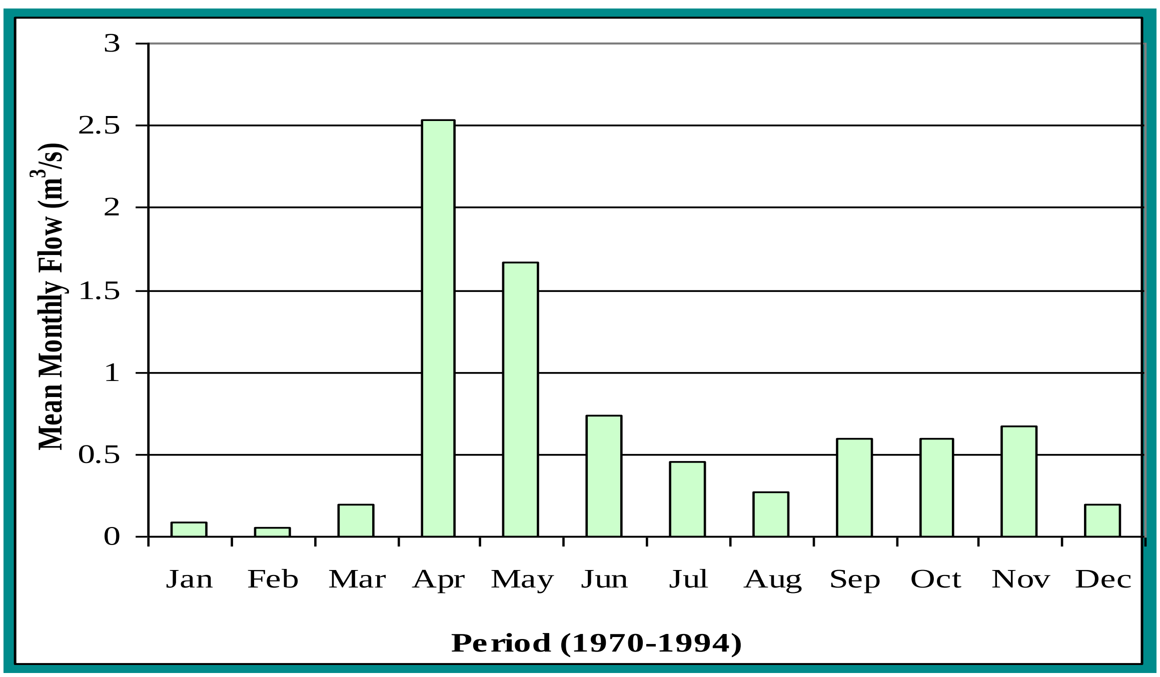
Surface Water Supply Evaluation

Although Lake Superior is the source of Municipal Residential Drinking Water Supply for the Thunder Bay (Bare Point Road) Water Treatment Plant, given Lake Superior's tremendous storage volume and the fact that it obtains recharge from multiple watersheds around the entire lake, it cannot be included in the calculations for the water budget analysis. As Loch Lomond no longer supplies potable water to the City of Thunder Bay Municipal Residential Drinking Water System (as of February 2008), the water supply from Loch Lomond is included as an estimation of water supply for the purposes of a Tier 1 analysis.

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-rated 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 14 depicts the mean monthly flow distribution at Loch Lomond with the highest flow occurring in April with a value of approximately 2.53 cubic metres per second. The lowest flow month is February with a mean flow of approximately 0.06 cubic metres per second. The mean annual flow at Loch Lomond is 0.68 cubic metres per second. 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 to 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 14: Mean Monthly Flow (Water Supply) at Loch Lomond



Groundwater Supply Evaluation

Within the Lakehead Source Protection Area, the only groundwater-based Municipal Residential Drinking Water Supply system is in Rosslyn Village. There are two wells in Rosslyn Village which operate alternately to feed the Municipal Residential Drinking Water Supply system. The following paragraphs summarize the results of a groundwater modelling study on the Rosslyn Village Subdivision Well Supply conducted by R.J. Burnside in association with AMEC Earth and 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 gravel/basal sand units. The gravel/basal sand unit was interpreted to extend over a distance of about 1,200 metres to 1,800 metres 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 metres 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 metres. 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 gravel/basal sand aquifer is expected to be about 66 square metres per day. Based on this transmissivity value and taking into account that the basal unit thickness is about three metres to six metres, the hydraulic conductivity of the basal unit is expected to be in the order .001 metres per second. Apparent transmissivity of the bedrock aquifer was estimated to be in the range of 0.08 square metres per day to 82.3 square metres per day, with a geometric mean of 2.8 square metres per day (Waters, 2003). The average penetration depth of wells in the area into this aquifer is about 37 metres.

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 the water level in the Kaministiquia River (about 195 metres above sea level) 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 Source Protection Area 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 Source Protection Area (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 Village is supplied from a Municipal groundwater well under the Ontario Ministry of Environment Permit to Take Water (#3684-65WJW8) with the maximum allowable water takings of 124.4 cubic metres per day for each pump. Some residents have chosen to drill their own wells which access the same aquifer. 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 cubic metres per day, most of which comes from recharge.

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 chapter, the consumptive surface water and groundwater use/demand was quantified based on the Ontario Ministry of Environment Permit To Take Water in the Lakehead Source Protection Area. The quantities of permitted water takings as reported in the Permit To Take Water 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 Source Protection Area is calculated based on the actual water takings from the watershed.

Surface Water Demand

The actual surface water takings from Loch Lomond, in cubic metres per month, in the year 2002 is shown in Table 28 and Figure 15. The 2002 monthly water taking data was used as it was the best available water supply data at the time the water budget analysis was completed. It should be noted that as of February 2008, Loch Lomond was no longer used as a source of Municipal Residential Drinking Water so there will be no other data records for Loch Lomond after this date.

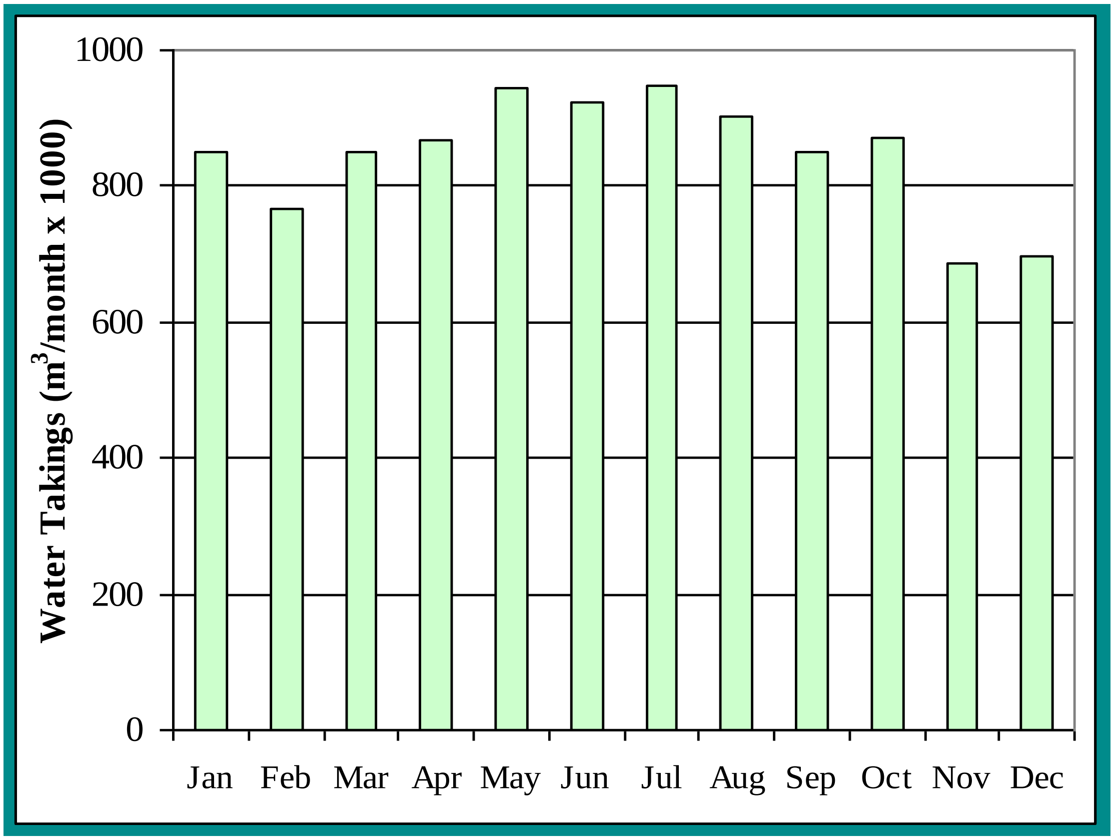
Table 28: Summary of Quantity of Water Supplied by the Loch Lomond Water Treatment Plant in the Year 2002

Period	**Water Takings** (cubic metres per month)	**Average Daily Takings** (cubic metres per 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 (cubic metres per year)	**10,152,800**	
Permitted Water Takings (cubic metres per year)	**28,207,930**	

Data source: City of Thunder Bay

The total actual water takings are about 10 million cubic metres per year, which is about 36 percent of the maximum allowable takings according to the Permit To Take Water database. Table 28 also shows that the maximum monthly water taking is in the month of July.

Figure 15: Monthly Water Takings from Loch Lomond Water Treatment Plant



Groundwater Demand

Calculated water takings from the Rosslyn Village Subdivision Well Supply are provided in Table 29 and graphically shown in Figure 16. As only daily average water takings data 35 cubic metres per day, Burnside and AMEC (2005) were available for the Rosslyn Village Subdivision Well Supply, 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 cubic metres (Table 28);
b) This annual total was divided by 12 to get an average monthly taking of 846,067 cubic metres;
c) The actual given monthly takings (column c in Table 29) were divided by the arithmetically averaged monthly takings (b, Table 29) to get a coefficient for each month (column d in Table 29); and

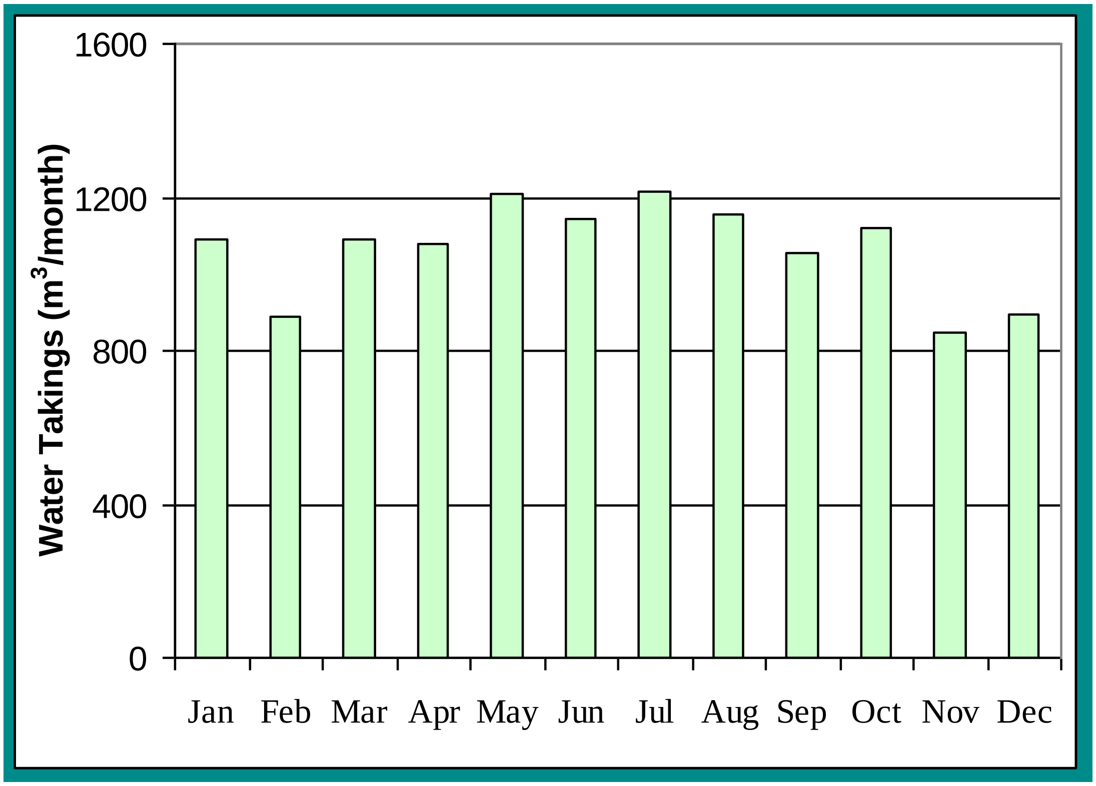
d) The coefficient, which is variable for each month, was then multiplied by the given monthly average takings from the Rosslyn Village Subdivision Well Supply to get monthly water takings for the Rosslyn Village Subdivision Well Supply (Table 29). The consultant did not receive actual water taking records during the study period for the water budget analysis.

Table 29: Summary of Water Takings Calculated for the Rosslyn Water Supply Well

Period (a)	Days of the Month (b)	Monthly Water Takings (cubic metres per month)* (c)		Coefficient ** (d)		Monthly Water Takings (cubic metres per 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 (cubic metres per year)		**12,787**				

Notes: * Calculated by multiplying the reported average daily water takings (35 cubic metres per 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 16: Calculated Monthly Water Takings from the Rosslyn Water Supply Well



<u>Water Reserve Estimation (Surface Water and Groundwater)</u>

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 (instreamflow needs) as well as other human uses, 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 Source Protection Area, 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 Ontario Ministry of Environment (MOE) Guidance Module 7 as ten percent of the total supply. For groundwater, the reserve quantity is also estimated as ten percent 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.

3.4 Water Budget Summary

In addition to providing an integrated water budget summary for the entire Lakehead Source Protection Area, water budgets were calculated for twelve subwatersheds under the Conceptual Water Budget section of this chapter. 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 percent of surplus water was identified as baseflow.

For the purposes of the water budget analysis an estimation of Loch Lomond's water use in the future (assumed at the rate detailed in the data used for the analysis), a detailed water budget analysis for Loch Lomond was conducted for its contributing watershed as a part of Tier 1 analysis. Note that as Loch Lomond ceased operation in 2008, this calculation was made for the purposes of calculating future water supply and demand, only in order to fill a data gap for the water budget analysis. The total contributing catchment area for Loch Lomond (including the lake itself) is estimated to be 76.7 square kilometres. The mean monthly and annual water balances for Loch Lomond are summarized in Table 30.

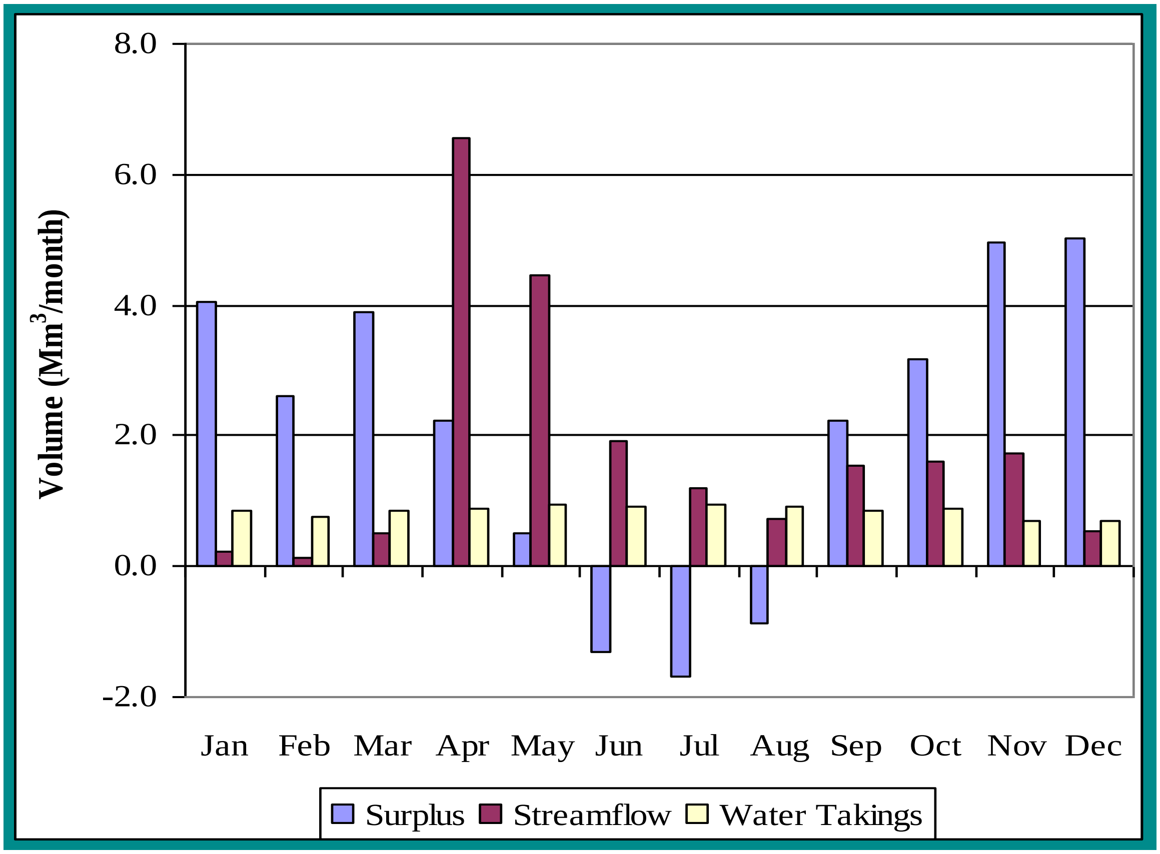
As shown in Table 30, the annual total precipitation applied to Loch Lomond is approximately 63.5 million cubic metres. Approximately 39 million cubic metres (or approximately 61 percent of annual precipitation) is lost through evapotranspiration. Approximately 25 million cubic metres (or approximately 39 percent assumed to reach the lake through groundwater flow and runoff). Out of 25 million cubic metres of surplus water, approximately ten million cubic metres has typically been withdrawn from Loch Lomond for Municipal water supply. As mentioned previously, the total streamflow 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 ± 15 percent. A breakdown of water surplus, streamflow, and water takings on a monthly basis is shown on Figure 17 graphically.

Table 30: Monthly and Annual Water Budget for the Loch Lomond Watershed

Month	**Precipitation** (million cubic metres)	**Actual ET** (million cubic metres)	**Surplus** (million cubic metres)	**Streamflow** [(1)] (million cubic metres)	**Water Takings** (million cubic metres)
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 an areal proportional basis.

Figure 17: 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. It should be noted that in the summer months the water level at Loch Lomond drops below the dam spillway level but as the dam leaks there is always some flow in the stream.

3.4.1 Subwatershed Stress Assessment

Assessment Report Map # 23A – Surface Water Stress
Map Binder – Map sleeve #23A

This map illustrates on a subwatershed basis, the levels of water quantity stress on surface water in the Lakehead Source Protection Area, as determined by the subwatershed stress assessment.

Assessment Report Map # 23B – Groundwater Stress
Map Binder – Map Sleeve #23A

This map illustrates on a subwatershed basis, the levels of water quantity stress on groundwater in the Lakehead Source Protection Area, as determined by the 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: current conditions and future growth demand.

The Percent 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 31: Tier 1 Stress Assessment Scenarios

Time Period	Average Annual Percent Water Demand	Highest Monthly Percent Water Demand
Current Conditions	Groundwater Supplies	Groundwater and Surface Water Supplies
Future Growth Demand	Groundwater Supplies	Groundwater and Surface Water Supplies

Table 31 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 Percent 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 "Ontario Ministry of Environment Module 7 October 2006", those subwatersheds receiving a low level of stress will require no further water budgeting 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 32 and 33 identify the Tier 1 stress thresholds for surface and for groundwater, respectively.

Table 32: Tier 1 Stress Thresholds (Surface Water) (MOE, 2007)

Surface Water Quantity Stress Level Assignment	Maximum Monthly Percent Water Demand
Significant	> 50 percent
Moderate	20 percent – 50 percent
Low	< 20 percent

Table 33: Tier 1 Stress Thresholds (Groundwater) (MOE, 2007)

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

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.

<u>Inland Surface Water Source – Loch Lomond Municipal Residential Drinking Water System</u>

Historically, Loch Lomond was the only inland surface water Municipal Residential Drinking Water System in the Lakehead Source Protection Area. Although no longer operating as a Municipal Residential Drinking Water System, Loch Lomond was the only existing inland surface water system with data within the watershed, a surface water stress calculation was performed for Loch Lomond. The calculation was made using historical data and under the assumption that Loch Lomond was still in use for the purposes of the completion of the Water Budget Tier 1 Analysis only.

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:

$$\textit{Percent Water Demand (Surface Water)} \quad \frac{Q_{DEMAND}}{Q_{SUPPLY} - Q_{RESERVE}} \times 100$$

The terms of the equation were determined as follows:

***Q_{Supply}* (Surface Water Supply):**
Calculated on a 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 square kilometres, a lake depth of 10 metres and dividing the total volume by 12.

***Q_{Demand}* (Surface Water Demand):**
Taken as the estimated water takings from Loch Lomond in 2002, the year of the data used for all calculations.

***$Q_{Reserve}$* (Surface Water Reserve):**
Calculated as 10 percent of the lake reserve.

***Percent Surface Water Demand*:**
Calculated using the expression mentioned above.

Table 34 provides monthly percentage surface water demand calculated using the above expression. Also shown in Table 34 is the monthly stress level assignment based on the threshold values listed in Table 33.

Table 34: Summary of Tier 1 Surface Water Stress Assessment for Loch Lomond

Month	**Streamflow** (million cubic metres)	**Lake Reserve** (million cubic metres)	**Inflow into the Lake** (million cubic metres)	**Water Takings** (million cubic metres)	**Percent 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 percent, 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 32. Future growth demand is not calculated, as the potential water use from the lake is not known and the existing use ceased in February 2008.

<u>Groundwater Source – Rosslyn Water Supply Well</u>

Within the Lakehead Source Protection Area, the only groundwater based Municipal Residential Drinking Water System is in Rosslyn Village in the Municipality of Oliver Paipoonge. Therefore, a groundwater stress calculation is performed and a stress level is assigned for the Rosslyn Village subcatchment. The Tier 1 Groundwater Stress Assessment for the Rosslyn Village subwatershed determined the following terms/parameters by using a simple calculation:

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

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 percent of the groundwater recharge (supply).

Percent 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 35. Table 35 indicates that Rosslyn Village's water requirements can be met by pumping one production well. The consumption rate is far below the maximum allowable water takings Permit To Take Water and therefore, it is unlikely that the village should exceed its permit allowance.

The annual maximum (based on the Permit To Take Water database) and average annual percentage groundwater demand is 2.15 percent and 0.60 percent, respectively. The stress assessment for either scenario is low (see Table 35) as they are below the threshold value of ten. Since 99 percent 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 future population trend available, however if one assumes an increase of ten percent the above figures do not change appreciably (< one percent) and therefore a LOW stress level is determined for the future growth scenario.

Table 35: Summary of Tier 1 Groundwater Stress Assessment for the Rosslyn Water Supply Well

Tier 1 Components	Cubic metres per year	Cubic metres per month	Comments
Recharge	2,315,560	195,963	From a 3-D GW Flow Model (Burnside and AMEC, 2005)
Groundwater Inflow	31,755	2,646	From a 3-D GW Flow Model (Burnside and AMEC 2005)
Water Supply (Recharge + Groundwater Inflow)	2,347,315	195,609	
Maximum Water Takings (Water Demand)	45,398	3,783	Permit To Take Water # 3684-65WJW8
Average Annual Water Takings (Water Demand)	12,787	1,065	Based on daily average water takings
Reserve	234,731	19,561	10 percent of Water Supply
Percent Water Demand (Maximum Water Takings)	2.15	2.18	Considered Max Water Takings + Reserve; monthly percent water demand accounts for only recharge instead of total water supply
Percent Water Demand (Actual Water Takings)	0.60	0.61	Considered Ave Annual Water Takings + Reserve; monthly percent water demand accounts for only recharge instead of total water supply
Stress Assessment Assignment	Low	Low	Percent Demand <10 percent of threshold level

The available water supply in the Source Protection Area is magnitudes greater than the consumptive water takings. The two subwatersheds that have the largest number of water takings including municipal systems only amount to a percent water demand of 5.84% (maximum monthly) for surface water and 2.15% (average annual) for groundwater. Both result in an assignment of LOW subwatershed stress. Applying this understanding to all the other subwatersheds where there is little to no water demand would result in percent water demands of the same order of magnitude and with a high certainty of being less than the provincial thresholds required to assign a moderate subwatershed stress. Therefore, all the subwatersheds in the Source Protection Area are assigned a subwatershed stress of LOW with high degree of certainty.

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 ten percent should check all calculations to ensure that all estimates can be considered conservative. This is not the case for the Lakehead Source Protection Area where the Percent Water Demand is generally less than six percent; therefore, there is a high level of certainty in assigning a low stress to those areas of the Source Protection Area with significant water resources and limited to no water takings.

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 uncertainly. 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. One unknown consumptive use of the aquifer is the volume of water that is drawn from private wells. The volume of draw on the well from private users is not captured in any certificate, Permit To Take Water or other documentation related to the Rosslyn Village Municipal Residential Drinking Water System.

4.0 Vulnerability

Information gathered during technical studies required to create the previous chapters of the Assessment Report was instrumental in identifying vulnerabilities to sources of drinking water. The completion of a watershed characterization and determination of a water budget are important first steps in accurately determining all potential situations which could jeopardize the safety of a Municipal Residential Drinking Water Source.

The consultants used the Ministry of Environment "Assessment Report Draft Guidance Modules, October 2006" to complete the technical studies that determined the vulnerable areas around the Municipal groundwater source in Rosslyn Village and Municipal surface water source for the City of Thunder Bay. The Lakehead Region Conservation Authority technical staff worked in partnership with Municipal staff from the Municipality of Oliver Paipoonge and City of Thunder Bay, to assist and guide the consultant as required. The draft work of these studies was reviewed by the Lakehead Region Conservation Authority and respective Municipal technical staff prior to the consultant producing the final report. These reviewers concluded that the consultants completed the recommended revisions for the final report as requested and in compliance with the Ministry of Environment "Assessment Report Draft Guidance Modules, October 2006". These reports were completed and provided to the Lakehead Source Protection Committee for their consideration in the development of the Assessment Report in late 2008 and early 2009. Subsequent to receiving these technical reports, the Ministry of Environment released the

"Directors Technical Rules, Clean Water Act, 2006" in November 2008 and then a Revised "Directors Technical Rules, Clean Water Act, 2006" in November 2009. During the development of the Assessment Report and in order to meet the requirements of the "Directors Technical Rules, Clean Water Act, 2006", the Lakehead Source Protection Committee has amended and updated some of the information provided in the technical reports. The following reports, studies and other information were used in the determination of Municipal source water vulnerability.

Study/Report/Information	Source
"Directors Technical Rules, Clean Water Act, 2006"	Ontario Ministry of Environment (November 2009)
"Assessment Report Draft Guidance Modules, October 2006"	Ontario Ministry of Environment
"Lakehead Region Conservation Authority Thunder Bay Aquifer Characterization, Groundwater Management and Protection Study" ("Groundwater Study")	R.J. Burnside and Associates and AMEC Earth and Environmental (2005)
"Watershed Characterization Report – A Draft Report for Consideration of the Lakehead Source Protection Committee"	Lakehead Region Conservation Authority, 2008)
"Groundwater Vulnerability Analysis Issues Evaluation Threats, Inventory and Water Quality Risk Assessment for the Hamlet of Rosslyn Village Wellhead Protection Area, Municipality of Oliver Paipoonge, Ontario"	AMEC Earth and Environmental (December 2008)
"City of Thunder Bay Source Protection Technical Study – Bare Point Water Treatment Plant, Final Phase 1 Report"	Stantec Consulting Limited (January 2009)
"City of Thunder Bay Source Protection Technical Study – Bare Point Water Treatment Plant, Final Phase 2 Report"	Stantec Consulting Limited (February 2009)

4.1 Groundwater Vulnerability

This chapter will identify areas of groundwater vulnerability, assess the potential for contamination and identify areas of potential concern within the Lakehead Source Protection Area. The geology and hydrogeological conditions within the Lakehead Source Protection Area have been discussed in previous chapters of this Assessment Report. Within the Lakehead Source Protection Area, the focus of the groundwater vulnerability analysis was on the two Municipal Drinking Water Wells that service the Rosslyn Village Subdivision Well Supply. Groundwater vulnerability information was primarily obtained from the two reports entitled: "Lakehead Region Conservation Authority Thunder Bay Aquifer Characterization, Groundwater Management and Protection Study" ("Groundwater Study") R.J. Burnside and Associates Ltd. and AMEC Earth and Environmental 2005, and "Groundwater Vulnerability Analysis Issues Evaluation Threats, Inventory and Water Quality Risk Assessment for Hamlet of Rosslyn Village Wellhead Protection Area Municipality of Oliver Paipoonge, Ontario" AMEC Earth and

Environmental 2008. The "Groundwater Study" was a broad, overreaching analysis of aquifers and groundwater within a boundary determined by encompassing 95 percent of the population in the populated areas of the City of Thunder Bay and surrounding Municipalities, Townships and unorganized territories. The AMEC Earth and Environmental 2008 report is an assessment of a study area limited to the immediate areas surrounding the Rosslyn Village Subdivision Well Supply.

4.1.1 Uncertainty Analysis

The uncertainty of the data related the in groundwater vulnerability analysis was assessed at two levels.

a) A broad vulnerability analysis related to aquifer vulnerability and groundwater recharge within the scientific boundaries of the Lakehead Source Protection Area
b) A more focused area that surrounds the Rosslyn Village Subdivision Well Supply.

Aquifer vulnerability for the entire study area of the "Groundwater Study" was assessed using the Groundwater Intrinsic Susceptibility Index approach as referenced in the Ministry of Environment "Groundwater Study Technical Terms of Reference, November 2001" and an unknown addendum to the "Groundwater Study Technical Terms of Reference, November 2001" stated in the "Groundwater Study" as being issued in August 2002. A large portion of the vulnerability assessment carried out in the "Groundwater Study" was based on existing well data (2003) that the consultant reviewed. In the absence of useful well data over the Precambrian Uplands, additional information with respect to the location of water table and the hydraulic characteristics was needed, therefore the "Groundwater Study" states that "for this purpose, the hydraulic conductivities of the upper weathered and fractured rocks were considered and assumed as relatively high". As a result of these broad and far reaching assumptions which may not be accurate or reflective of the local conditions, combined with sparse well data which can be prone to data shifting, the Lakehead Source Protection Committee feels that there is a high level of uncertainty in the groundwater vulnerability analysis of aquifer vulnerability and groundwater recharge within the Lakehead Source Protection Area.

The conceptual hydrogeologic model in the vicinity of the Rosslyn Village Subdivision Well Supply was based on several confidently located, water well records. The majority of wells with known locations, are clustered in the vicinity of the two wells associated with Rosslyn Village Subdivision Well Supply. The next closest wells are a cluster of four wells located north of Highway 11/17 outside of the northern boundary of the conceptual ground water model. Two wells located about 700 metres north of the two wells associated with Rosslyn Village Subdivision Well Supply, in the vicinity of Blind Line Road, provide some additional information for development of the conceptual model. It is assumed that the unnamed tributary to Pennock Creek (and ultimately the Neebing River), located about 1.5 kilometres north of the Rosslyn Village Subdivision Wells is the northern recharge boundary for the aquifer. The "Ground Water Study" stated that the uncertainty in the accuracy of the conceptual model is moderate and the level of confidence in the interpreted bedrock topography and distribution of saturated soil layers and types is moderate to high. Uncertainty increases at greater distance from the developed part of Rosslyn Village.

4.1.2 Highly Vulnerable Aquifers

Assessment Report Map #24 – Intrinsic Susceptibility to Contamination
Map Binder - Map Sleeve #24

This map illustrates the intrinsic susceptibility to contamination index results (ISI) for the area, with available data, within the Lakehead Source Protection Area. Intrinsic susceptibility is assigned to areas based on the properties of soil depth and permeability. These score areas are assigned a classification of High, Medium or Low depending on their intrinsic susceptibility index (ISI) score according to Part IV.1 of the "Ministry of Environment Director Technical Rules: Assessment Report Clean Water Act, 2006".

Assessment Report Map #25 – Vulnerability Scores for Highly Vulnerable Aquifers
Map Binder - Map Sleeve #25

This map illustrates Highly Vulnerable Aquifers for the area, with available data, within the Lakehead Source Protection Area. Highly Vulnerable Aquifers are areas with an Intrinsic Susceptibility Index score less than 30. All Highly Vulnerable Aquifers are assigned an automatic vulnerability score of 6. Vulnerability scores are assigned according to Part V11.1 of the "Ministry of Environment Director Technical Rules: Assessment Report Clean Water Act, 2006".

Table 36 provides a summary of the area coverage of Highly Vulnerable Aquifers. As data is not available for the entire Source Protection Area, percentages were calculated for the both the "Groundwater Study" area and entire Lakehead Source Protection Area.

Table 36: Area Coverage of Highly Vulnerable Aquifers

Intrinsic Susceptibility Index Score (ISI)	Area Within "Groundwater Study" Boundary (hectares)	Percentage of Area Within "Groundwater Study" Boundary	Percentage of Total Area Within Lakehead Source Protection Area
High (ISI < 30)	452,151	75	39
Medium (30 < ISI < 80)	127,998	21	11
Low (ISI > 80)	21,500	4	2

The potential vulnerability of an aquifer to groundwater contamination is a function of the susceptibility of infiltration to the recharge area. A vulnerable aquifer can be defined by the tendency or likelihood of contamination reaching a specified position in the groundwater system and accessing the aquifer. Aquifer vulnerability is not an absolute property but a relative indication of areas where contamination is likely to occur. The "Ground Water Study" identified areas of susceptibility to contamination using the Intrinsic Susceptibility Index (ISI) method. As the ISI method was one of the methods referenced by the "Directors Technical Rules, Clean

Water Act, 2006", it was used by the Lakehead Source Protection Committee to assess groundwater vulnerability This method uses a combination of soil depth and permeability to determine an intrinsic susceptibility to contamination. The area considered in the "Groundwater Study" does not include the extents of the Lakehead Source Protection Area, but includes the Lakehead Region Conservation Authority boundaries and an additional area to the north and west. It was assumed, for the purposes of the "Groundwater Study" that this area encompassed 95 percent of the population in the populated areas of the City of Thunder Bay and surrounding Municipalities, Townships and Unorganized Territories.

Existing well data for this area covered by the "Groundwater Study" is sparse and often inaccurate. Well data appears to be contained in a narrow band outside the limits of the City of Thunder Bay, extending into the rural areas.

Given a lack of data for the northern reaches of this area, certain assumptions were made in determining susceptibility to contamination. The "Ground Water Study" assumed that for a large portion of the area that the groundwater table coincides with the water level in nearby surface water bodies and that the hydraulic conductivities of the upper weathered and fractured rocks are relatively high. In Precambrian Shield formations, such as those found across the Lakehead Source Protection Area noted in Map #11A, Quaternary Geology, there is low-permeability and complicated branched, drainage pathways and the assumptions made in the "Ground Water Study" are not accurate for these types of geological formations. In these cases, groundwater flow is not simply or easily described, partially due to the large networks of overland water pathways and connections to surface water bodies. The "Groundwater Study" states that given the variable nature of the surficial material in the study area and the variability of the bedrock material itself, delineation of aquifer suitability in terms of water supply potential and water quality would require site-specific hydrogeological studies.

In an attempt to improve on the available information related to groundwater data, the Lakehead Source Protection Committee researched alternative methods of determining Highly Vulnerable Aquifers. A discussion with Mattagami Region Source Protection Authority determined that their Highly Vulnerable Aquifers were also determined using the Intrinsic Susceptibility Index approach, which was supplemented with borehole data available within the Mattagami Region . By using a cell-based statistical approach to combine borehole data with intrinsic susceptibility data the Mattagami Region Source Protection Authority was able to identify areas of high aquifer vulnerability. The availability of similar borehole data for the Lakehead Source Protection Area is not existent and in addition, the Ontario Ministry of Natural Resources Water Resources Information Program (WRIP) identified some inaccuracies in the Water Well Information System (WWIS) that was available during the development of the Assessment Report.

Highly Vulnerable Aquifers have been included in the Assessment Report but with questionable accuracy and reliability. The large geographical area and limited data on the depth, soil composition and water table depth requires large assumptions to be made in order to delineate Highly Vulnerable Aquifers using the Intrinsic Susceptibility Index method. As there is a high level of uncertainty, with these assumptions given, the highly variable nature of the subsurface conditions within northern Ontario and the Canadian Shield. This information gap cannot be filled unless new detailed data related to soil identification, depth and composition, in addition to, water table depth would allow for additional Intrinsic Susceptibility Index calculations with more reliability. A study such as this is beyond the scope and capabilities of the Lakehead Source Protection Committee.

4.1.3 Significant Groundwater Recharge Areas (SGRAs)

The delineation of the Significant Groundwater Recharge Areas within the Lakehead Source Protection Area was based on available datasets and completed according to Rule 44.(1) in "Directors Technical Rules, Clean Water Act, 2006". This method states the following:

44. Subject to rule 45, an area is a significant groundwater recharge area if,
    (1) the area annually recharges water to the underlying aquifer at a rate that is greater than the rate of recharge across the whole of the related groundwater recharge area by a factor of 1.15 or more.

Rule 45 of the "Directors Technical Rules, Clean Water Act, 2006" states that only those areas of high recharge that have a hydrological connection to a surface water body or aquifer that is a source of drinking water for a drinking water system are identified as a Significant Groundwater Recharge Area.

For the Lakehead Source Protection Area the Significant Groundwater Recharge Areas were identified by overlaying Ontario Ministry of Environment water well and non-municipal drinking water systems records over the areas of high recharge dataset obtained from the "Lakehead Source Protection Area – Water Budget and Water Quantity Stress Assessment" study. The areas of high recharge are shown on the Assessment Report Map # 26 – Distribution of Recharge Greater than Average Annual Recharge (Map Binder – Map Sleeve #26).

Anywhere a well intersected with an area of recharge that is 1.15 times greater than the annual recharge, a Significant Groundwater Recharge Area was identified. The rationale for this approach is that water wells have the potential to create a linkage between the surface and an aquifer. In this situation, there is a significant risk that a contaminant can migrate into an aquifer through surface water recharging the subsurface aquifer. Most of the contaminants that commonly cause concern originate on the ground as a result of human activities. Thus, a major consideration in groundwater contamination is the position and condition of wells. These intersections were identified in the Geographic Information System (GIS) environment and used to create Significant Groundwater Recharge Areas.

The Ontario Ministry of Environment Water Well Information System for the "Groundwater Study" contained 3,789 records in 2003-2005. When compared to entire area of the Lakehead Source Protection Area, at 11,526 square kilometres, this corresponds to a density of one well record for approximately every three square kilometres. At this density, it is very difficult to accurately interpret the hydrogeological characteristics for this area. The large geographical area and limited data on the soil depth, soil composition and water table depth required large assumptions to be made in order to delineate Significant Groundwater Recharge Areas. A high level of uncertainty occurs with these assumptions given the highly variable nature of the subsurface conditions within northern Ontario and the Canadian Shield.

As a result of the geospatial analysis mentioned above, two large Significant Groundwater Recharge Area polygons were delineated in the northern and western part of the Lakehead Source Protection Area, 1,763 and 1,085 square kilometres, respectively. They were the result of intersections with one well for the northern area and three wells for the western area. Although the methodology used was correct, it would be difficult to justify that these drinking water wells have a clear hydrologic connection throughout the full extent of the SGRA polygon delineation. Therefore, local knowledge and professional judgment have been used to significantly reduce the SGRA associated with those wells. The new polygons were delineated based on the topographic features around the wells. They were based on the height of land and sized to an area that reasonably would be connected hydraulically to the wells in question.

Areas within the Lakehead Source Protection Area have been identified as a Significant Groundwater Recharge Area using the methods above and only include areas for which a vulnerability score can be assigned. There is no information for the northern region of the Source Protection Area as the "Groundwater Study" contained no data for that area. Assessment Report Map #24 reflects the area with available information. Given the data gap the vulnerability cannot be determined for the northern regions of the Lakehead Source Protection Area. Due to the limited amount of groundwater vulnerability data available, only some portions of the Significant Groundwater Recharge Areas could be assigned vulnerability scores.

Using the available data and local knowledge, the Lakehead Source Protection Committee has presented the data related to Significant Groundwater Recharge Areas on Assessment Report Map #27 – Significant Groundwater Recharge Areas (Map Binder - Map Sleeve #27).

Assessment Report Map # 26 – Distribution of Recharge Greater than Average Annual Recharge
Map Binder - Map Sleeve #26

This map illustrates the delineation of the distribution of recharge that is 1.15 times greater than the average annual recharge for the Lakehead Source Protection Area as per Director's Technical Rule 44(1).

Assessment Report Map #27 – Significant Groundwater Recharge Areas Map Binder - Map Sleeve #27

Significant Groundwater Recharge Areas within the Lakehead Source Protection Area were identified by overlaying Ministry of Environment Water Well data over recharge areas that are 1.15 times greater than the average annual recharge. Anywhere a recorded water well location intersects with recharge areas that are 1.15 times greater than the average annual recharge, creating a hydrologic relationship, is considered a Significant Groundwater Recharge Area.

4.1.4 Wellhead Protection Areas

Groundwater Vulnerability Assessment in the Lakehead Source Protection Area focused on an area in close proximity to the Municipal Residential Drinking Water System for the Rosslyn

Village Subdivision. The Wellhead Protection Areas for the two wells related to the Rosslyn Village Subdivision Well Supply Municipal Residential Drinking Water System were initially delineated using a three-dimensional flow model entitled "Modular Finite-Difference Groundwater Flow Model (MODFLOW)". The Modular Finite-Difference Groundwater Flow Model (MODFLOW) and a Particle Tracking Post-Processing Package for MODFLOW called MODPATH are well accepted by regulatory agencies and widely used for a variety of applications including delineation of capture zones for pumping wells. The study area (model domain) boundaries for determining the Wellhead Protection Areas are outlined below:

- Two kilometres east of the Rosslyn Village Subdivision.
- One kilometre west of Rosslyn Village Subdivision.
- Seven kilometres north of the North Drinking Water Supply Well
- South to the Kaministiquia River

The model was developed with six layers. The uppermost layer (Model Layer 1) represents spatial distribution of surficial material shown in Figure 18. Model Layer 2 represents a lacustrine clay unit in the southern portion of model domain and undifferentiated till north of Canadian National Railway Road. Model Layer 3 represents the till unit within the entire model domain and undifferentiated till north of Canadian National Railway Road. Model Layer 4 represents the basal sand/gravel unit in the southern portion of model domain and glacial till further north, in the area where the basal sand/gravel unit thins out (Figure 18). Model Layers 5 and 6 represent the upper 30 metres of bedrock. Groundwater flow in bedrock below the 30 metre depth zone was neglected and therefore, the bottom of Model Layer 6 was assumed to be impermeable for flow (i.e. a no flow boundary).

The bedrock surface, created by kriging interpolation of the borehole data, was used for the bottom of Model Layer 4. Bottom elevations of Model Layers 5 and 6 were established at 15 and 30 metres below the overburden/bedrock interface, respectively. The top of Model Layer 4 was established based on its bottom elevation and the interpolated thickness of the basal sand/gravel unit. The top and bottom of Model Layer 2 (bottom of Model Layer 1 and top of Model Layer 3, respectively) were established based on the interpolated upper and lower surfaces of clay unit. The interpreted and interpolated water table surface constituted top of the Model Layer 1.

The grid for the numerical finite-difference groundwater flow model consisted of about 170,000 active cells. The majority of numerical cells were constructed with horizontal sizes of approximately 30 metres. Finer grid spacing of about five metres was utilized in the vicinity of the Rosslyn Village Subdivision Well Supply wells in order to provide a more refined simulation of the groundwater flow system effected by the wells.

The boundary conditions, specified along the perimeter of modeling domain, account for the interaction between the groundwater flow within the modeled area and the rest of the aquifer. The specification of the boundary conditions was based on the interpreted groundwater flow system.

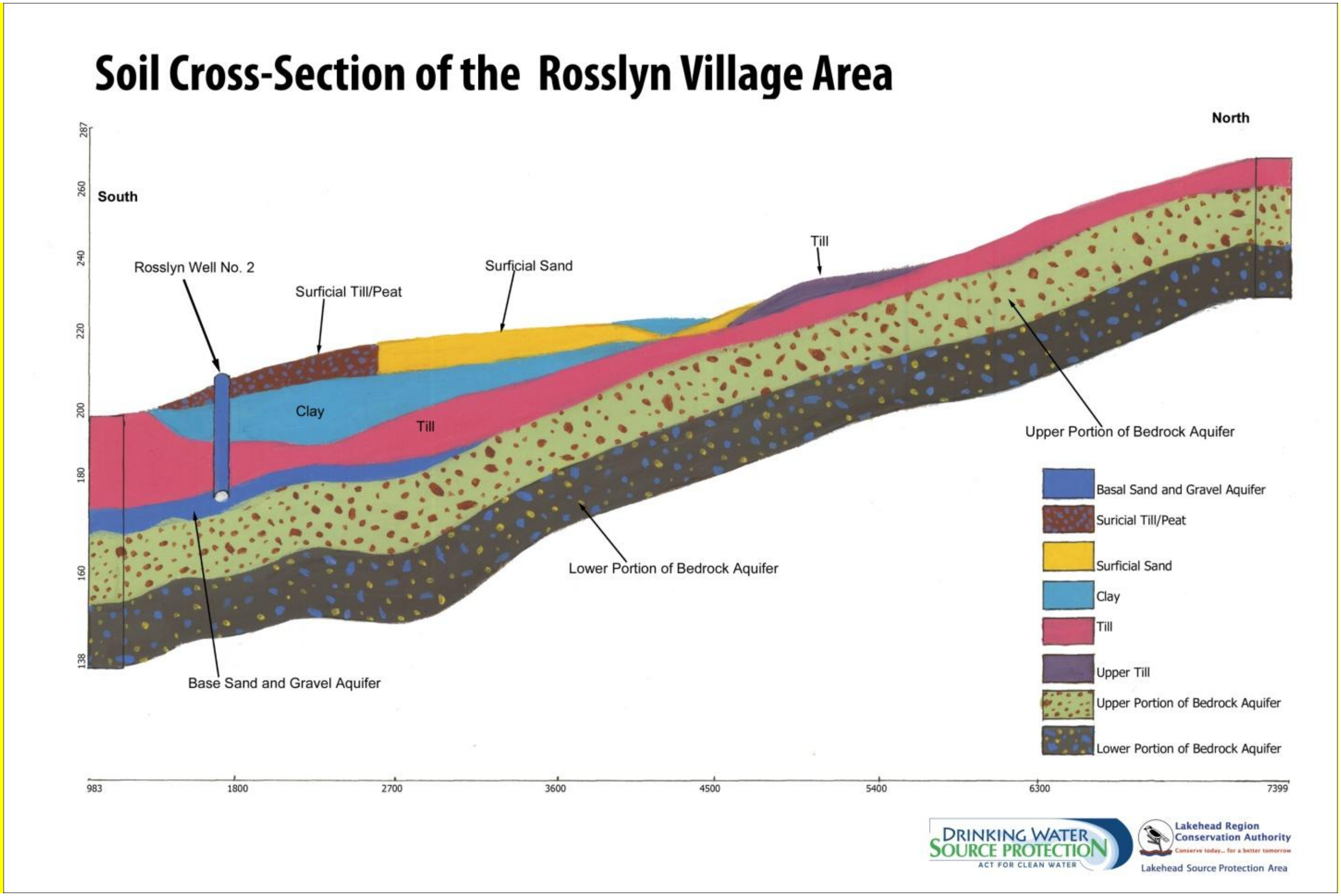
A no-flow boundary condition was specified along the western and eastern boundaries of the model domain since these boundaries were made parallel to the interpreted regional groundwater flow direction.

A hydraulic head of 195 metres above sea level was specified in Model Layers 2 and 3 along the southern boundary of the model domain. This head value represented water level in the Kaministiquia River. A hydraulic head of 300 metres above sea level was specified in the northwestern corner of the model domain. This head value represented observed water levels in documented residential wells in this area. Permanent streams located within the model domain were simulated using drain nodes. According to the MODFLOW concept, the discharge to the drain occurs only when heads in the cells adjacent to the drain are higher than the assigned drain (stream) elevation. Leakage from the drain to the aquifer is not allowed by the drain package. Therefore, all simulated streams were assumed to be gaining water from the aquifer. Hydraulic conductivities initially specified for each stratigraphic unit of the simulated aquifer zone are summarized in Table 37.

Table 37: Initial and Calibrated MODFLOW Model Input Parameters

Subsurface Material	Recharge Rate (millimetres per year)		Hydraulic Conductivity (centimetres per seconds)	
	Initial values	Calibrated Values	Initial values	Calibrated Values
Surficial Sand	200	180	1.0×10^{-3}	1.0×10^{-3}
Silty Clay	20	18	1.0×10^{-6}	1.2×10^{-7}
Till/Peat	100	90	1.0×10^{-4}	2.0×10^{-4}-5×10^{-4}
Basal Sand/Gravel	N/A	N/A	1.0×10^{-2}	1.0×10^{-2}
Upper 15 metres of Bedrock	N/A	N/A	1.0×10^{-3}	1.0×10^{-3}
Lower 15 metres of Bedrock	N/A	N/A	2.0×10^{-4}	2.0×10^{-4}

Figure 18: Soil Cross-Section of the Rosslyn Village Area



The Lakehead Source Protection Area has two Municipal wellheads which supply treated, Municipal Residential Drinking Water to approximately 29 houses (as of January 2010) in the Rosslyn Village subdivision. A Wellhead Protection Area is the volume of soil/geologic material that contributes groundwater to a water supply well. To determine this area a hydrogeological survey is required to identify this area of influence in three dimensions. Detailed Wellhead Protection Areas are typically based on a Time-of-Travel (TOT) assessment which identifies the area supplying groundwater to the well over a given time frame. Identifying a time-based area provides a reasonable length of time to respond to environmental issues while maintaining a small enough area to be effectively managed. The following Wellhead Protection Areas have been identified around the Rosslyn Village Subdivision Well Supply:

Wellhead Protection Area A -Being the surface and subsurface area centred on the well with an outer boundary identified by a radius of 100 metres.

Wellhead Protection Area B - Being the surface and subsurface areas within which the time of travel to the well is less than or equal to two years but excluding Wellhead Protection Area -A.

Wellhead Protection Area C - Being the surface and subsurface areas within which the time of travel to the well is less than or equal to five years but greater than 2 years.

Wellhead Protection Area D- Being the surface and subsurface areas within which the time of travel to the well is less than or equal to twenty-five years but greater than 5 years.

Assessment Report Map # 28A– Delineation of Vulnerable Areas around the Rosslyn Village Subdivision Well Supply
Map Binder - Map Sleeve #28A

This map illustrates the delineated vulnerable areas around the Rosslyn Village Subdivision Well Supply Municipal Drinking Water Wells. Vulnerable areas are based on a number of factors including source location, contaminant time-of travel and geological conditions. The vulnerable zones related to the Rosslyn Village Subdivision Well Supply are identified as Wellhead Protection Areas (WHPAs). Vulnerability zones were delineated according to the "Director Technical Rules: Clean Water Act, 2006".

Assessment Report Map # 28B– Delineation of Vulnerable Areas around the Thunder Bay (Bare Point Road) Water Treatment Plant Surface Water Intake
Map Binder - Map Sleeve #28B

This map illustrates the delineated vulnerable areas around Thunder Bay (Bare Point Road) Water Treatment Plant Surface Water Intake. Vulnerable areas are based on a number of factors including source location, contaminant time-of travel and geological conditions. The vulnerable zones related to the Thunder Bay (Bare Point Road) Water Treatment Plant Surface Water Intake as Intake

Protection Zones (IPZs). Vulnerability zones were delineated according to the "Director Technical Rules: Clean Water Act, 2006".

4.1.5 Groundwater Vulnerability Scores

Vulnerability scores are assigned to vulnerable areas based on the anticipated vulnerability to contamination in that area. These scores are developed on a scale of 2-10 according to Part VII of "Director Technical Rules, Clean Water Act, 2006". Vulnerability scores are directly linked to the significance of threats within vulnerable areas. Higher scores will contribute increased risk levels being assigned to threats based around land use activities.

4.1.5.1 Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas

Highly Vulnerable Aquifers are automatically assigned a vulnerability score of six according to "Director Technical Rules, Clean Water Act, 2006" Part VII.1, Rule 79. Significant Groundwater Recharge Areas are assigned a vulnerability score between two and six depending on the vulnerability of the groundwater in the area as determined by "Directors Technical Rules, Clean Water Act, 2006" Part IV.1, Rule 38. A vulnerability score of six is assigned to a Significant Groundwater Recharge Area located in an area of high groundwater vulnerability, four in an area of medium groundwater vulnerability and two in an area of low groundwater vulnerability as determined using the Intrinsic Susceptibility to Contamination approach to determining aquifer vulnerability outlined in the "Directors Technical Rules, Clean Water Act, 2006", Part IV.1, Rule 31(1).

Vulnerability scores were assigned for Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas within the Lakehead Source Protection Area. There is insufficient data available for Lakehead Source Protection Area to accurately determine aquifer vulnerability in large parts of the Source Protection Area. The areas identified for Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas do not encompass the scientific boundary delineated for the Lakehead Source Protection Area but include 95 percent of the population located within the area. As a result of the limited data available, scores for potential Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas located outside of the "Groundwater Study" area cannot be determined.

These scores would have been combined with threat hazard scores to determine the risk of contamination from land use activities within the Lakehead Source Protection Area. Although unknown at this time, there is a potential for some land uses within the Lakehead Source Protection Area, outside of the zones delineated in the "Groundwater Study" that could or would be threats to aquifers or recharge areas as per the Table of Drinking Water Threats, "Clean Water Act, 2006".

Assessment Report Map #29A – Vulnerability Scores for the Rosslyn Village Subdivision Well Supply, Wellhead Protection Areas
Map Binder - Map Sleeve #29A

This map illustrates the Vulnerability Scores for the vulnerable zones related to the Rosslyn Village Subdivision Well Supply, Wellhead Protection Areas. Vulnerability scores are assigned to vulnerable areas based on the anticipated vulnerability to contamination in that area. These scores are developed on a scale of 2-10 according to the "Director Technical Rules, Clean Water Act, 2006".

Assessment Report Map #29B – Vulnerability Scores for the Thunder Bay (Bare Point Road) Water Treatment Plant, Intake Protection Zones
Map Binder - Map Sleeve #29B

This map illustrates the Vulnerability Scores for the vulnerable zones related to the Thunder Bay (Bare Point Road) Water Treatment Plant, Intake Protection Zones (IPZ's). Vulnerability scores are assigned to vulnerable areas based on the anticipated vulnerability to contamination in that area. These scores are developed on a scale of 1-10 according to the "Director Technical Rules, Clean Water Act, 2006".

Assessment Report Map #30 – Vulnerability Scores for Significant Groundwater Recharge Areas
Map Binder - Map Sleeve #30

This map illustrates the Vulnerability Scores for the vulnerable zones related to Significant Groundwater Recharge Areas scores are assigned to vulnerable areas based on the anticipated vulnerability to contamination in that area. These scores are developed on a scale of 2-6 according to the "Director Technical Rules, Clean Water Act, 2006".

4.1.5.2 Wellhead Protection Areas

Wellhead Protection Areas are assigned a vulnerability score between two and ten depending on the vulnerability of the groundwater in the area as determined by "Director Technical Rules, Clean Water Act, 2006" Part IV.1, Rule 38. "Director Technical Rules, Clean Water Act, 2006" Part VII.3, Rule 83 outlines the vulnerability scores associated with Wellhead Protection Areas. For the Lakehead Source Protection Area "Director Technical Rules, Clean Water Act, 2006" Part VII, Rule 83, Table 2(a) is applicable for Wellhead Protection Areas A to D. Wellhead Protection Area-A will always be assigned a vulnerability score of ten. In the Lakehead Source Protection Area, the remaining Wellhead Protection Areas contain vulnerability scores of either four or six, depending on the Intrinsic Susceptibility to Contamination as determined using Intrinsic Susceptibility to determine aquifer vulnerability as outlined in the "Directors Technical Rules, Clean Water Act, 2006" Part IV.1, Rule 38. The area for each level of vulnerability within the Wellhead Protection Area is detailed in Table 38.

Table 38: Wellhead Protection Area Vulnerability Scores

Vulnerability Score	Area (hectares)			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
10	5.43	0	0	0
6	0	4.89	9.72	14.15
4	0	0	3.49	10.19

Vulnerability scores will be combined with threat hazard scores to determine the risk of contamination from land use activities within these areas.

The vulnerability scores within the Wellhead Protection Areas vary as you travel north of the Rosslyn Village Subdivision Municipal Drinking Water Wells. The entirety of the Wellhead Protection Area-A is assigned a vulnerability score of 10 as per "Director Technical Rules, Clean Water Act, 2006". Once you are outside the Wellhead Protection Area-A zone, the vulnerability score is based on the Intrinsic Susceptibility Index rankings for the area. Figure 18 illustrates the subsurface soil profile in the vicinity of the wells. In the vicinity of the Rosslyn Village Subdivision Municipal Drinking Water Supply Wells, there is a clay layer which extends approximately 1.8 kilometres north of the Municipal Drinking Water Supply Wells. As this layer extends north, it gradually decreases in depth from a maximum of approximately 15 metres until it disappears 1.8 kilometres north of the wells. This clay layer is overlain by a surficial layer of till/peat in the vicinity of the wells which transitions to a surficial sand layer as you proceed north from the Municipal Drinking Water Supply Wells. These differences in surficial geology correspond to differences in the aquifer vulnerability which influence the vulnerability scores within the Wellhead Protection Areas according to the "Directors Technical Rules, Clean Water Act, 2006", Part VII.3 Rule 83.(1). Within the Wellhead Protection Areas the aquifer vulnerability changes from low to medium, just north of the transition from Wellhead Protection Area-B to Wellhead Protection Area-C. The aquifer vulnerability then changes again from medium to high, north of the transition between Wellhead Protection Area-C and Wellhead Protection Areas-D.

4.1.6 Groundwater Transport Pathways

Transport pathways or shortcuts, can make it easier for contaminants to migrate into drinking water sources. Transport pathways are defined as being of anthropogenic (human influenced) origin. Some groundwater transport pathways include:

- Existing and abandoned wells.
- Pits and quarries.
- Mines.
- Construction activities.
- Stormwater infiltration.
- Septic systems.
- Sanitary sewer infrastructure.

There have been no known transport pathways identified within the Lakehead Source Protection Area that will impact the Rosslyn Village Subdivision Well Supply Municipal Residential Drinking Water System. Private drinking water wells have been identified in the Rosslyn Village Subdivision Well Supply Wellhead Protection Area and it is assumed that these wells have been installed in accordance with Ontario Regulation 903, which would mean they have been constructed properly, therefore are not considered a transport pathway to the aquifer servicing the Rosslyn Village Subdivision Well Supply.

Transport pathways have not been identified for Highly Vulnerable Aquifers or Significant Groundwater Recharge Areas as these pathways to not have a direct impact on the Municipal Residential Drinking Water quality for the localized area of the Rosslyn Village Subdivision within the Lakehead Source Protection Area. In areas privately serviced by dug or drilled wells, improperly constructed wells and other transport pathways may be present in location which could impact local, small-scale drinking water systems.

4.2 Surface Water Vulnerable Areas

Information for this section has been extracted from the two technical studies entitled: "City of Thunder Bay Source Protection Technical Study – Bare Point Water Treatment Plant, Final Phase 1 Report" Stantec Consulting Limited (January 2009) and "City of Thunder Bay Source Protection Technical Study – Bare Point Water Treatment Plant, Final Phase 2 Report" Stantec Consulting Limited (February 2009).

The objective of this section is to identify areas of surface water vulnerability, assess the potential for contamination and identify areas of concern within the Lakehead Source Protection Area. The area and intake conditions for the surface water source within Lakehead Source Protection Area have been discussed in previous chapters of this Assessment Report. The "Clean Water Act, 2006", defines four different types of surface water intakes associated with a Type I, II or III Drinking Water System. In the Lakehead Source Protection Area, the Thunder Bay (Bare Point Road) Water Treatment Plant Municipal Surface Water Intake is a Type A (Great Lakes) intake according to "Director Technical Rules, Clean Water Act, 2006" Part VI.1, Rule 55(1).

4.2.1 Uncertainty Analysis

The uncertainty level is an assessment of the confidence in the validity of delineation of the Intake Protection Zones and associated vulnerability scores. The determination of an uncertainty level for Intake Protection Zones relates to:

- Data used in the delineation of vulnerability scores, its completeness (extent and density), quality, statistical validity, relevance and local content.
- The numerical models or methods used to delineate the protection zones, their relevance and suitability for the local condition.

Dimensions for Intake Protection Zone-1 delineation are prescribed in "Director Technical Rules, Clean Water Act, 2006". Local conditions do not indicate a need to extend the zone beyond the prescribed minimum one kilometre radius. Local data factors contributing to the zone vulnerability score are from reliable, ongoing Provincial and Federal monitoring programs, and the Thunder Bay (Bare Point Road) Water Treatment Plant. This data is of sufficient density, frequency and quality to impart a high level of confidence in the vulnerability score. This level of confidence contributes to a low uncertainty level for the Intake Protection Zone-1

The determination of the Intake Protection Zone-2 involves much more variability. There is moderate uncertainty associated with the determination of the in-water component of Intake Protection Zone-2 delineation. This is a direct result of the considerable variability in environmental conditions contributing to near shore hydrodynamics around the Thunder Bay (Bare Point Road) Water Treatment Plant intake. Up-tributary extents for Intake Protection Zone 2 are calculated using Manning's equation and bank full flow conditions. There is a high level of confidence associated with the up-tributary extents of the Intake Protection Zone-2. There is a number of unnamed surface water conveyances associated with the Intake Protection Zone-2 determination. There is the potential that these unnamed drains extend beyond the area delineated as the Intake Protection Zone-2. There is also the potential for Municipal storm sewers or privately owned and operated drains to discharge into these unnamed surface water conveyances. The upland and up-tributary extents of the Intake Protection Zone-2 have a high degree of uncertainty associated with them. When you combine the in-water component, the upland component and the up-tributary component of the Intake Protection Zone-2 the overall uncertainty in the determination of the Intake Protection Zone-2 is high.

4.2.2 Thunder Bay (Bare Point Road) Water Treatment Plant

The Bare Point Water Treatment Plant was originally built in 1903 and expanded in 1978. In 2007, it underwent a major upgrade and is the sole source of Municipal Residential Drinking Water for the City of Thunder Bay.

There are many different processes our water undergoes from the time it enters the plant to the time it is transported through the extensive distribution system to our homes and businesses. At the Thunder Bay (Bare Point Road) Water Treatment Plant raw water is fed by gravity into the plant through a pipe that is 1350 millimetres in diameter, approximately 10.2 metres below the surface of Lake Superior and approximately 840 metres from the shoreline. Screens remove debris and particles from the raw water where it enters the plant. The Thunder Bay (Bare Point Road) Water Treatment Plant has the operational capacity to produce 113.5 million litres of water per day, through seven pressure zones, seven pump stations, and five reservoirs. The Thunder Bay (Bare Point Road) Water Treatment Plant utilizes pre-chlorination, followed by membrane ultra-filtration and post chlorine disinfection.

4.2.3 Delineation of Intake Protection Zones (IPZs)

Three vulnerable zones apply to a Great Lakes (Type A) Municipal Residential Drinking Water System intake.

- Intake Protection Zone-1, a primary zone immediately about the intake having a radius of 1,000 metres (one kilometre) as defined in "Directors Technical Rules, Clean Water Act, 2006" Part VI.3, Rule 61(1)(a). This represents the most immediate and vulnerable area around the intake.

- Intake Protection Zone-2, a secondary zone having dimensions determined from calculations based upon characteristics of the local environment such as local water movement vectors and nearby shoreline and tributary watercourse features.

- Intake Protection Zone-3, a tertiary zone having dimensions determined using an Events Based Approach (EBA). An approach that quantifies the distance from which contaminants could travel in an extreme event and contaminate the surface water intake. To be determined in a future Assessment Report as technical study related to the determination and delineation of an Intake Protection Zone-3 for the Thunder Bay (Bare Point Road) Water Treatment Plant has not been completed to date.

Assessment Report Map #29B – Vulnerability Scores for the Thunder Bay (Bare Point Road) Water Treatment Plant, Intake Protection Zones
Map Binder - Map Sleeve #29B

This map illustrates the Vulnerability Scores for the vulnerable zones related to the Thunder Bay (Bare Point Road) Water Treatment Plant, Intake Protection Zones (IPZ's). Vulnerability scores are assigned to vulnerable areas based on the anticipated vulnerability to contamination in that area. These scores are developed on a scale of 1-10 according to Part VII of the "Director Technical Rules, Clean Water Act, 2006".

4.2.3.1 Delineation of Intake Protection Zone 1

The Intake Protection Zone-1 for the Thunder Bay (Bare Point Road) Water Treatment Plant is a one kilometre radius circle around the intake. The Thunder Bay (Bare Point Road) Water Treatment Plant intake is located approximately 840 metres offshore. Consequently, the Intake Protection Zone-1 intersects the shoreline and extends inland for a distance of 120 metres along the shoreline where the arc of the zone radius intersects the shore. The 120 metre zone was measured from the edge of water (i.e. Lake Superior shoreline), as indicated in the Land Information Ontario (LIO) data warehouse.

4.2.3.2 Delineation of Intake Protection Zone 2

Water movement modeling was employed to conceptualize water movement vectors and delineate the in-water and alongshore component of the Intake Protection Zone-2. The modeling approach to defining the in-water and alongshore component of the Intake Protection Zone 2 boundary for the Thunder Bay (Bare Point Road) Water Treatment Plant includes:

- Review of pertinent literature and background information regarding the lake and nearshore processes in Lake Superior and Thunder Bay.
- Review of existing environmental data (winds, waves, hydrologic inputs, water levels, raw water quality at intake) and relevant current monitoring information where available.

- Collection of field (current monitoring) data at the Thunder Bay (Bare Point Road) Water Treatment Plant.
- Interpretation of existing environmental data with regard to significant local and regional processes and their relative influence.
- Preliminary 2-D hydrodynamic modeling with refinement to 3-D modeling using the ADCIRC model.
- Definition of in-water and alongshore component of the Intake Protection Zone 2 boundary.

The approximate dimensions of the in-water Intake Protection Zone 2 based on a two hour Time of Travel and a ten year return period inputs for wind and waves are:

- Southwest 3200 metres.
- Northeast 2600 metres.
- Offshore 1730 metres.

The in-water and alongshore zone connects to shore approximately 1.8 kilometres northeast of the Thunder Bay (Bare Point Road) Water Treatment Plant near the confluence of North Star Creek with Thunder Bay. It connects to the harbour breakwall about 4.1 kilometres southwest of the Thunder Bay (Bare Point Road) Water Treatment Plant, near Bare Point. The zone takes in approximately 5.9 kilometres of shoreline about the Thunder Bay (Bare Point Road) Water Treatment Plant including 4.9 kilometres of natural shoreline and one kilometre of harbour breakwall.

The upland and up-tributary extents of the Intake Protection Zone-2 for the Thunder Bay (Bare Point Road) Water Treatment Plant are based on the alongshore extents and Time of Travel contours provided for the in-water Intake Protection Zone-2 modeling. The upland and up-tributary components of the Intake Protection Zone-2 were delineated using the administratively set limit of 120 metres inland or to the limit of the Regulated area as per "Conservation Authorities Act" Ontario Regulation 180/06 "Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses", whichever is greater, as well as a surface water conveyance Geographic Information System layer. The 120 metre zone was measured from the edge of water (i.e. lake or water course). The data set was obtained from the Land Information Ontario (LIO) data warehouse. It should be noted that water flow on North Star Creek is not regulated by a surface water control structure.

The surface water conveyance layer contains storm sewer outfall locations provided by the City of Thunder Bay and storm sewer outfall locations and corresponding drains identified in two private industry stormwater control studies. Based on available information, there are no known Municipal storm sewer outfalls to Thunder Bay within the alongshore extent of Intake Protection Zone-2. Seven un-named drains were identified in the Municipality of Shuniah portion of the Intake Protection Zone-2. The majority of the Intake Protection Zone-2 does not extend further inland than the Canadian Pacific rail line. However, two drains located just east of Bare Point and one drain located at the Thunder Bay (Bare Point Road) Water Treatment Plant western perimeter extend beyond and include portions of the Canadian Pacific and Canadian National rail lines. In the upland area not influenced by watercourses or drains the Intake Protection Zone-2 extends inland 120 metres.

The only natural watercourse that outfalls within the alongshore extent of the Intake Protection Zone-2 is Northstar Creek. The distance of Intake Protection Zone-2 up Northstar Creek was calculated directly from the stream section velocity estimates and a 30 minute residual Time of Travel. The upstream limit of the zone in Northstar Creek is approximately 2.6 kilometres from its confluence with Lake Superior in the bay of Thunder Bay. It should be noted that water flow on North Star Creek is not regulated by a surface water control structure.

4.2.3.3 Delineation of Intake Protection Zone-3

"Directors Technical Rules, Clean Water Act, 2006" Rule 69 limits the extent of the Intake Protection Zone-3 to that of the surface water area that is influenced by the extreme event. Extreme event is defined in Part 1.1 definitions Rule 1, as:

(a) a period of heavy precipitation or winds up to a 100 year storm event;
(b) a freshet; or
(c) a surface water body exceeding its high water mark.

At the time the Assessment Report was released, the Lakehead Source Protection did not have any information available related to the determination of the delineation of an Intake Protection Zone-3 in the Lakehead Source Protection Area. It is the intention of the Lakehead Source Protection Committee to provide this information, when available, in a future Assessment Report.

4.2.4 Surface Water Vulnerability Scores

Vulnerability scores are assigned to vulnerable areas based on the anticipated vulnerability to contamination in that area. These scores are developed on a scale of one to ten according to the "Directors Technical Rules, Clean Water Act, 2006" Part VIII. The vulnerability score is based on two factors, the area vulnerability factor and the source vulnerability factor. Each of these factors is determined by considering certain intake characteristics. The area vulnerability factor requires the consideration of:

- Percent of Intake Protection Zone-2 that consists of land (as opposed to water).
- The land cover, soil type, permeability and slope.
- Hydrological and hydrogeological conditions of the area where the transport pathway is located.

The source vulnerability factor is based upon several different factors including:

- Depth of intake from the top of the water surface.
- Length of the intake from the shoreline.
- Historical water quality data.

The factors determining the area vulnerability factor and the source vulnerability factor for the Thunder Bay (Bare Point Road) Water Treatment Plant Municipal Drinking Water Intake are detailed in Tables 39 and 40.

Table 39: Scoring Criteria Matrix for Area Vulnerability Factor Determination

<table>
<tr><th rowspan="2">Sub Factor</th><th rowspan="2">Component</th><th colspan="3">Criteria</th><th rowspan="2">Sub Factor Score</th></tr>
<tr><th>7</th><th>8</th><th>9</th></tr>
<tr><td rowspan="2">Percent Land</td><td>Not Applicable</td><td>Less than 33 percent.</td><td>33 to 66 percent.</td><td>Greater than 66 percent.</td><td>Equal to 7</td></tr>
<tr><td colspan="4">Percent Land Score</td><td>Equal to 7</td></tr>
<tr><td rowspan="5">Land Characteristics</td><td>Land Cover</td><td>Mainly Forested</td><td>Agriculture and/or Mixed Vegetated and Developed</td><td>Mainly Developed</td><td>Equal to 7.</td></tr>
<tr><td>Soil type</td><td>Sandy</td><td>Sandy Loam</td><td>Bedrock</td><td>Equal to 8.</td></tr>
<tr><td>Permeability</td><td>Greater than 66 percent.</td><td>33 to 66 percent.</td><td>Less than 33 percent.</td><td>Equal to 7.</td></tr>
<tr><td>Percent Slope</td><td>Less than 2 percent.</td><td>2 to percent.</td><td>Greater than 5 percent.</td><td>Equal to 9.</td></tr>
<tr><td colspan="4">Land Characteristics Score</td><td>$= \frac{cover + soil + perm + slope}{4}$
$= \frac{(7+8+7+9)}{4}$
=7.75</td></tr>
<tr><td rowspan="4">Transport Pathways</td><td>Storm catchment area</td><td>Less than 33 percent.</td><td>33 to 66 percent.</td><td>Greater than 66 percent.</td><td>Equal to 7.</td></tr>
<tr><td>Number of storm outfalls, watercourses and drains per 1000 hectares</td><td>0 to 3</td><td>4 to 7</td><td>Greater than 7.</td><td>Equal to 9.</td></tr>
<tr><td>Percent tile drain area.</td><td>Less than 33 percent.</td><td>33 to 66 percent.</td><td>Greater than 66 percent.</td><td>Equal to 7.</td></tr>
<tr><td colspan="4">Transport Pathways Score</td><td>$= \frac{storm\ area + outfalls + tile\ area}{3}$
$= \frac{(7+9+7)}{3}$
=7.67</td></tr>
<tr><td colspan="6">*Area Vulnerability Factor $= \frac{(percent\ land + land\ characteristics + transport\ pathways)}{3}$ = 7
*Final area vulnerability factor score to be rounded to the nearest whole number. The set ranges (7 to 9) of the area vulnerability factor are independent values used for reference in the area vulnerability factor calculation and do not indicate the vulnerability or sensitivity of the intake.</td></tr>
</table>

Table 40: Scoring Criteria Matrix for Source Vulnerability Factor Determination

Sub Factor	Criteria			Sub Factor Score
	0.5	0.6	0.7	
Depth of Intake	Greater than 6.1 metres.	3.1 to 6.0 metres	0 to 3.0 metres	**0.5**
Offshore distance of Intake	Greater than 500 metres.	300 to 500 m	Less than 300 metres,	**0.5**
Recorded Water Quality Issues	Minimal parameter results measured above Ontario Drinking Water Quality Standards.	-Some parameter results measured above Ontario Drinking Water Quality Standards. - Similar operator concerns. -Watershed Characterization Report concerns.	-Several parameter results measured above Ontario Drinking Water Quality Standards. -Operator and/or Municipal staff confirmation of raw water quality concerns.	**0.5**

***Source Vulnerability Factor** $= \frac{Depth + offshore\ length + water\ quality)}{3}$ **= 0.5**

*Final source vulnerability factor score to be rounded to the one decimal place. The set ranges (7 to 9) of the area vulnerability factor are independent values used for reference in the area vulnerability factor calculation and do not indicate the vulnerability or sensitivity of the intake.

For a surface water intake the vulnerability score (V) is determined by multiplying the area vulnerability factor by a source vulnerability modifying factor. The following score ranges are possible for Great Lakes surface water intakes. Further information on the methodology is detailed in the report entitled "City of Thunder Bay Source Protection Technical Study – Bare Point Water Treatment Plant, Final Phase 1 Report" Stantec Consulting Limited (January 2009). Table 41 provides a summary of Vulnerability Score Ranges for Great Lakes Type-A Intakes.

Table 41: Vulnerability Score Ranges for Great Lakes Type-A Intakes

Intake Type	Area Vulnerability Factor (Vf_z)		Source Vulnerability Modifying Factor (Vf_s)	Vulnerability Score	
	Intake Protection Zone-1	Intake Protection Zone-2		Intake Protection Zone-1	Intake Protection Zone-2
Great Lakes Type-A	10	7 to 9	0.5 to 0.7	5 to 7	3.5 to 6.3

4.2.4.1 Intake Protection Zone -1 and Intake Protection Zone -2 Vulnerability Scores

Table 42 provides a summary of the vulnerability scores for Intake Protection Zone-1 and Intake Protection Zone-2. These scores will be combined with threat hazard scores to determine the risk of contamination from land use activities within these areas.

Table 42: Intake Protection Zone Vulnerability Scores

Intake Type	Area Vulnerability Factor (Vf_z)		Source Vulnerability Modifying Factor (Vf_s)	Vulnerability Score (V)	
	Intake Protection Zone-1	Intake Protection Zone-2		Intake Protection Zone-1	Intake Protection Zone-2
Great Lakes Type-A	10	7	0.5	5 **LOW**	3.5 **LOW**

Assessment Report Map #29B – Vulnerability Scores for the Thunder Bay (Bare Point Road) Water Treatment Plant, Intake Protection Zones
Map Binder - Map Sleeve #29B

This map illustrates the Vulnerability Scores for the vulnerable zones related to the Thunder Bay (Bare Point Road) Water Treatment Plant, Intake Protection Zones (IPZ's). Vulnerability scores are assigned to vulnerable areas based on the anticipated vulnerability to contamination in that area. These scores are developed on a scale of 1-10 according to Part VII of the "Director Technical Rules, Clean Water Act, 2006".

4.2.5 Storm Sewers

Storm sewers outlets can convey contaminants into drinking water sources. There are a number of unnamed surface water conveyances which discharge within the alongshore extent of the Intake Protection Zone-2. Based on available data during the development of the Assessment Report, consultation with the City of Thunder Bay and consultant-provided information, it has been confirmed that these unnamed drains do not extend further than identified in the report entitled "City of Thunder Bay Source Protection Technical Study – Bare Point Water Treatment Plant – Phase One Report, January 2009" and that Municipal storm sewers do not discharge into these drains. This information is based on the most up-to-date Municipal storm sewer mapping available to the Lakehead Source Protection Committee from the City of Thunder Bay during the development of the Assessment Report.

4.2.6 Surface Water Transport Pathways

Transport pathways or shortcuts, can make it easier for contaminants to migrate into drinking water sources. Transport pathways are defined as being of anthropogenic origin. Several transport pathways have been identified within the Intake Protection Zones that have the potential to impact the source water contributing to the Municipal Residential Drinking Water System intake. Surface water transport pathways include:

- Drains and ditches.
- Hard-surfacing.
- Irrigation ditches and subsurface tiling.

Surface water transport pathways relating to roads, drains and ditches are the main concern within the vulnerable zones around the Thunder Bay (Bare Point Road) Water Treatment Plant Intake.

4.3 Conclusions

Vulnerability assessments for Municipal Residential Drinking Water Sources within the Lakehead Source Protection Area will be used in the next chapter of the Assessment Report to delineate threats to the local drinking water sources. These scores have been determined according to established scientific methods and will provide the most rational approach to delineating threats and prioritizing areas for inclusion in the next phases of the Source Protection Planning Process.

5.0 Drinking Water Threats

Threats assessment work was initially completed in the technical studies carried out by consultants using the Ontario Ministry of Environment "Assessment Report Draft Guidance Modules, October 2006". The "Directors Technical Rules, Clean Water Act 2006" indicated a change in the methodology for identifying potential or actual Municipal Residential Drinking Water threats. The "Directors Technical Rules, Clean Water Act, 2006" indicate that Municipal Residential Drinking Water threats can arise from either pre-existing conditions resulting from prior land uses or from existing land-use activities. Issues in the quality of raw water at the intake can also be identified based on the presence of contaminants in exceedances of Ontario Drinking Water Quality Standards or water quality results trending towards exceedances. The following reports, studies and other information were used in the determination of Municipal Source Water vulnerability.

Study/Report/Information	Source
"Directors Technical Rules, Clean Water Act, 2006"	Ontario Ministry of Environment (November 2009)
"Assessment Report Draft Guidance Modules, October 2006"	Ontario Ministry of Environment
"Table of Drinking Water Threats, Clean Water Act, 2006"	Ontario Ministry of Environment
"Threats Look-up Table Database version 7.0"	Ontario Ministry of Environment
"Lakehead Region Conservation Authority Thunder Bay Aquifer Characterization, Groundwater Management and Protection Study" ("Groundwater Study")	R.J. Burnside and Associates and AMEC Earth and Environmental (2005)
"Watershed Characterization Report – A Draft Report for Consideration of the Lakehead Source Protection Committee"	Lakehead Region Conservation Authority, 2008)

"Groundwater Vulnerability Analysis Issues Evaluation Threats, Inventory and Water Quality Risk Assessment for Hamlet of Rosslyn Village Wellhead Protection Area Municipality of Oliver Paipoonge, Ontario"	AMEC Earth and Environmental (December 2008)
"City of Thunder Bay Source Protection Technical Study – Bare Point Water Treatment Plant, Final Phase 1 Report"	Stantec Consulting Limited (January 2009)
"City of Thunder Bay Source Protection Technical Study – Bare Point Water Treatment Plant, Final Phase 2 Report"	Stantec Consulting Limited (February 2009)
Rosslyn Village Water Treatment Plant Operational Plan	Municipality of Oliver Paipoonge
"Transportation and Works Department Environment Division Drinking Water Quality Annual Report 2007"	City of Thunder Bay
Rosslyn Village Water Quality Results	Water Quality Service
"An Illustrated Handbook of DNAPL Transport and Fate in the Subsurface".	Environment Agency

5.1 Tools used in Threats Determination

One key difference in these two approaches was in the determination of threats in vulnerable areas. The "Directors Technical Rules, Clean Water Act, 2006" provide a much more rigidly defined method for determining threats. The approach in the "Directors Technical Rules, Clean Water Act, 2006" is based on a defined table of threats as per the Ministry of Environment "Table of Drinking Water Threats, Clean Water Act, 2006". This massive list of tables has been simplified using two main tools:

1. "Threats Look-up Table Database (Threats_LUT_v7.0)"
2. "Upper Thames River Conservation Authority Threats Analysis Tool"

For the development of this Assessment Report the "Threats Look-up Table Database version 7.0" was utilized for the threats determination requirements. This tool is used in combination with area vulnerability scores to output lists of potential threats for the given vulnerable areas within the Lakehead Source Protection Area. Previous studies have used similar approaches for the determination of threats based around chemical hazard scoring and the likelihood of release for a given particular area.

Consultants' reports prepared for both the Wellhead Protection Areas and Intake Protection Zones provided very valuable data which aided in the threats determination process. Field visits were also used to verify site conditions within vulnerable areas. Source Protection Committee members were also provided with the opportunity to use their knowledge of local conditions to help identify threats within vulnerable areas. Using a combination of tools available, the Lakehead Source Protection Committee is of the opinion that threats within vulnerable areas have been identified with confidence.

5.2 Definition of Drinking Water Threats

The "Clean Water Act, 2006" defines a drinking water threat as an activity or condition that adversely affects or has the potential to adversely affect the quality or quantity of any water that is or may be used as a source of drinking water, and includes an activity that is prescribed by the regulations as a drinking water threat. Conditions are determined locally and the rules indicate when these conditions are drinking water threats, as per Director's Technical Rule 126. Threats are considered to be of two main types: threats related to pre-existing circumstances (conditions) and threats related to current land use practices (activities).

5.2.1 Drinking Water Threats - Conditions

The Source Protection Committee has a responsibility to list any drinking water conditions resulting from past activities that they are aware of. The following five conditions resulting from past activities shall constitute a drinking water threat under clause 15(2)(g)(ii) of the "Clean Water Act, 2006".

i. The presence of a non-aqueous phase liquid in groundwater in a Highly Vulnerable Aquifer, Significant Groundwater Recharge Area or Wellhead Protection Area.

ii. The presence of a single mass of more than 100 litres of one or more dense non-aqueous phase liquids (DNAPL) in surface water in a surface water Intake Protection Zone.

iii. The presence of a contaminant in groundwater in a Highly Vulnerable Aquifer, Significant Groundwater Recharge Area or Wellhead Protection Area, if the contaminant is listed in Table 2 of the Soil, Ground Water and Sediment Standards and is present at a concentration that exceeds the potable groundwater standard set out for the contaminant in that Table.

iv. The presence of a contaminant in surface soil in a surface water Intake Protection Zone if, the contaminant is listed in Table 4 of the Soil, Ground Water and Sediment Standards is present at a concentration that exceeds the surface soil standard for industrial/commercial/ community property use set out for the contaminant in that Table.

v. The presence of a contaminant in sediment, if the contaminant is listed in Table 1 of the Soil, Ground Water and Sediment Standards and is present at a concentration that exceeds the sediment standard set out for the contaminant in that Table.

5.2.2 Drinking Water Threats – Activities

The following 21 activities are prescribed as "drinking water threats" in subsection 2(1) of the "Clean Water Act, 2006":

1. 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.
3. The application of agricultural source material to land.
4. The storage of agricultural source material.
5. The management of agricultural source material.
6. The application of non-agricultural source material to land.
7. The handling and storage of non-agricultural source material.
8. The application of commercial fertilizer to land.
9. The handling and storage of commercial fertilizer.
10. The application of pesticide to land.
11. The handling and storage of pesticide.
12. The application of road salt.
13. The handling and storage of road salt.
14. The storage of snow.
15. The handling and storage of fuel.
16. The handling and storage of a dense non-aqueous phase liquid.
17. The handling and storage of an organic solvent.
18. The management of runoff than contains chemicals used in the de-icing of aircraft.
19. An activity that takes water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body.
20. An activity that reduces the recharge of an aquifer.
21. The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard.

5.3 Drinking Water Threats – Activities Description

The 21 activities listed in section 5.2.2 are prescribed drinking water threats. The following sections in 5.3 detail the activity.

5.3.1 The Establishment, Operation or Maintenance of a Waste Disposal Site Within the Meaning of Part V of the "Environmental Protection Act"

The main consideration for reducing or eliminating drinking water threats related to waste disposal sites is to make sure that any discharge from the sites does not result in a significant risk to drinking water through appropriate measures to mitigate the threat. Future waste disposal sites must be located in an area which will not create a significant drinking water threat.

There are thirty-five chemicals listed in the MOE Tables of Drinking Water Threats. These chemicals have the potential to be introduced into surface and groundwater as a result of the storage and land disposal of a prescribed waste.

5.3.2 The Establishment, Operation or Maintenance of a System That Collects, Stores, Transmits, Treats or Disposes of Sewage

The main consideration for reducing or eliminating drinking water threats related to on-site sewage systems is to prevent unacceptable impact on the water resource from chemical and pathogen parameters.

Poorly operating, failing or improperly sited septic systems can be a significant source of pathogen and chemical threats into a drinking water supply. The primary contaminants of concern from septic systems include (*E. coli*, fecal coliforms, nitrates and phosphates).

In the Lakehead Source Protection Area, residential septic systems are a potential source of contamination within both the Wellhead Protection Areas and Intake Protection Zones. All of the occupied residences and properties located within the Wellhead Protection Areas in Rosslyn Village Subdivision are serviced by septic systems.

The types of septic systems have not been ground-verified within Wellhead Protection Areas but it has been confirmed by the Thunder Bay District Health Unit that their records indicate that all systems are conventional systems with the exception of one recently replaced system. For this reason it has been assumed, in conjunction with Health Unit records that only class 4 on-site wastewater systems under Part 8 of the Building Code exist within the Rosslyn Village Wellhead Protection Areas. Figure 19 provides a graphic illustration of a Conventional Class 4 Septic System.

5.3.3 The Application of Agricultural Source Material (ASM) to Land

The primary consideration for reducing or eliminating drinking water threats related to the application of agricultural source material is to make sure nitrogen, phosphorus and pathogens do not enter surface water and/or groundwater. Nitrogen, total phosphorus and pathogens are contaminants that could make their way into surface and groundwater as a result of the application of ASM to land. The primary source of nitrogen, total phosphorus and pathogens in ASM is from animal waste and by-products.

5.3.4 The Storage of Agricultural Source Material (ASM)

The primary consideration for reducing or eliminating drinking water threats related to the storage of agricultural source material is to make sure nitrogen, phosphorus and pathogens do not enter surface water and/or groundwater. Nitrogen, total phosphorus and pathogens are contaminants that could make their way into surface and groundwater as a result of the storage of ASM. The primary source of nitrogen, total phosphorus and pathogens in ASM is from animal waste and by-products.

5.3.5 The Management of Agricultural Source Material (ASM)

The primary consideration for reducing or eliminating drinking water threats related to the management of agricultural source material is to make sure nitrogen, phosphorus and pathogens do not enter surface water and/or groundwater. Nitrogen, total phosphorus and pathogens are contaminants that could make their way into surface and groundwater as a result of the management of ASM. The primary source of nitrogen, total phosphorus and pathogens in ASM is from animal waste and by-products.

5.3.6 The Application of Non-Agricultural Source Material (NASM) to Land

The primary consideration for reducing or eliminating drinking water threats related to the application of non-agricultural source material (NASM) is to make sure it does not enter surface water and/or groundwater. Nitrogen, total phosphorus and pathogens are contaminants that could make their way into surface and groundwater as a result of the application of NASM to land. These nutrients and pathogens could threaten the safety of drinking water sources in certain situations due to runoff or spills.

5.3.7 The Handling and Storage of Non-Agricultural Source Material (NASM)

The primary consideration for reducing or eliminating drinking water threats related to the handling and storage of non-agricultural source material is to make sure it does not enter surface water and/or groundwater. Nitrogen, total phosphorus and pathogens are contaminants that could make their way into surface and groundwater as a result of the handling and storage of NASM. These nutrients and pathogens could threaten the safety of drinking water sources in certain situations due to runoff or spills.

5.3.8 The Application of Commercial Fertilizer

The main consideration for reducing or eliminating drinking water threats related to the land application of commercial fertilizer is to make sure it does not enter surface water and/or groundwater sources. Nitrogen and total phosphorus are substances that could make their way into surface and groundwater as a result of the application of commercial fertilizer to land. These nutrients could threaten the safety of drinking water sources in certain situations due to runoff or spills.

5.3.9 The Handling and Storage of Commercial Fertilizer

The main consideration for reducing or eliminating drinking water threats related to the handling and storage of commercial fertilizer is to make sure it does not enter surface water and/or groundwater sources. Nitrogen and total phosphorus are substances that could make their way into surface and groundwater through spills resulting from the handling and storage of fertilizer. These nutrients could threaten the safety of drinking water sources in certain situations due to runoff or spills.

5.3.10 The Application of Pesticide to Land

The main consideration for reducing or eliminating drinking water threats related to the land application of pesticides is to make sure it does not enter surface water and/or groundwater. Pesticides contain chemicals that can adversely affect the safety of drinking water sources.

5.3.11 The Handling and Storage of Pesticides

The main consideration for reducing or eliminating drinking water threats related to the handling and storage of pesticides is to make sure it does not enter surface water and/or groundwater. Pesticides contain chemicals that can adversely affect the safety of drinking water sources.

Pesticides can be stored for retail sale or for use in extermination (such as application to land) since this activity is generally associated with agricultural, recreational, commercial land uses and public works (roads and utility corridors).

The classification of this activity as a significant, moderate or low drinking water threat is dependent on the location as well as the quantity of pesticide stored.

5.3.12 The Application of Road Salt

The main consideration to reduce or eliminate drinking water threats related to the application of road salt is to eliminate or reduce sodium and chloride entering surface water and/or groundwater. Sodium and chloride are contaminants that could make their way into surface and groundwater from road salt application. Sodium and chloride could threaten drinking water sources in certain situations by making it unpalatable or unsafe.

5.3.13 The Handling and Storage of Road Salt

The main consideration to reduce or eliminate drinking water threats related to the handling and storage of road salt is to eliminate or reduce sodium and chloride entering surface water and/or groundwater. Sodium and chloride are contaminants that could make their way into surface and groundwater from road salt storage and handling. Sodium and chloride could threaten drinking water sources in certain situations by making it unpalatable or unsafe.

5.3.14 The Storage of Snow

The primary consideration for reducing or eliminating drinking water threats related to the storage of snow is to make sure contaminated runoff does not enter surface water and/or groundwater. Runoff from snow storage areas can contain chemicals that could threaten the safety of drinking water sources.

5.3.15 The Handling and Storage of Fuel

The main consideration to reduce or eliminate drinking water threats related the handling and storage of fuel is to prevent fuel spills that could enter surface water or groundwater. Benzene, toluene, ethylbenzene and xylenes (BTEX) compounds and petroleum hydrocarbons are contaminants that could make their way into surface water or groundwater from spills associated with the handling of fuel and the storage of fuel. These contaminants could threaten the safety of drinking water sources.

The Thunder Bay (Bare Point Road) Water Treatment Plant has a significant quantity of diesel fuel present on site required for emergency operation of the Water Treatment Plant. In addition, adjacent to the Thunder Bay (Bare Point Road) Water Treatment Plant is a Hydro One Transformer Station Plant that has the potential to have fuels and organic solvents on site.

5.3.16 The Handling and Storage of a Dense Non-Aqueous Phase Liquid

The primary consideration for reducing or eliminating drinking water threats related to the handling and storage of a dense non-aqueous phase liquid (DNAPL) is to make sure it does not enter surface water and/or groundwater. DNAPLs could make their way into surface and groundwater as a result of a spill from the handling and/or storage of these chemicals. These chemicals could threaten the safety of drinking water sources in certain situations

The presence of dense non-aqueous phase liquids poses a threat to drinking water supplies because dense non-aqueous phase liquids can "pool" in the subsurface. Slow dissolution into large volumes of water results in a long-term source of contamination while very small volumes of contaminant are required to render drinking water sources unsafe. Common dense non-aqueous phase liquids are chlorinated solvents such as trichloroethylene (TCE), perchloroethylene (PCE), carbon tetrachloride (CCl_4), and chloroform ($CHCl_3$). These chlorinated solvents have been used as degreasing agents for mechanical components and are often located on and around locations operating and maintaining machinery. Dense non-aqueous phase liquids can also be present where dry-cleaning facilities and other industrial corporations have been situated.

As per the "Directors Technical Rules, Clean Water Act, 2006", dense non-aqueous phase liquids are considered a significant threat in either the Wellhead Protection Areas A, B or C zones regardless of the vulnerability scores for these areas. Dense non-aqueous phase liquids are also considered a threat if they are present in any volume, regardless of how small. The majority of dense non-aqueous phase liquids threats within the vulnerable areas will be related to existing, old household products. Solvents and cleaners located at any commercial and industrial establishments may also be present. Figure 21 provides a graphic illustration of how a dense non-aqueous phase liquids can travel through soil and contaminate an aquifer.

5.3.17 The Handling and Storage of an Organic Solvent

The primary consideration for reducing or eliminating drinking water threats related to the handling and storage of an organic solvent is to make sure it does not enter surface water and/or groundwater. The main contaminants of concern from solvent handling include pentachlorophenol, carbon tetrachloride, dichloromethane and chloroform.

Organic solvents are a chemical class of compounds that are used routinely in commercial industries and industrial sites. These chemicals could threaten the safety of drinking water sources in certain situations.

The main sources of fuels and organic solvents in the vulnerable zones within the Lakehead Source Protection Area are small commercial garages, forestry equipment distribution centres, industrial sites and individual property owner fuel storage.

The Thunder Bay (Bare Point Road) Water Treatment Plant has a significant quantity of diesel fuel present on site required for emergency operation of the Water Treatment Plant. In addition, adjacent to the Thunder Bay (Bare Point Road) Water Treatment Plant is a Hydro One Transformer Station Plant that has the potential to have fuels and organic solvents on site.

Industrial sites present the potential for threats due to their associated land uses. Within the Lakehead Source Protection Area, several industrial sites exist within the proximity of the Intake Protection Zones. According to the "2007 National Pollutant Release Inventory" reporting results, there are two industrial sites present within the vulnerable area for the Thunder Bay (Bare Point Road) Water Treatment Plant: the former Smurfit-Stone Box Mill and Thunder Bay (Bare Point Road) Water Treatment Plant. The Lakehead Source Protection Committee has agreed that if an industrial site's Certificate of Approvals for Waste Disposal, Air and Wastewater Emissions are not current and active, then the industrial site is deemed inactive for the purposes of identifying threats associated with the industrial site. At the time of the development of the Assessment Report, all industrial production activities at the Smurfit-Stone facility were halted. Industrial land use activities associated with the former Smurfit-Stone Box Mill, included solid waste landfilling, industrial sewage discharge, fuel, solvent and dense non-aqueous phase liquids (DNAPL) handling which could be potential threats. Currently the Smurfit-Stone facility has three active approvals, two for Industrial Sewage Works and one approval with two amendments for a waste disposal site. Copies of these Certificates of Approval are located in Appendix V. Primary sources of potential threats related to the Thunder Bay (Bare Point Road) Water Treatment Plant are the handling and storage of fuel related to the emergency back-up generators, and the application of chemicals during the water treatment process. Figure 20 provides a graphic illustration of industrial activities and how they can contaminate groundwater.

5.3.18 The Management of Runoff That Contains Chemicals Used in the De-Icing of an Aircraft

The primary consideration for reducing or eliminating drinking water threats related to the management of runoff that contains aircraft de-icing chemicals is to make sure it does not enter surface water and/or groundwater. The runoff of large volumes of de-icing fluids into surface water bodies over a short period of time can lead to oxygen depletion which results in poor water quality and toxicity to aquatic life and mammals.

5.3.19 An Activity that Takes Water from an Aquifer or a Surface Water Body Without Returning the Water Taken to the Same Aquifer or Surface Water Body

An activity that takes water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body is considered a threat.

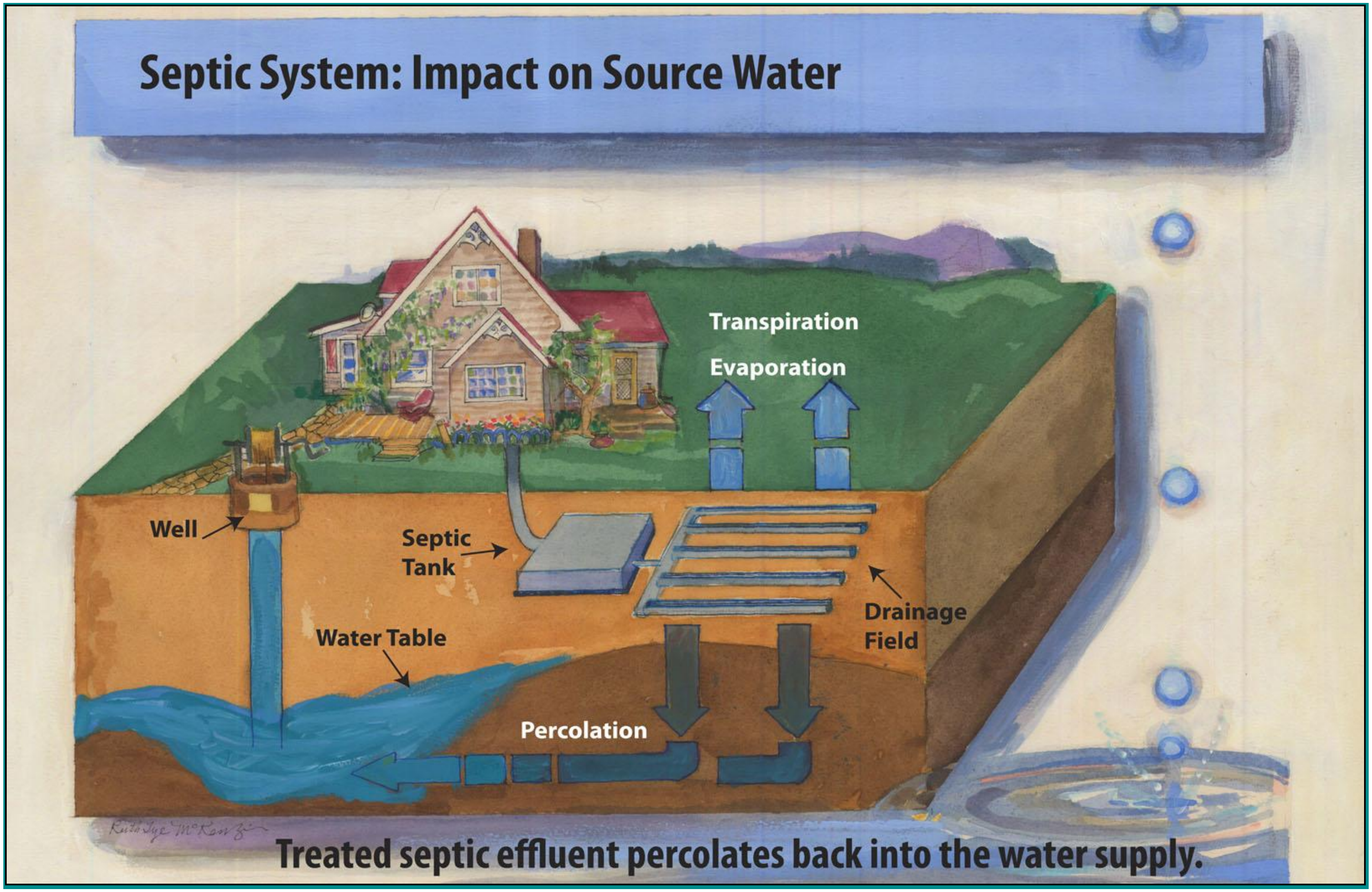
5.3.20 An Activity that Reduces the Recharge of an Aquifer

An activity that reduces the recharge of an aquifer is considered a threat.

5.3.21 The Use of Land as Livestock Grazing or Pasturing Land, an Outdoor Confinement Area or a Farm-Animal Yard

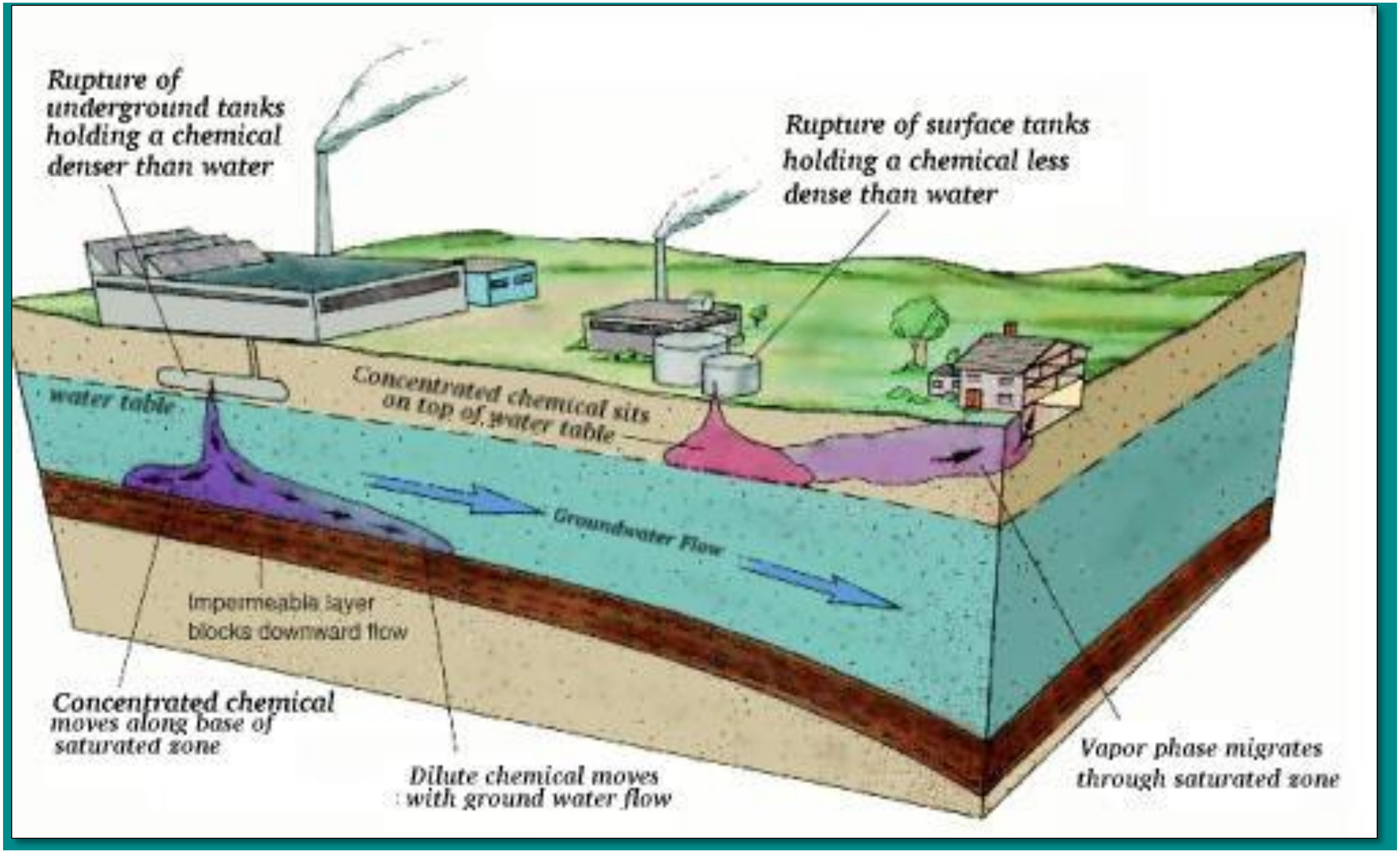
Nitrogen, total phosphorus and pathogens (such as E.coli) are contaminants that could make their way into surface and groundwater from outdoor livestock areas. Nitrogen is a concern for both surface and groundwater. Total phosphorous is only considered for surface water because excessive inputs result in eutrophication and can cause toxic algae blooms. These nutrients and pathogens found in animal manure could threaten the safety of drinking water sources in certain situations. Keeping greater numbers of livestock in a space intensifies the accumulation of nutrients and pathogens, thereby increasing the risk of contamination and the requirement for more active management.

Figure 19: Conventional Class 4 – Septic System



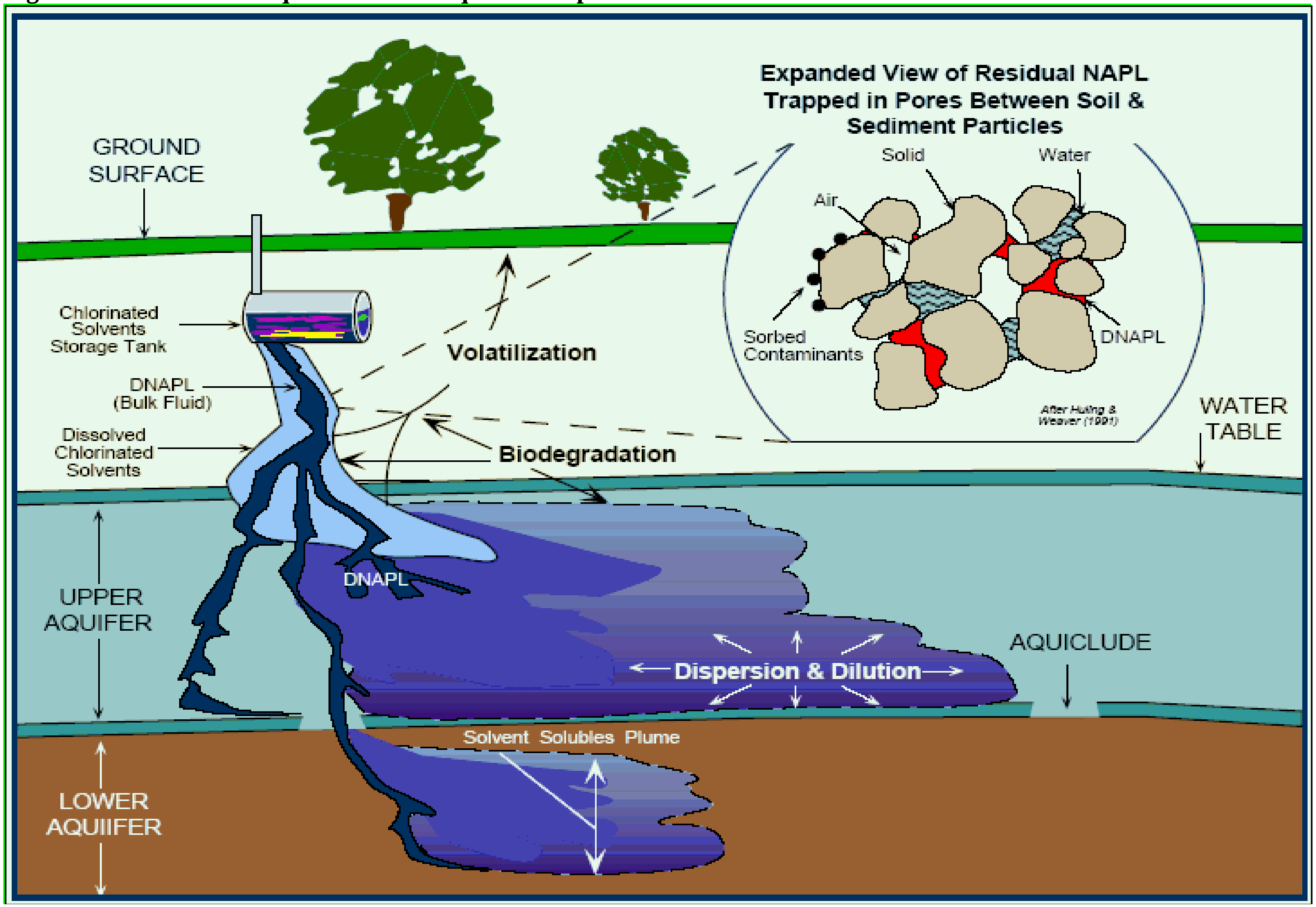
Source: Lakehead Region Conservation Authority

Figure 20: Example of Industrial Groundwater Contamination



Source:http://earthsci.org/education/teacher/basicgeol/groundwa/plume2

Figure 21: Dense Non-Aqueous Phase Liquid Transport in Soil



Source: http://oceanworld.tamu.edu/resources/environment-book/Images/DNAPL.gif

5.4 Corridor Source Threats

A corridor source is defined as a "transportation route or other linear feature (e.g. sewer pipes, shipping routes) upon which chemical or pathogenic contaminants are transported".

Corridors can vary in size, volume and types of products and goods carried. Table 43 summarizes the potential corridor source threats to the Bare Point Water Treatment Plant. The Rosslyn Village Municipal Water Supply is much less vulnerable to corridor source threats.

The Lakehead Source Protection Committee has determined that, on a local level, the transportation along these corridors does not warrant inclusion as activities that can lead to threats to the local source water intakes.

Although it cannot be identified as a potential threat due to regulatory limitations, the Lakehead Source Protection Committee has identified concerns related to the commercial shipping anchorage location within the Intake Protection Zone - 2.

Table 43: Corridor Source Threats

Corridor	Description
Canadian Pacific Railway (CPR)	Located close to and aligned parallel to the shoreline, the rail line carries various products including; automotive, coal, ethanol, fertilizer and potash, food products, forest products, grain, etc.
Canadian National (CN) Railway	No longer in service. Track currently being removed.
Commercial Shipping Lanes	Commercial shipping lines in and out of the Thunder Bay Harbour carry a variety of goods and services that have the potential to impact the Thunder Bay (Bare Point Road) Water Treatment Plant.
TransCanada Highway	Located inland and aligned parallel to the shoreline, this corridor is the trans Canadian transportation route in northwestern Ontario
Commercial Shipping Anchorage	Overflow and emergency anchorage for large ships in the Harbour located just offshore from the Thunder Bay (Bare Road) Water Treatment Plant and next to the raw water intal
Strathcona Avenue / Lakeshore Drive	Located close to and aligned parallel to the shoreline this corridor is in close proximity to the Thunder Bay (Bare Point Road) Water Treatment Plant.
Sanitary Sewer (force main)	Located in the rail corridor right-of-way and linking the Thunder Bay (Bare Point Road) Water Treatment Plant discharge, east end City of Thunder Bay sanitary sewers and former boxboard plant solid waste disposal leachate collection system to City of Thunder Bay sanitary collection system.

5.4.1 Constructed Preferential or Transport Pathways

Preferential pathways allow contaminants to migrate to a drinking water source. Transport pathways can be of both natural and anthropogenic origin. A natural pathway would be the outlet of a creek or river into a water body. A transport pathway of anthropogenic origin includes, drains, hard surfacing or stormwater outfalls into receiving waters. Within Intake Protection Zone -2 zones it is important to note the differences between stormwater management and other transport pathways.

Within Intake Protection Zones storm water drains, storm water ditches and impervious surfaces are the transport pathways of greatest concern. Within the Intake Protection Zone-2 area there is a fair amount of impervious surfaces (roads, rail and parking lots). All water from these surfaces should drain into the storm water sewer system. Natural pathways, such as stream courses, were included in the preferential pathways inventory since urban drainage and storm sewers often discharge to natural watercourses. Within Wellhead Protection Areas the transport pathways of greatest concern would be roads, storm water ditches and improperly constructed wells. Table 44 details the transport pathways in the area of the Thunder Bay (Bare Point Road) Water Treatment Plant that have the potential to impact the Thunder Bay (Bare Point Road) Water Treatment Plant surface water intake.

Table 44: Transport Pathways

Pathway	Description	Number of Outfalls	Straight Line Distance to Intake (metres)	Extent of Network (square kilometres)
Northstar Creek	Minor creek. Water Treatment Plant operators did not note any negative impact from discharge.	1	900	4.3
Stormwater Outlets	Identified from reports on storm water management (CGandS, 1998; UMA, 2002).	4	840	N/A
			960	
			1150	
			1290	
Drains/Watercourses	Identified from reports on storm water management (CGandS, 1998; UMA, 2002).	4	810	N/A
			1690	
			2050	
			2240	
Smurfit-Stone Box Mill Sewer Outlet	From sewage works Certificate of Approval Number 5333-6TZG2N.	1	1000	N/A

5.5 Groundwater Threats

Three main areas of groundwater vulnerability have been identified by the "Clean Water Act, 2006". These areas include, Significant Groundwater Recharge Areas, Highly Vulnerable Aquifers and Wellhead Protection Areas. The Lakehead Source Protection Area contains one groundwater Municipal Residential Drinking Water System located in Rosslyn Village in the Municipality of Oliver Paipoonge. Some Significant Groundwater Recharge Areas and Highly Vulnerable Aquifers are also present within the Lakehead Source Protection Area. Due to a significant lack in reliable data, aquifer vulnerability was not assessed outside of the study area identified in the "Groundwater Study". As a result, vulnerability scores could be determined only for Significant Groundwater Recharge Areas and Highly Vulnerable Aquifers within this area identified in the "Groundwater Study" which includes over 95 percent of the regional population.

5.5.1 Issues in Highly Vulnerable Aquifers

No known issues have been identified within Highly Vulnerable Aquifers within the Lakehead Source Protection Area.

5.5.2 Conditions in Highly Vulnerable Aquifers

There are no pre-existing conditions found in Highly Vulnerable Aquifers within the Lakehead Source Protection Area.

5.5.3 Threats in Highly Vulnerable Aquifers

Threats that could arise from land-use activities or pre-existing conditions within Highly Vulnerable Aquifers can be referenced in the Ministry of Environment "Table of Drinking Water Threats, Clean Water Act, 2006" and have been listed in the provincially created tables listed below in Table 45 and located in "Table of Drinking Water Threats, Clean Water Act, 2006" Threats Binders A and B.

Table 45: Chemical Threats within Highly Vulnerable Aquifers

Vulnerability Score	Table Name		
	Significant	Moderate	Low
6	N/A	CSGRAHVA6M	CSGRAHVA6L

5.5.4 Issues in Significant Groundwater Recharge Areas

No known issues have currently been identified within Significant Groundwater Recharge Areas.

5.5.5 Conditions in Significant Groundwater Recharge Areas

There are no pre-existing conditions found in Significant Groundwater Recharge Areas within the Lakehead Source Protection Area.

5.5.6 Threats in Significant Groundwater Recharge Areas

Threats that could arise from land-use activities or pre-existing conditions within Significant Groundwater Recharge Areas can be referenced in the Ministry of Environment "Table of Drinking Water Threats, Clean Water Act, 2006" and have been listed in the provincially created tables listed below in Table 46 and located in "Table of Drinking Water Threats, Clean Water Act, 2006" Threats Binders A and B.

Table 46: Chemical Threats within Significant Groundwater Recharge Areas

Vulnerability Score	Table Name		
	Significant	Moderate	Low
6	N/A	CSGRAHVA6M	CSGRAHVA6L

5.5.7 Issues in Wellhead Protection Areas

The Rosslyn Village Subdivision Well Supply drinking water has been regularly tested and monitored for drinking water quality since 2001. This data includes testing results for organics, inorganics, iron, manganese, hardness, chloride, sodium, nitrates, nitrites and fluoride. The report entitled "Groundwater Vulnerability Analysis Issues Evaluation Threats, Inventory and Water Quality Risk Assessment for Hamlet of Rosslyn Village Wellhead Protection Area Municipality of Oliver Paipoonge, Ontario", AMEC Earth and Environmental (December 2008) stated that the water quality for the Rosslyn Village Municipal Water Supply appeared to be stable with no apparent trends or impacts from surficial or near surface activities.

A number of Rosslyn Village subdivision residents have decided to construct their own wells and discontinue delivery of Municipal Residential Drinking Water to their homes. Drilling many wells in close proximity to private septic systems and other supply wells has the potential to compromise the confining layer and open up preferential pathways for surficial or shallow soil contamination. Development of a dense distribution of private wells in the Rosslyn Village subdivision area could be potentially detrimental to water quality.

Several years of water quality sampling was available for the Rosslyn Village Municipal Water Supply. These raw water samples were compared to Ontario Drinking Water Quality Standard and Provincial Water Quality Objective and analyzed for potential trending. From the available data the following was noted:

- Two incidences of a parameter exceeding the Ontario Drinking Water Quality Standard – Maximum Allowable Concentration (fluoride).

- Zero incidence of a parameter measuring above Ontario Drinking Water Quality Standard – Interim Maximum Allowable Concentration.
- Zero incidence of a parameter measuring above the Ontario Drinking Water Quality Standard – ½ Maximum Allowable Concentration.
- Zero incidences of a parameter measuring above Ontario Drinking Water Quality Standard – Operating Guidelines.
- Two incidences of parameters measuring above Ontario Drinking Water Quality Standard – Aesthetic Objective (sodium, turbidity).
- Zero incidences of parameters measuring above Provincial Water Quality Objective and Method Detection Limits.
- Zero incidences increasing over the reporting period towards an Ontario Drinking Water Quality Standards or Provincial Water Quality Objective benchmark.

In order for these concerns to be elevated into drinking water issues, they need to be present at a concentration that may result in the deterioration of the quality of water for use as a source of drinking water or have a trend of increasing concentrations where a continuation of that trend would result in the deterioration of the quality of the Municipal Residential Drinking Water source. As a result of the data collected, there are no known issues identified within the Rosslyn Village Subdivision Well Supply Wellhead Protection Areas.

5.5.8 Conditions in Wellhead Protection Areas

There are no known pre-existing known conditions which have been identified within the Rosslyn Village Subdivision Well Supply Wellhead Protection Areas.

5.5.9 Threats in Wellhead Protection Areas

The Ministry of Environment "Table of Drinking Water Threats, Clean Water Act, 2006" and Threats Database was used to list all potential contamination sources located in the Rosslyn Village Subdivision Well Supply Wellhead Protection Areas. The "Threats Look-up Table Database version 7.0" is a tool for use in Source Protection Planning that is used to narrow down the potential threats for an area based on the vulnerability score of the area and a hazard rating for the contaminant of concern. There are separate tables located in the database for chemical threats, pathogen threats and dense non-aqueous phase liquid threats. These threats are matched up with chemical hazard ratings to determine whether they are significant, moderate or low threats.

When the Provincial Threats Tables are examined there are only a few threats to the Rosslyn Village Subdivision Well Supply present within the Wellhead Protection Areas. The main potential threats to groundwater are limited to:

- Local individual private septic systems.
- Fuels and solvent handling and storage.
- Management and application of agricultural and non-agricultural source material.
- Application of fertilizers and pesticides.
- Use of land for livestock grazing.

- Road salt application.

All residences in the Rosslyn Village Subdivision are serviced by an individual septic system. Based on the results presented in the report entitled "Groundwater Vulnerability Analysis Issues Evaluation Threats, Inventory and Water Quality Risk Assessment for Hamlet of Rosslyn Village Wellhead Protection Area Municipality of Oliver Paipoonge, Ontario" AMEC Earth and Environmental (December 2008), there are twenty five septic systems in the Rosslyn Village Subdivision Wellhead Protection Areas located within the Wellhead Protection Area A and B zones. Septic systems can be a source of pathogens and nitrates, both potential health related threats to drinking water.

Threats from fuels, hydrocarbons or solvents may originate from any vehicle restoration activities occurring in the area. These compounds would be chronic, aesthetic and health-related threats to ground water. Based on field observations at several sites within the Wellhead Protection Areas, certain contaminants of concern have the potential to be present within the Wellhead Protection Areas. Several vehicle maintenance and impoundment operations are present within the area. These operations have the potential to threaten the ground water with compounds related to petroleum hydrocarbons and solvents. These contaminants of concern can include the volatile compounds benzene, toluene, ethylbenzene, xylene (BTEX) and petroleum hydrocarbon (PHC) fractions F1 through F4.

All properties surveyed within the Wellhead Protection Areas had either natural gas, electricity, wood or combinations of these sources, for home heating sources. Home heating oil is not listed as threat because only one of the residences surveyed had a visible home heating oil tank on the property and this residence was well outside of the Wellhead Protection Area. Should heating oil be introduced to any residence it would become a concern. No known impacts from these threats are known to exist in the Rosslyn Village Subdivision Well Supply. The issues and threats should be evaluated regularly in conjunction with a review of collected water quality data.

A full listing of potential threats in Wellhead Protection Areas is provided in a series of tables provided by the Ministry of Environment. These tables provide a listing of land-use activities which could or would result in threats within the associated vulnerable zones. Assessment Report Map #29A – Vulnerability Scores for the Rosslyn Village Subdivision Well Supply (Map Binder –Map Sleeve #29A) illustrates the applicable Provincial Threats Tables as they correspond to the different vulnerability scores within the Wellhead Protection Areas and can be used as a tool to visualize the location of threats as detailed in the tables below.

Table 47: Chemical Threats within Wellhead Protection Areas

Vulnerability Score	**Table Name**		
	Significant	**Moderate**	**Low**
10	CW10S	CW10M	CW10L
6	N/A	CW6M	CW6L
4	N/A	N/A	N/A

Table 48: Pathogen Threats within Wellhead Protection Areas

Vulnerability Score	Table Name		
	Significant	**Moderate**	**Low**
10	PW10S	PW10M	N/A
6	N/A	N/A	PW6L
4	N/A	N/A	N/A

It should be noted that dense non-aqueous phase liquids are a significant threat in Wellhead Protection Areas A, B and C regardless of the vulnerability score. Dense non-aqueous phase liquids are considered moderate or low threats in Wellhead Protection Area D due to a vulnerability score of 6.

Table 49: Dense Non-Aqueous Phase Liquids Threats within Wellhead Protection Areas

Vulnerability Score	Table Name		
	Significant	**Moderate**	**Low**
10	DWAS	DWAS	DWAS
6	DWAS	DWAS, DW6M	DWAS, DW6L
4	N/A	N/A	N/A

Potential threats identified in Tables 50 and 51 have been identified by the Lakehead Source Protection Committee as being activities or pre-existing conditions which would or could be present in the vulnerable area. The Lakehead Source Protection Committee believes that currently there is not enough information available to say with certainty that the circumstances enumerated below do not exist within the associated vulnerable areas.

The final portion of this exercise was enumerating significant drinking water threats that are known to be present within the vulnerable area. The Lakehead Source Protection Committee has reasonable belief that the activities and circumstances listed below are currently a significant threat within the Wellhead Protection Area.

Table 50: Significant Chemical Threats within Wellhead Protection Area

Reference Number	Threat	Circumstance	Chemical	Number of Occurrences
1215	The storage of agricultural source material.	1. A portion, but not all, of the agricultural material is stored above grade in or on a permanent nutrient storage facility. 2. The weight or volume of manure stored annually on a farm unit is sufficient to annually land apply agricultural source material at a rate that is more than 0.5, but not more than 1.0 nutrient unit per acre of the farm units.	Nitrogen	1

Table 51: Significant Pathogen Threats within Wellhead Protection Area

Reference Number	Threat	Circumstance	Number of Occurrences
1944	The application of agricultural source material to land	1. Agricultural source material is applied to land in any quantity. 2. The application may result in the presence of one or more pathogens in groundwater or surface water.	1
1945	The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard.	1. The use of land as livestock grazing or pasturing land for one or more animals. 2. The land use may result in the presence of one or more pathogens in groundwater or surface water.	1
1946	The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard.	1. The use of land as an outdoor confinement area or a farm-animal yard for one or more animals. 2. The land use may result in the presence of one or more pathogens in groundwater or surface water.	1
1956	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	1. The system is an earth pit privy, privy vault, cesspool, or a leaching bed system and its associated treatment unit and is a sewage system as defined in Section 1 of Ontario Regulation 350/06 (Building Code) made under the "Building Code Act, 1992" or a sewage works as defined in Section 1 of the "Ontario Water Resources Act". 2. A discharge from the system may result in the presence of one or more pathogens in groundwater or surface water	25
1962	The storage of agricultural source material	1. Any portion of the agricultural source material is stored at or above grade in or on a permanent nutrient storage facility.	1

		2. A spill of the material or runoff from an area where the material is stored may result in the presence of one or more pathogens in groundwater or surface water.	
1964	The storage of agricultural source material	1. The agricultural source material is stored at a temporary field nutrient storage site. 2. A spill of the material or runoff from an area where the material is stored may result in the presence of one or more pathogens in groundwater or surface water.	1

Assessment Report Map #29A – Vulnerability Scores for the Rosslyn Village Subdivision Well Supply
Map Binder – Map Sleeve #29A

This map illustrates the vulnerability scores for the vulnerable zones related to the Rosslyn Village Subdivision Well Supply, Wellhead Protection Areas. Vulnerability scores are assigned to vulnerable areas based on the anticipated vulnerability to contamination in that area. These scores are developed on a scale of 1-10 according to Part VII of the "Director Technical Rules, Clean Water Act, 2006".

5.5.10 Ground Water Threats Risk Assessment

Risks associated with Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas have not been included in a risk level assessment. It is not possible for a land-use activity or a pre-existing condition within a Highly Vulnerable Aquifer or Significant Groundwater Recharge Areas to result in a significant threat to drinking water quality due to the associated vulnerability scoring.

5.6 Surface Water Threats

Surface water intakes have been classified by the "Clean Water Act, 2006" according to the location of the intake. As per the "Directors Technical Rules, Clean Water Act, 2006", the surface water intake for the Thunder Bay (Bare Point Road) Water Treatment Plant is considered a Type A intake (Great Lakes). The Thunder Bay (Bare Point Road) Water Treatment Plant surface water intake is the sole source of Municipal Residential Drinking Water Supply for over 90 percent of the City of Thunder Bay and Fort William First Nation residents.

5.6.1 Issues in Intake Protection Zones

Fifteen years (1990-2005) of sampling data was available for the Thunder Bay (Bare Point Road) Water Treatment Plant. The raw water samples were compared to Ontario Drinking Water Quality Standards and Provincial Water Quality Objectives and analyzed for potential trending. From the available data the following was noted:

- One incidence of a parameter measuring above Ontario Drinking Water Quality Standard – Interim Maximum Allowable Concentration (antimony).
- One incidence of a parameter measuring above the Ontario Drinking Water Quality Standard – ½ Maximum Allowable Concentration (lead).
- Zero incidences of a parameter measuring above Ontario Drinking Water Quality Standard – Operating Guideline.
- Four incidences of parameters measuring above Ontario Drinking Water Quality Standard – Aesthetic Objective (temperature, turbidity, colour and organic chemical: 2,4-dichlorobenzene).
- Five incidences of parameters measuring above Provincial Water Quality Objective and Method Detection Limits (total coliform, *E. coli*, cadmium, cyanide and lead).
- Zero incidences increasing over the reporting period towards an Ontario Drinking Water Quality Standard or Provincial Water Quality Objective benchmark.

Some of the drinking water concerns identified by the Thunder Bay (Bare Point Road) Water Treatment Plant operators are listed below:

- Highway runoff.
- Industrial wastewater discharges.
- Paper mill landfills.
- Incidental spills.
- Municipal drain influences.

Other concerns identified and detailed in earlier sections of the Assessment Report include:

- Spills along marine and terrestrial transportation corridors including commercial shipping anchorage located within Intake Protection Zone 2.
- Industrial sites.
- Residential/cottage development.
- Water circulation patterns.

In order for these concerns to be elevated into drinking water issues, they need to be present at a concentration that may result in the deterioration of the quality of water for use as a source of drinking water or have a trend of increasing concentrations where a continuation of that trend would result in the deterioration of the quality of the drinking water source. These concerns are not considered issues under the “Clean Water Act”. As a result, there are currently no known issues identified for the Thunder Bay (Bare Point Road) Water Treatment Plant Intake Protection Zones.

5.6.2 Bare Point Water Intake Conditions

The Source Protection Committee has not identified any known pre-existing conditions within Intake Protection Zones 1 and 2 surrounding the Bare Point Municipal water intake. Industrial sites adjacent and within the surface water vulnerable zones may contain pre-existing conditions that were not identified during the commissioned studies. Proprietary information regarding site decommissioning including soil, sediment and groundwater testing results may not have been made available to consultants and the Lakehead Source Protection Committee during the development of the Assessment Report

5.6.3 Threats in Intake Protection Zones

The Ontario Ministry of Environment "Table of Drinking Water Threats, Clean Water Act, 2006" and "Threats Look-up Table Database version 7.0" was used to list all potential contamination sources located within the Thunder Bay (Bare Point Road) Water Treatment Plant Intake Protection Zones. The "Threats Look-up Table Database version 7.0" is a tool for use in Source Protection Planning to provide a score of the area and a hazard rating for the contaminant of concern. There are separate tables located in the database for chemical threats, pathogen threats and dense non-aqueous phase liquids threats. These threats are matched up with chemical hazard ratings to determine whether they are significant, moderate or low threats. A full listing of potential threats in the Intake Protection Zones as determined by the "Threats Look-up Table Database version 7.0"is contained in the attached Threats Tables Binders A and B. There are very few threats present in the Thunder Bay (Bare Point Road) Water Treatment Plant Intake Protection Zones. The main potential threats to the surface water intake are limited to:

- Local individual private septic systems.
- Fuels and solvent handling and storage.
- Application of fertilizers and pesticides.
- Natural and artificial watercourse outfalls.
- Road salt application.
- Land uses associated with paper production.
- Land uses associated with marine activities.
- Storm and sanitary force mains.
- Transportation corridors.

All nearby residences are serviced by an individual septic system. Based on aerial photographs, there are eleven septic systems located within The Intake Protection Zone 2 for the Thunder Bay (Bare Point Road) Water Treatment Plant Intake Protection Zones. Septic systems can be a source of pathogens and nitrates, both potential health related threats to drinking water.

Threats from fuels, hydrocarbons or solvents may originate from any vehicle restoration activities or heavy equipment storage occurring in the area. There may also be bulk quantities of these potential threat compounds located in several locations within the Intake Protection Zones (wholesaler/distributor and at the water treatment plant itself). These compounds would be chronic, aesthetic and health-related threats to groundwater. These operations have the potential to threaten the groundwater with compounds related to petroleum hydrocarbons and solvents. These contaminants of concern can include the volatile compounds benzene, toluene, ethylbenzene, xylene (BTEX) and petroleum hydrocarbon (PHC) fractions F1 through F4. Groundwater contamination has the potential to migrate into the surface water source.

Home heating oil is not currently listed as threat because none of the residences surveyed had a visible home heating oil tank on the property. Should heating oil be introduced to any residence it could become a concern.

No impacts from these threats are known to exist in the Thunder Bay (Bare Point Road) Water Treatment Plant Municipal Residential Drinking Water Supplies. The issues and threats should be evaluated regularly in conjunction with a review of collected water quality data.

The Threats Tables Binders A and B contains the identified threats and their associated hazard scores determined by the "Threats Look-up Table Database version 7.0" for the Thunder Bay (Bare Point Road) Water Treatment Plant, Municipal Residential Drinking Water System Intake Protection Zones.

Assessment Report Map #29B – Vulnerability Scores for the Thunder Bay (Bare Point Road) Water Treatment Plant, Intake Protection Zones
Map Binder - Map Sleeve #29B

This map illustrates the Vulnerability Scores for the vulnerable zones related to the Thunder Bay (Bare Point Road) Water Treatment Plant, Intake Protection Zones (IPZ's). Vulnerability scores are assigned to vulnerable areas based on the anticipated vulnerability to contamination in that area. These scores are developed on a scale of 1-10 according to Part VII of the "Director Technical Rules, Clean Water Act, 2006".

5.6.3.1 Threats in Intake Protection Zones

Threats that could arise from land-use activities or pre-existing conditions within Intake Protection Zones can be referenced in the Ontario Ministry of Environment "Table of Drinking Water Threats, Clean Water Act, 2006". Identified below are the provincially created tables and their location in the "Table of Drinking Water Threats, Clean Water Act, 2006" Binder A and B.

Table 52: Chemical Threats within Intake Protection Zones

Vulnerability Score	Table Name		
	Significant	Moderate	Low
5	N/A	N/A	CIPZWE5L

Table 53: Pathogen Threats within Intake Protection Zones

Vulnerability Score	Table Name		
	Significant	Moderate	Low
5	N/A	N/A	PIPZ5L

As a result of the low vulnerability score for the Thunder Bay (Bare Point Road) Water Treatment Plant Intake Protection Zone 2, (vulnerability score = 3.5) there are no threats (low, moderate or significant) that will be generated from the Ontario Ministry of Environment "Table of Drinking Water Threats, Clean Water Act, 2006" and "Directors Technical Rules, Clean Water Act, 2006".

The Ontario Ministry of Environment "Table of Drinking Water Threats, Clean Water Act, 2006" and "Directors Technical Rules, Clean Water Act, 2006" were both used to determine a vulnerability score of 3.5 with no results for pathogen, chemical or dense non-aqueous phase liquids Threats. It should be noted that significant drinking water threats can still be generated by conditions and issues within this area. Identification of these threats would be on the direction of the Lakehead Source Protection Committee and dependent on whether appropriate data is available for the Lakehead Source Protection Committee.

The final portion of this exercise was enumerating significant drinking water threats that are known to be present within the vulnerable area. Due to the low vulnerability scores within Intake Protection Zones there are currently no significant chemical, pathogen or dense non-aqueous phase liquids threats within the Intake Protection Zones as currently delineated.

5.6.4 Threats Risk Assessment in Intake Protection Zones

Full details of the surface water threats risk assessment determined using the Ontario Ministry of Environment "Table of Drinking Water Threats, Clean Water Act, 2006" and "Directors Technical Rules, Clean Water Act, 2006", are detailed in the "Table of Drinking Water Threats, Clean Water Act, 2006" Threats Binders A and B.

There are no identified land-use activities or pre-existing conditions that will contribute low, moderate or significant threats within Intake Protection Zone 2. Any land-use activities or pre-existing conditions resulting in threats within this vulnerable zone would have to be identified by the Lakehead Source Protection Committee.

6.0 Great Lakes Considerations

The Lakehead Source Protection Area drains into Lake Superior via three subwatersheds: the Dog, Arrow, and Black Sturgeon. This chapter addresses the requirements of the "Clean Water Act, 2006" that are applicable to Source Protection Areas that drain into the Great Lakes.

6.1 Consideration of Great Lakes Agreements

The "Clean Water Act, 2006" requires that the Terms of Reference for the preparation of the Assessment Report and Source Protection Plan for Source Protection Areas, that contain water that flows into the Great Lakes or the St. Lawrence River, must consider the following documents: Great Lakes Water Quality Agreement, Canada-Ontario Agreement Respecting the Great Lakes Ecosystem, Great Lakes Charter and any other Agreement to which the Government of Ontario or Canada is a party. The "Directors Technical Rules, Clean Water Act, 2006" indicate that a written description of how these Agreements were considered in the work undertaken in accordance with the "Directors Technical Rules, Clean Water Act, 2006"must be included in the Assessment Report.

Although all three prescribed documents share common goals with the Source Protection Planning process, the Great Lakes Water Quality Agreement is the only prescribed document that has specific links to the preparation of this Assessment Report.

6.1.1 Great Lakes Water Quality Agreement (GLWQA)

The purpose of the Great Lakes Water Quality Agreement is defined in the Agreement itself. The most recent amendment to the Agreement, signed November 18, 1987, reads as follows:

> “The purpose of the Parties is to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem. In order to achieve this purpose, the Parties agree to make maximum effort to develop programs, practices, and technology necessary for a better understanding of the Great Lakes Basin Ecosystem and to eliminate or reduce to the maximum extent practicable the discharge of pollutants into the Great Lakes System.

Consistent with the provisions of this Agreement, it is the policy of the Parties that:

a) The discharge of toxic substances in toxic amounts be prohibited and the discharge of any or all persistent toxic substances be virtually eliminated.

b) Financial assistance to construct publicly owned waste treatment works be provided by a combination of local, state, provincial and federal participation.

c) Coordinated planning processes and best management practices be developed and implemented by the respective jurisdictions to ensure adequate control of all sources of pollutants.”

The participating stakeholder groups in co-operation with the International Joint Commission identified 43 polluted areas on the Great Lakes as individual Areas of Concern (AOCs), for which a cleanup or Remedial Action Plan (RAP) was required. Seventeen Areas of Concern (AOCs) were in Ontario and four, including Thunder Bay, are located on the north shore of Lake Superior.

6.1.1.1 Thunder Bay Remedial Action Plan

The “Thunder Bay Area of Concern Remedial Action Plan Stage 1” (1991) report provided a definition and detailed description of the environmental problems within the Area of Concern (AOCs) and identified the beneficial use impairments for the Thunder Bay Harbour and adjoining tributaries. Thunder Bay was originally classified as an Area of Concern (AOCs) because of problems associated with heavy metals, toxic organics, contaminated sediments, fish consumption advisories, impacted biota, beach closings and conventional pollutants.

The “Thunder Bay Area of Concern Remedial Action Plan Stage 1” (1991) Report identified ten beneficial uses as "impaired", three as "not impaired", and one as "requiring further assessment".

The “Thunder Bay Area of Concern Remedial Action Plan Stage 2” (2004) Report identified one beneficial use as impaired (one delisted due to local sources) and five as unimpaired.

The Thunder Bay Remedial Action Plan (RAP) program is currently being facilitated by Lakehead University under the supervision and guidance of Environment Canada, Ontario Ministry of the Environment and Ministry of Natural Resources. The remedial actions undertaken and identified within the “Thunder Bay Area of Concern Remedial Action Plan Stage 2” (2004) Report are currently in the process of being reviewed by the Thunder Bay Area of Concern Public Advisory Committee (PAC). The Public Advisory Committee is an organization comprised of: members of the public, non-Government organizations, academia, industry, recreational groups and property owners. Their review will provide recommendations to both the Provincial and Federal Governments on how to proceed forward with the delisting of Thunder Bay as an Area of Concern.

The Thunder Bay Remedial Action Plan was an important consideration in the development of this Assessment Report. Data and reports made available through the Thunder Bay RAP were reviewed during the creation of this document. After review of the information provided in the reports related to the Remedial Action Plan (RAP), the Lakehead Source Protection Committee has concluded that the current Areas of Concern (AOCs) do not have any known direct impacts on the water quality within the Intake Protection Zones 1 and 2 for the Bare Point Intake. The consultant also considered the “Thunder Bay Area of Concern Remedial Action Plan Stage 1” (1991) and “Thunder Bay Area of Concern Remedial Action Plan Stage 2” (2004) Reports during the preliminary research carried out for the determination and delineation of the Intake Protection Zones.

6.1.2 Canada-Ontario Agreement Respecting the Great Lakes Ecosystem

Since 1971, the Canada-Ontario Agreements Respecting the Great Lakes Basin Ecosystem has guided the Provincial and Federal Governments in their work to improve the environmental quality of the Basin. Along with the efforts of the Basin's residents, these Agreements have contributed to:

- Reducing the amount of pollution that enters the Basin.
- Improving and protecting the habitat of fish and wildlife.
- Working toward the goal of having water that is safe to swim in and to drink.
- Fostering a sense of stewardship throughout the region for the Basin ecosystem.

The Agreement outlines how the Provincial and Federal Governments will cooperate and coordinate their efforts to restore, protect and conserve the Great Lakes Basin ecosystem and contributes to meeting Canada’s obligations under the Great Lakes Water Quality Agreement. The purpose of this Agreement is the protection of water quality but it does not include any specific technical information which would pertain to the preparation of this Assessment Report.

6.1.3 Great Lakes Charter (GLC)

The purposes of the Great Lakes Charter are: to conserve the levels and flows of the Great Lakes and their tributary and connecting waters, protect and conserve the environmental balance of the Great Lakes Basin ecosystem, provide for cooperative programs and management of the water resources of the Great Lakes Basin by the signatory States and Provinces, make secure and protect present developments within the region and provide a secure foundation for future investment and development within the region. The Great Lakes Charter proposes to do this according to five principles.

1. Principle I – Integrity of the Great Lakes Basin.
2. Principle II – Co-operation Among Jurisdictions.
3. Principle III – Protection of the Water Resources of the Great Lakes.
4. Principle IV – Prior Notice and Consultation.
5. Principle V – Cooperative Programs and Practices.

The Great Lakes Charter was supplemented in 2001 by the Great Lakes Charter Annex, which reaffirmed the principles of the Charter and committed the Governors and Premiers of the Great Lakes States and Provinces to "developing an enhanced water management system that protects, conserves, restores and improves the Waters and Water-Dependent Natural Resources of the Great Lakes Basin" (Council of Great Lakes Governors, 2001). The Great Lakes Charter Annex implementing Agreements including the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement, attempt to provide this water management system (Environment Canada, 2005).

6.1.4 Great Lakes Targets

The "Clean Water Act, 2006" allows for the Minister of Environment to establish targets relating to the use of the Great Lakes as a source of drinking water for any of the Source Protection Areas that contribute water to the Great Lakes. If and when targets are set, policies and steps will need to be established in order to achieve these targets. At the time of the development of the Assessment Report (February 2010), the Minster of Environment had not set any targets. It is the intent of the Lakehead Source Protection Committee to include any new or updated information related to Great Lakes Targets in future Assessment Reports.

6.1.5 Lake Superior Binational Forum

Since 1991, the Lake Superior Binational Forum has served as the principal public body working with the governments responsible for implementing the Lake Superior Binational Program and its Lakewide Management Plan. The purpose of the Lake Superior Binational Forum is to further consultation and participation among government, industry and environmental stakeholders on the restoration and protection of Lake Superior. The Lake Superior Binational Forum is composed of Canadian and American stakeholders representing environmental, Tribal/First Nations, industrial, business, recreational, tourism, health, labour and academic interests.

The Lake Superior Binational Forum has held various technical workshops since 1991 for the purpose of acquiring necessary background information to help develop proposals for phase-out schedules and reduction recommendations. These recommendations on critical pollutants may be found in the report entitled "Lake Superior Lakewide Management Plan (LaMP) 2008" (Lake Superior Binational Forum, 2008). The Lake Superior Binational Forum has held information workshops to provide information on critical pollutants such as mercury, polychlorinated biphenyls (PCBs) and pesticides; sustainability indicators, and land use.

The Lake Superior Bi-national Forum has also held "Public Input Sessions" related to Lake Superior's environmental Areas of Concern (AOC), invasive species, Lake Superior National Marine Conservation Area and other related topics. Additionally, the Lake Superior Binational Forum has partnered with other organizations to carry out projects related to habitat, pollution prevention and public outreach. The Lake Superior Binational Forum is currently funded by Environment Canada and the U.S. Environmental Protection Agency.

7.0 Implications of Climate Change for Source Protection Planning in the Lakehead Source Protection Area

7.1 Introduction

Climate change is a reality that is increasingly required to be considered in environmental protection planning. The impacts of climate change on the world's water sources are a cause for concern. Since 1970, global average temperatures have increased by 0.2 degrees Celsius per decade. The cause has been hypothesized as a result of anthropogenic emissions of greenhouse gases.

Temperate mid-continent regions such as the shoreline regions of Lake Superior, not insulated by the buffering effects of ocean heat capacity or tropical moisture, have warmed even faster, and impacts on ecosystems and large lakes are starting to be felt. Lakes, especially large lakes, are known to be an important component of regional and possibly global biogeochemical cycles, yet little is known about the impact of climatic warming on large lake physical and biological environments. This is of particular importance to regions which rely on the Great Lakes as a source of drinking water.

Climate change modeling is one method of attempting to predict the future implications of climate change on drinking water sources. Dr. Adam Cornwall and Dr. Robert Stewart, Department of Geography, Lakehead University have worked with Atmosphere General Circulation Models (AGCMs) and Regional Climate Models (RCMs) to attempt to predict the impact of climate change on total precipitation, evapotranspiration, total runoff, surface runoff and ice cover within the Lakehead Source Protection Area. These factors all contribute to the quantity and quality of our drinking water.

As the "Clean Water Act, 2006" requires a climate change analysis to be included in the Assessment Report, the purpose of this chapter to incorporate the best information available in order to understand potential climate change impacts in the Lakehead Source Protection Area.

The remainder of this chapter includes the report entitled "Implications of Climate Change for Source Protection Planning in the Lakehead Source Protection Area" prepared by Lakehead University professors Dr. Adam Cornwall and Dr. Robert Stewart and provided to the Lakehead Source Protection Committee for inclusion into the "Assessment Report for the Lakehead Source Protection Area". Drs. Cornwall and Stewart used data from the the report entitled "Lakehead Source Protection Area – Water Budget and Water Quantity Stress Assessment for the Consideration of the Lakehead Source Protection Committee Water Budget" to perform climate change modeling.

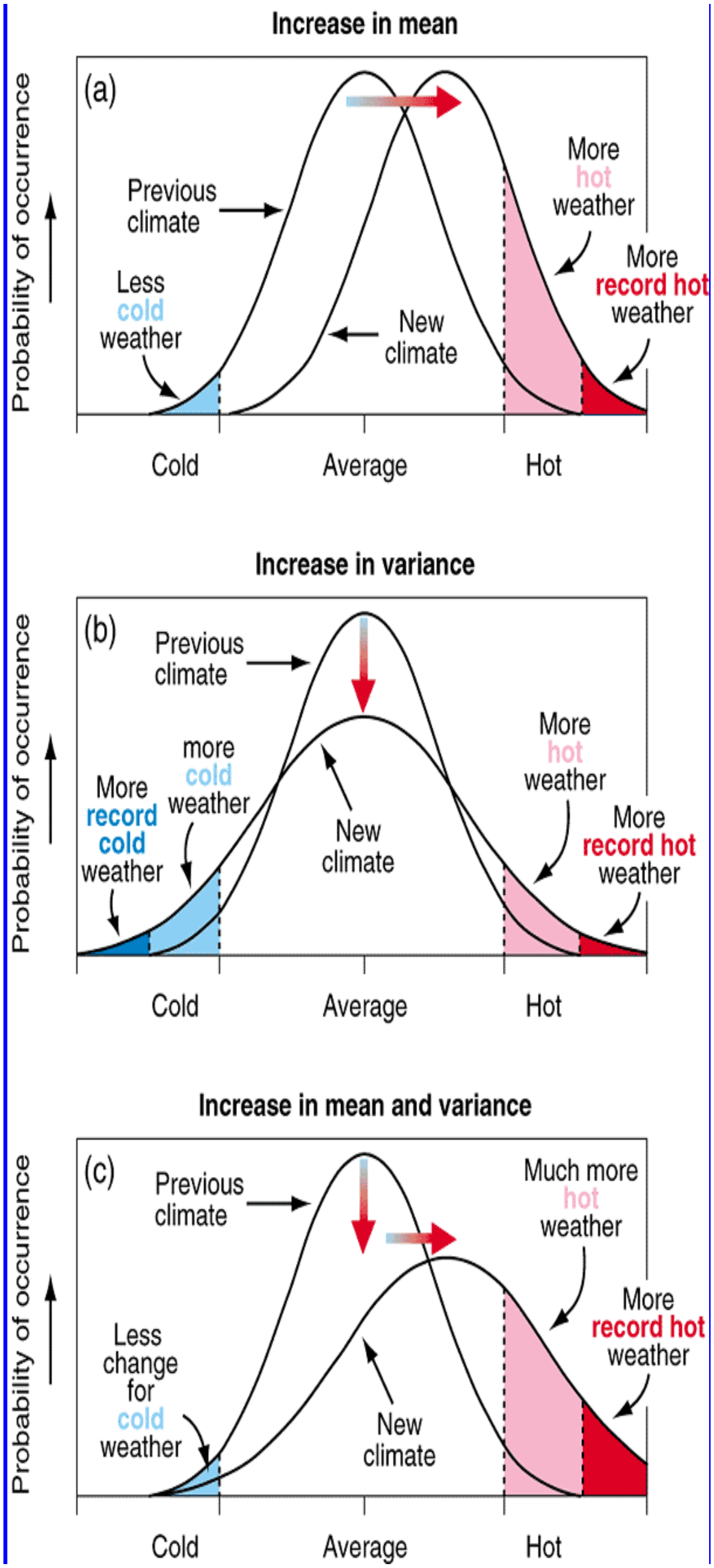
7.2 Foreword

This draft document serves as an introductory and background document for inclusion in the "Assessment Report for the Lakehead Source Protection Area" to address climate change implications for Drinking Water Source Protection. In addition to providing relevant information on climate change as it relates to the Source Protection Planning process, the purpose of the document is to provide the Lakehead Source Protection Authority and Committee with the best available information needed to understand potential climate change impacts in the Lakehead Source Protection Area and to make decisions based on the implications these impacts may have on drinking water source protection. The document integrates regional climate change model predictions within an adaptive risk management decision-making framework in order to provide an additional source of information that complements the historically-based modeling approaches being used in current Source Protection Planning in Ontario (i.e. Water Budget Reports).

7.3 Understanding Climate Change and Source Protection Planning

Whether induced by natural causes or by the activities of humans, there is scientific agreement that the Earth's climate is indeed changing. According to the Intergovernmental Panel on Climate Change, the world's average surface temperature is expected to increase by 1.4 degrees Celsius to 5.8 degrees Celsius over the period 1990-2100 (IPCC, 2001). This represents a change that is without precedent in the last 10,000 years. As a result of this increase, Canada may experience significant shifts in weather and hydro-climatic trends within the next century. Observed climate data indicates that nine of the warmest years on record in this country occurred between 1995-2009 and data from the winter of 2005/2006 indicates that it was the warmest Canada has experienced since nationwide records began in 1948 (Environment Canada, 2009).

Figure 22: Climate Change Impacts on Temperature Mean and Variance



The scientific consensus is that climatic changes will not simply involve a steady rise in temperature, but will be felt through variation within the climate system. Climate model projections show greater variability as temperatures increase in the atmosphere over the next 100 years (Bellamy et al., 2000).

Figure 22 (left) is a schematic diagram showing the effects on extreme temperature when (a) the mean temperature increases, (b) the temperature variance increases, and (c) both the mean temperature and variance increase (IPCC, 2001). It demonstrates that changes in the variance and frequency of extremes of climatic variables could be a possible outcome of climate change.

There is also growing recognition that planning for changes in variance and an increase in the frequency of extreme events may pose the most challenging problems for managers and decision-makers (IPCC, 2001).

7.4 Climate Change Impacts to Water Resources in Ontario

Climate projections produced by the Canadian Climate Change Modeling Centre's General Circulation Model indicate that Ontario is sensitive to climate change. Recent projections suggest that Ontario's climate in a hundred years will be considerably different than the one we experience today. Substantial temperature increases are expected in all seasons by the end of the century. Confidence around this projection is very strong (GCSI, 2000).

Projections for precipitation vary among studies. However, studies consistently point to a change in the seasonal distribution of precipitation, with more expected in the winter and less in summer. Extremes, in the form of droughts and high-intensity rainfall events (i.e. severe one day rain storms), are also expected to become more common. Evapotranspiration is also expected to increase, although confidence in this projection is lower than for temperature.

These predicted changes as a result of temperature increase are outside of the historical or observed range of variability and may not reflect climates of the past. Water resource impacts could therefore include the following as summarized in Table 54.

Table 54: Source Water Impacts and Threats

Impact to Source Water	Source Drinking Water Threats
Increases in winter runoff, but total annual runoff is expected to decrease; summer and fall low flows are expected to be lower and longer lasting.	Decreased runoff during summer is likely to lead to reduced water quantity and quality, and as a result, increased water treatment costs.
Groundwater recharge is expected to decrease due to a greater frequency of droughts and extreme precipitation events.	Changes to wetland form and function may be expected as groundwater discharge decreases; Competition/conflict for reduced water supplies during drought periods.
Shallow aquifers will be more sensitive to these changes than deep ones as they depend more on continual precipitation at the surface than the base flow contributions to deep aquifers.	Water users dependent on groundwater for their supplies may expect increased costs because of a need to drill deeper wells; in rural areas, the frequency of shallow wells drying up may increase.
Water temperature in rivers and streams is expected to rise as air temperatures increase, and as summer base-flow is reduced.	Increased concentrations of non-point sources of pollution in tributaries.

Source: IPCC, 2001

Documented effects of climate change on the Great Lakes ecosystem include:

- Shorter winters.
- Warmer annual average temperatures.
- More frequent extreme heat events (i.e. heat waves).
- Less ice cover and shorter duration of lake ice cover.
- More frequent precipitation of rain and snow.
- Lower water levels.

The Lake Superior Lakewide Management Plan is beginning to address the potential problems and effects of climate change on the basin through outreach and education, mitigation activities and adaptation projects. Source Protection Planning provides the opportunity to incorporate climate change scenarios into current risk management frameworks to complement and enhance this initiative.

7.5 Climate Change Impacts and Municipalities Involved in Source Protection Planning

> "The potential impacts of a changing climate are closely related to the safety and protection of people, protection of property and environment, public health and safety of Municipalities. Therefore, adaptation to climate change is in the interest of Municipal governments." - Global Change Strategies International Inc., (2000)

Municipalities should expect both positive and negative impacts on communities as a result of climate change (GCSI, 2000). The links between climate change and changes in water resources are important for Municipal officials to understand and particularly that even small shifts in climate can have large impacts on existing infrastructure (Auld and McIver, 2005). Traditional risk management using historical records and past experiences provide a cost-effective way to avoid or minimize known risk, but does not prepare a community to cope with uncertain climate changes. Managing for uncertainty requires that communities enhance adaptive capacity, or their ability to adjust to climate variability and extremes and take advantage of opportunities, reduce vulnerability and cope with impacts (IPCC, 2001). Adaptive management involves trade-offs between short-term and long-term community objectives and implementing no-regrets strategies that provide multiple benefits to social, economic and environmental conditions in the community.

Source Protection Committees can incorporate climate change into the Source Protection Planning process through a number of existing planning phases including:

- Using threats assessment to analyze current and future situations pertaining to water availability and threats.
- Consideration of climate change scenarios and implications.
- Assessment of potential future vulnerabilities (i.e. water use and infrastructure changes).
- Development of contingency plans and recommendations to planning initiatives based on historical climate assessments.

On the technical end of Source Protection Planning in Ontario, there are two components of Assessment Reports pertinent to climate change:

- Watershed Characterization - Source Protection Committees should consider how climate change will influence vulnerable areas. The need for and vulnerability of, future drinking water sources, and the quality of water sources that supply drinking water.

- Water Budgets - Source Protection Committees could provide the detailed local understanding of the impacts of climate change on hydrology that has been difficult to incorporate in regional studies of climate impacts completed to date.

7.6 Climate Change Modeling for the Lakehead Source Protection Area

7.6.1 Motivation / Introduction

The goal of this section is to produce and analyze a reasonable scenario for climatic change in the Lakehead Source Protection Area. The scenario should ideally include any change in climate that might significantly affect the budget of available water in the region. This includes changes in both magnitude and timing of the precipitation, evapotranspiration and runoff fluxes that compose the surface water balance, and also changes in the character of these flows. More intense precipitation, for example, produces a greater ratio of surface runoff to subsurface drainage.

The most reliable and detailed forecasts of climate are produced by Atmosphere General Circulation Models (AGCMs), large and complex numerical models developed independently at a number of research institutions worldwide (de Loë and Berg, 2006; Randall et al., 2007). Atmosphere General Circulation Models make use of atmospheric theory and physical equations to model the flows of mass and heat through the atmosphere. As a predictive tool, they can take into account changes in radiative forcing that lead to warming or cooling on a global or local scale. Over the next century, increasing greenhouse gas concentration in the atmosphere is predicted by Atmosphere General Circulation Models to produce significant global warming.

7.6.2 Using Atmosphere General Circulation Models Data

From a local planning perspective, a shortcoming of Atmosphere General Circulation Models is that the resolution of these models is quite coarse as physical quantities such as temperature and humidity are resolved at a grid scale of hundreds of kilometres. This is a direct consequence of the computational expense of resolving the equations. The shortcoming is that the quality of the local prediction is limited; local management generally relies on data from much finer scales (Mearns et al., 2003; Varis et al., 2004). A key consideration of any local or regional application of Atmosphere General Circulation Model predictions is how to 'downscale' the data.

7.6.2.1 Regional Climate Models

A popular approach for improving the resolution is the application of Regional Climate Models (RCMs) (Mearns et al., 2003). Regional Climate Change Models are similar to Atmosphere General Circulation Models except that they operate on a much smaller scale. They compensate for the added computational expense by spanning a much smaller portion of the globe. Typically a Regional Climate Change Model is 'nested' inside an Atmosphere General Circulation Model. In this way global fluxes are still modelled as before, but there is higher resolution in the area of interest (de Loë and Berg, 2006).

This analysis makes use of Regional Climate Change Model data from the Canadian Centre for Climate Modelling and Analysis (CCCma). The data was obtained from the Canadian Regional Climate Model (CRCM), run using the Atmosphere General Circulation Model CGCM3 (described in Music and Caya, 2007). Climate is simulated using a standard forcing scenario ("A2") provided to climate modellers by the Intergovernmental Panel on Climate Change (IPCC) (Cusbach et al., 2001).

7.6.2.2 Observations and the Baseline Climatology

Records of climate require a long period of observations in order to properly represent the variable nature of weather. Unfortunately, in the Lakehead Source Protection Area long-term climatic records are very sparse outside of the City of Thunder Bay. There is not enough spatial distribution to accurately represent the different climatic experiences by location within the Lakehead Source Protection Area. Therefore, the baseline climatology in this analysis is taken from the early years of the Canadian Regional Climate Change Model simulation. As well, there is additional reason for making use of the simulated baseline climate. It is unlikely that the coarse model simulations will reproduce the observed record exactly. However, the change between the early years of the simulation and the late years of the simulation will be a good estimator of the change between the recently observed climate and the expected climate of the future.

7.6.3 The Data in Detail

7.6.3.1 Variables to be Analyzed

Data from Canadian Regional Climate Change Model is available on monthly timescales through the CCCma website. Five variables are used in this analysis, shown in Table 55. Total precipitation is the input of water into the Lakehead Source Protection Area; evapotranspiration is the return flow to the atmosphere where moisture is lost. When evapotranspiration is larger than precipitation there is a moisture deficit, but when precipitation is larger than evapotranspiration there is a moisture surplus. A surplus causes surface runoff to add water to lakes and streams. Total runoff is the sum of surface runoff and subsurface drainage (water that drains into the soil contributing to the recharge of groundwater supplies).

Table 55: Modeled Variables from Canadian Regional Climate Change Model Used in this Analysis

Variable
Total Precipitation
Evapotranspiration
Total Runoff
Surface Runoff
Ice Cover

Also of interest in the Lakehead Source Protection Area is the quality and quantity of water in Lake Superior. Lake levels are not modeled by Canadian Regional Climate Change Model, but ice cover is. Forecasting water levels in the Great Lakes has been a subject of several studies.

7.6.3.2 Compilation

Twenty-four grid points from the Canadian Regional Climate Change Model overlay the Lakehead Source Protection Area. These points are averaged together to produce a composite of the climate data.

For the purpose of comparison to the water budget model previously prepared for the Lakehead Source Protection Area, the baseline for most of the analysis will be the period from 1970-1994. The future climate will be the forecast by Canadian Regional Climate Change Model over the period 2070-2099.

7.6.4 Analysis and Results

7.6.4.1 Moisture Surplus

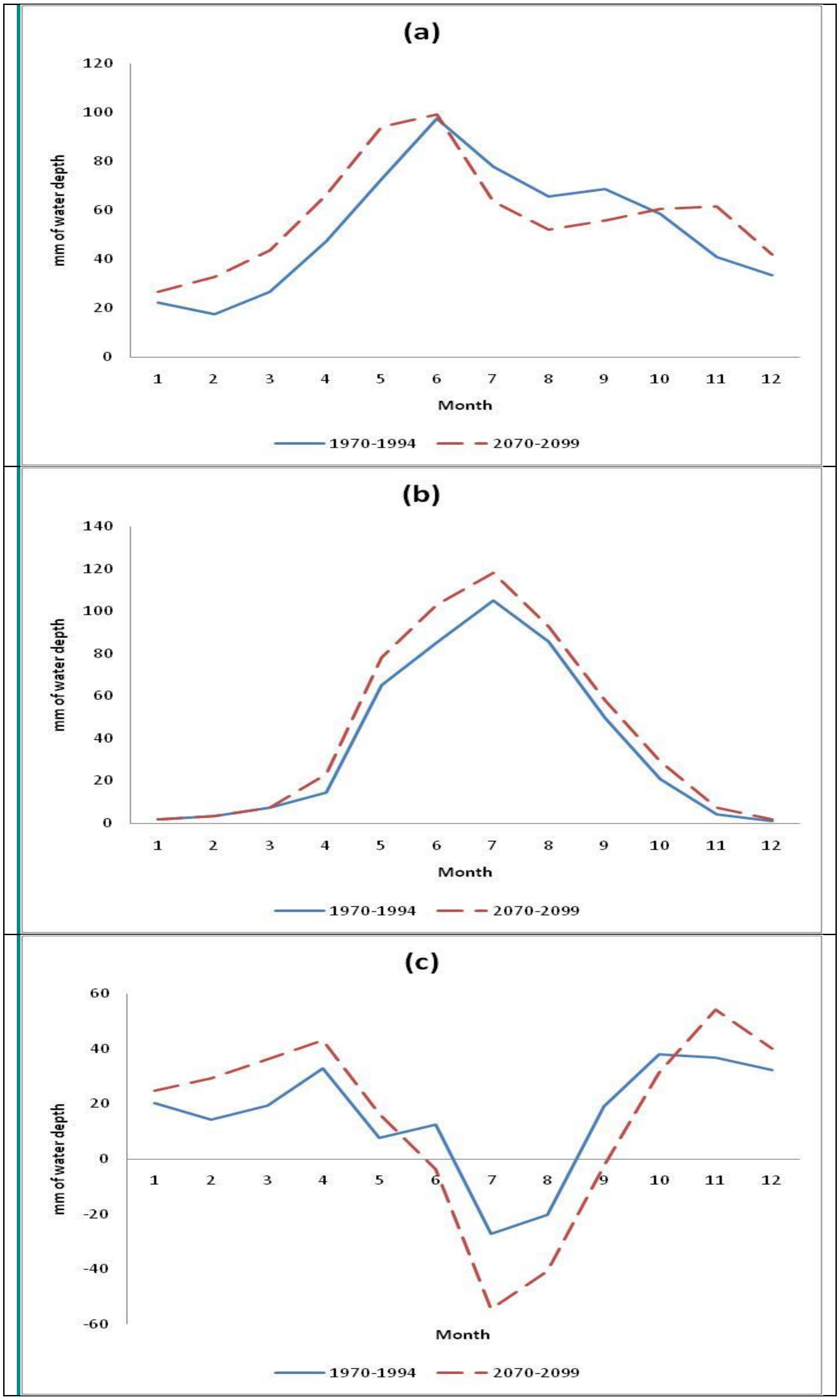
Canadian Regional Climate Change Model forecasts an overall increase in average precipitation (from 52.4 to 58.1 millimetres per month) over the Lakehead Source Protection Area. However, this increase is not evenly distributed throughout the year. Figure 22 contrasts the monthly cycle of precipitation, evapotranspiration and moisture surplus of the baseline climate (1970-1994) with the future climate (2070-2099). These changes are summarized in Table 56 with respect to the four seasons.

Table 56: Increases in Seasonal Amounts of Precipitation, Evapotranspiration and Moisture Surplus

Season	**Total Precipitation** (in millimetres per month of water depth)	**Evapotranspiration** (in millimetres per month of water depth)	**Moisture Surplus** (in millimetres per month of water depth)
December, January and February	9.2	0.2	9.0
March, April and May	16.9	3.0	13.9
June, July and August	-8.7	12.6	-11.7
September, October and November	3.2	6.8	31.3

What is apparent is that summers will be potentially dryer, resulting in a lower water table than is currently observed. By the end of August, a moisture deficit of 35 millimetres (on average) will have accumulated over the summer months due to increased evapotranspiration and decreased precipitation. More precipitation will fall as snow in the cold months, which combined with increased spring rains, could be expected to increase spring runoff, as shown in the subsequent figures.

Figure 23: Monthly Cycles of (a) Precipitation, (b) Evapotranspiration and (c) Moisture Surplus



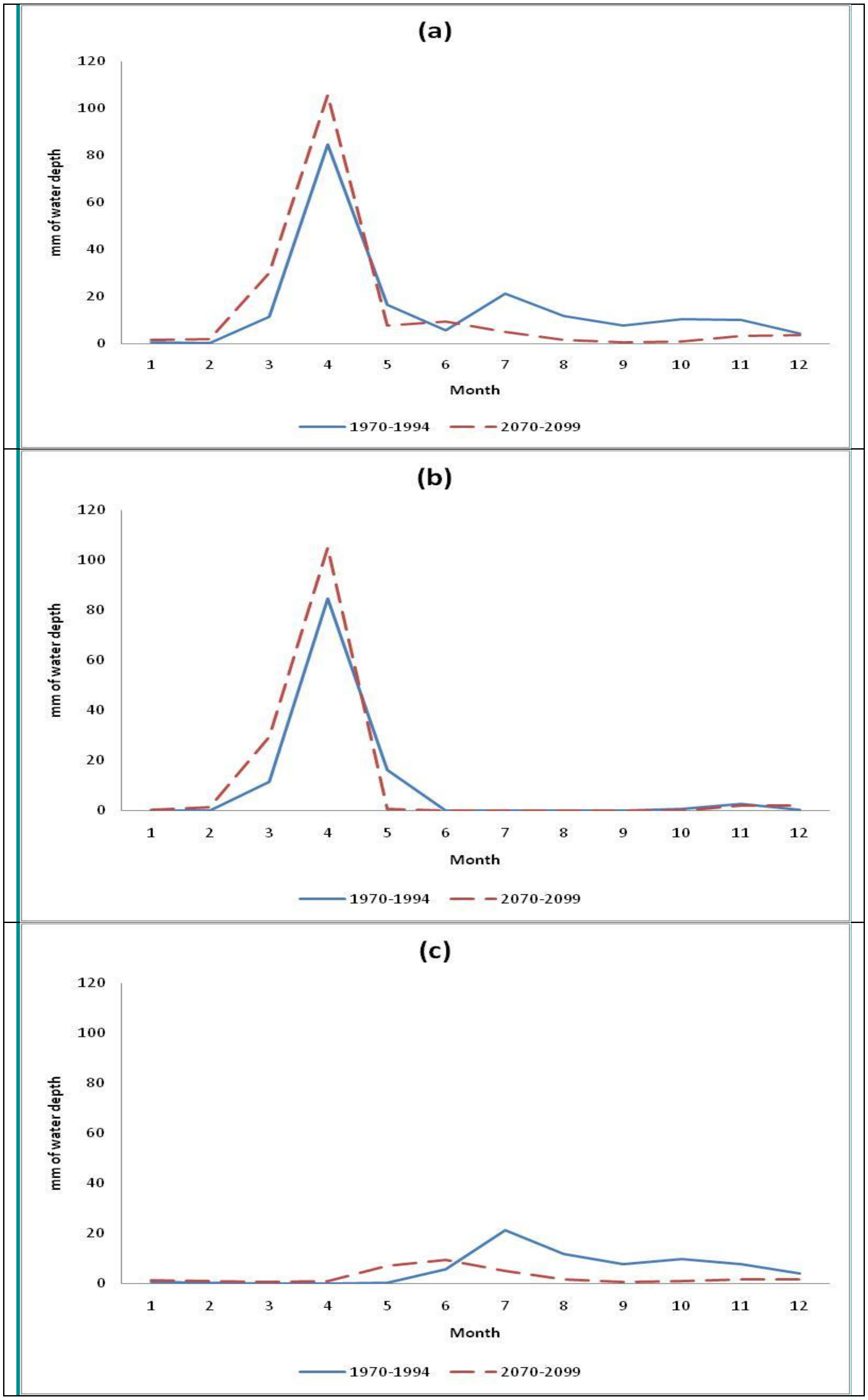
7.6.4.2 Runoff and Recharge

As shown in Table 57, March, April and May are the only months showing a surplus of subsurface drainage, while the remainder of the months indicate a deficit. This could mean that, although precipitation may increase on average, the extent and duration of seasonal rainfall is confined to the spring months.

Table 57: Increases in Seasonal Amounts of Total Runoff, Surface Runoff and Subsurface Drainage, in Millimetres per Month of Water Depth

Season	Total Runoff (in millimetres per month of water depth)	Surface Runoff (in millimetres per month of water depth)	Subsurface Drainage (in millimetres per month of water depth)
December, January and February	0.6	0.9	-0.4
March, April and May	13.9	13.3	0.6
June, July and August	-7.6	0	-7.6
September, October and November	-7.8	-0.4	-7.4

Figure 24: Monthly Cycles of (a) Total Runoff, (b) Surface Runoff and (c) Subsurface Drainage

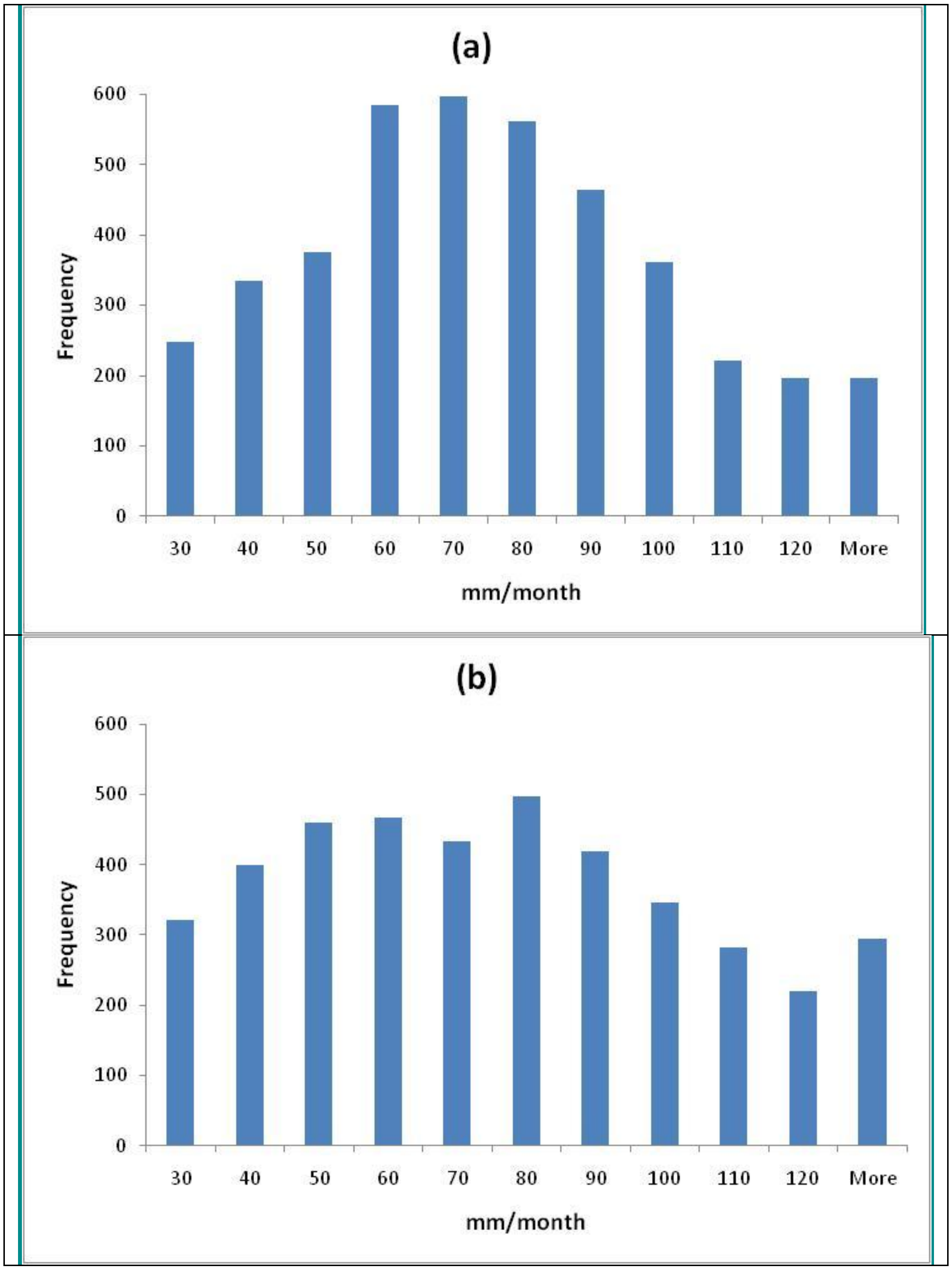


7.6.4.3 Droughts and Floods

Too much rainfall in a short time period can lead to flooding, while too little rainfall leads to drought. Both are undesirable for many reasons, including water resource management. An important question to examine is whether climatic change in the Lakehead Source Protection Area will lead to an increase in the frequency of either or both events.

Canadian Regional Climate Change Model simulates increasing precipitation variability in the Lakehead Source Protection Area over the next century. This is illustrated in Figure 24, where a histogram becomes 'flatter' as extreme values encompass a larger share of the total. In the period 1970-1994, for the wet months of April through September, only five percent of the time did a grid point receive more than 120 millimetres of precipitation in a single month. In the future period of 2070-2099 this occurred 8.2 percent of the time, the probability of extreme rainfall has increased by 60 percent. At the lower end, grid points for the same months of 1970-1994 received less than 29 millimetres of precipitation in a given month only five percent of the time, while in the future period this occurred 7.8 percent of the time (a 50 percent increase in probability). It is clear that the incidence of both droughts and floods will increase under this climatic change scenario.

Figure 25: Histograms of Precipitation per Month at All Grid Points, From April Through September, for (a) a Baseline of 1970-1994; and (b) a Future Climate of 2070-2099



7.6.4.4 Ice Cover and Lake Superior Levels

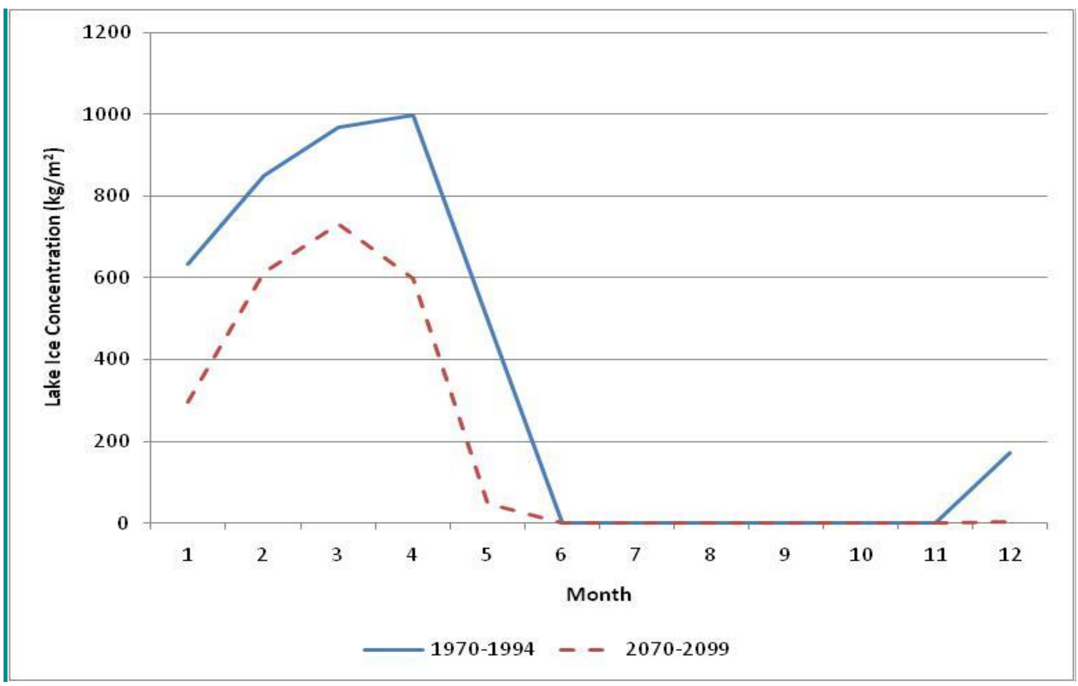
An expected impact of climatic warming is a general decrease in water levels in the Great Lakes, largely due to increases in evaporation over the lakes themselves (de Loë and Berg, 2006). Forecasting water levels is complicated by the fact that the outflows of Lakes Superior and Ontario are controlled according to regulatory plans set up by the International Joint

Commission. Reductions in Lake Superior levels could be exacerbated by demands to increase the outflow downstream.

Lofgren et al. (2002) conducted a study of Great Lakes water levels based on climate scenarios from two Atmosphere General Circulation Models. Applying this data to their own hydrologic modeling system, they produced an estimated range of changes in Lake Superior between -0.42 and +0.11 metres, with larger ranges in the other lakes. They also examined the downstream demands of hydro generation, shipping, recreation and riparian uses. Their determination was that almost all downstream users would be negatively influenced by a decrease in water levels, including hydroelectric plants that would no longer receive minimum flow requirements.

Warmer temperatures will have a direct affect on the amount of time that Lake Superior remains frozen in the winter. Figure 26 shows the annual cycle of lake ice at a Canadian Regional Climate Change Model grid point closest to the City of Thunder Bay. In the simulated future climate, significant ice does not appear until January, as compared to December in the baseline climate and most of the ice is lost before the end of May. The ice cover season is effectively reduced by as much as two months. A decrease in the ice cover season would result in increased evaporation that could further impact lake levels.

Figure 26: Annual Cycle of Ice Cover Along the Western Shore of Lake Superior



7.7 Conclusions

Based on the results of the Canadian Regional Climate Change Model scenarios, the potential changes in the water budget of the Lakehead Source Protection Area, as a result of climate change, are likely to result from an overall increase in average precipitation but not evenly distributed throughout the year. This could lead to:

i. Dryer summers (resulting in a lower water table; drought).
ii. An increase in spring runoff and intense rainfall events (erosion, drainage, flooding).
iii. A decrease in water levels due to increases in evaporation over Lake Superior.

Unfortunately Atmosphere General Circulation Models are not currently capable of forecasting changes in precipitation intensity. An increase in intense, convective rainstorms is considered very likely based on our understanding of the atmosphere (de Loë and Berg, 2006; Meehl et al., 2007). Where and when this occurs, it will increase surface runoff and decrease the recharge of groundwater.

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Acronym List

AO	Aesthetic Objective
AOC	Area of Concern
AR	Assessment Report
AMO	Association of Municipalities of Ontario
ANSI	Area of Natural and Scientific Interest
ASL	Above Sea Level
ASM	Animal Source Material
AST's	Above-ground Storage Tanks
AVI	Aquifer Vulnerability Index
BAF	Bioaccumulation Factor
BCC	Bioaccumulative Chemical of Concern
BCF	Bioconcentration Factor
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
CA	Conservation Authority
CABN	Canadian Aquatic Biomonitoring Network
CANSIS	Canadian Soils Information Service
CofA	Certificate of Approval
CDF	Confined Disposal Facility
CEPA	**"**Canadian Environmental Protection Act"
CO	Conservation Ontario
COA	Canada/Ontario Agreement
CNR	Canadian National Railway
CPR	Canadian Pacific Railway
CSO	Combined Sewer Overflow
CWA	"Clean Water Act"
DDD	Dichloro-Diphenyl-Dichloroethane
DDE	Dichloro-Diphenyldichloro-Ethylene
DDT	Dichloro-Diphenyl-Trichloroethane
DEM	Digital Elevation Model
DNAPL	Dense Non-Aqueous Phase Liquids
DO	Dissolved Oxygen
DFO	Department of Fisheries and Oceans Canada
EBR	Environmental Bill of Rights
EP	Environmental Protection
EPA	"Environmental Protection Act"
FIPPA	"Freedom of Information and Protection of Privacy Act"
FMSA	Future Municipal Supply Areas
FWFN	Fort William First Nation
GIS	Geographic Information System
GLC	Great Lakes Commission
GVA	Groundwater Vulnerability Analysis
HAPs	Hazardous Air Pollutants
HCB	Hexachlorobenzene
HG	Mercury
HVA	Highly Vulnerable Aquifer
HYDAT	Hydraulic Data – stream flow, water level and sediment data
IAGLR	International Association of Great Lakes Research

Acronym List

IJC	International Joint Commission
IMAC	Interim Maximum Allowable Concentration
IPZ	Intake Protection Zone
ISI	Intrinsic Susceptibility Index
LAMP	Lakewide Area Management Plans – Refers to Great Lakes
LIO	Land information Ontario
LRIA	**"**Lakes and Rivers Improvement Act"
LRCA	Lakehead Region Conservation Authority
LSPA	Lakehead Source Protection Area
LSPA	Lakehead Source Protection Authority
LSPC	Lakehead Source Protection Committee
LU	Lakehead University
MAC	Maximum Allowable Concentration
MCTS	Marine Communications and Traffic Services
MFIPPA	"Municipal Freedom of Information and Protection of Privacy Act"
MMAH	Ministry of Municipal Affairs and Housing
MNDMF	Ontario Ministry of Northern Development, Mines and Forestry
MNR	Ontario Ministry of Natural Resources
MOA	Memorandum of Agreement
MOE	Ministry of Environment
MOH	Medical Officer of Health
MOHLTC	Ministry of Health and Long Term Care
MOU	Memorandum of Understanding
MOA	Memorandum of Agreement
MOE	Ontario Ministry of the Environment
MTO	Ontario Ministry of Transportation
MTS	Municipal Technical Study
MOU	Memorandum of Understanding
MPAC	Municipal Property Assessment Corporation
NAPL	Non-Aqueous Phase Liquids
NMA	"Nutrient Management Act"
NOEGTS	Northern Ontario Engineering Geology Terrain Study
NRST	Northwest Region Science & Technology
NRVIS	Natural Resources and Values Information System
NU	Nutrient Units
OBBN	Ontario Benthos Biomonitoring Network
OBM	Ontario Base Mapping
ODGE	Ontario Geospatial Data Exchange
ODWS	Ontario Drinking Water Standards
OG	Operational Guideline
OGDE	Ontario Geospatial Data Exchange
OGS	Ontario Geological Survey
OMAFRA	Ontario Ministry of Agriculture, Food and Rural Affairs
OMNDMF	Ontario Ministry of Northern Development, Mines and Forestry
OMOE (MOE)	Ontario Ministry of Environment
OMNR (MNR)	Ontario Ministry of Natural Resources
OMTR	Ontario Ministry of Tourism and Recreation
OMTO	Ontario Ministry of Transportation
OP	Official Plan

Acronym List

OPG	Ontario Power Generation
OWRA	"Ontario Water Resources Act"
PAC	Public Advisory Committee
PAHs	Polyaromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PCE	Perchloroethylene
PGMN	Provincial Groundwater Monitoring Network Program
PLA	**"**Public Lands Act"
PPB	Parts per Billion
PPCP	Pollution Prevention and Control Plan
PPM	Parts per Million
PPT	Parts per Thousand
PSW	Provincially Significant Wetland
PWD	Percent Water Demand
PWQMN	Provincial Water Quality Monitoring Network
PWQO	Provincial Water Quality Objectives
PTTW	Permit to Take Water
QA/QC	Quality Assurance / Quality Control
RAP	Remedial Action Plans
ROMA	Rural Ontario Municipal Association
SAAT	Surface to Aquifer Advective Time
SGRA	Significant Groundwater Recharge Areas
SO2	Sulfur Dioxide
SOLRIS	Southern Ontario Land Resource Inventory Mapping
STP's	Sewage Treatment Plants
SWOOP	South-western Ontario Ortho-Photography
SWVA	Surface Water Vulnerability Analysis
TCDD	Dioxin
TCE	Trichloroethylene
TBDHU	Thunder Bay District Health Unit
TDS	Total Dissolved Solids
TOR	Terms of Reference
TOT	Time of Travel
TSSA	Technical Standards and Safety Authority
TWCA	Total Water Contributing Area
UL	Use Limitations
UST's	Underground Storage Tanks
UTM	Universal Transverse Mercator
VOH	Volatile Organic Hydrocarbons
WPCP	Water Pollution Control Plant
WHPA	Wellhead Protection Area
WMP	Water Management Plan
WTP	Water Treatment Plant
WWTP	Waste Water Treatment Plant
WRIP	Water Resource Information Program
ZDP	Zero Discharge Pilot Plan

Glossary

The following definitions have been gathered from multiple sources and are provided for local information purposes to assist the reader to understand the Draft Proposed Assessment Reports for the Lakehead Source Protection Area. Where pertinent, the legal definitions as per the "Clean Water Act, 2006" and associated Regulations and Director's Technical Rules have been used.

100-Year Monthly Mean Lake Level (Great Lakes-St. Lawrence River system and large inland lakes) - the monthly mean lake level having a total probability of being equaled or exceeded during any year of one per cent. Monthly mean level refers to the average water level occurring during a month computed from a series of readings in each month.

100 Year Storm - a frequency based storm that on average will occur once every hundred years; however, has a one percent chance of occurring or being exceeded in any given year.

100-Year Wind Setup (Great Lakes-St. Lawrence River system and large inland lakes) - the wind setup having a total probability of being equaled or exceeded during any year of one percent. Wind setup refers to the vertical rise above the normal static water level on the leeward side of a body of water caused by wind stresses on the surface of the water.

A

Abandoned Well - a well that is deserted because it is dry, contains non potable water, was discontinued before completion, has not been properly maintained, was constructed poorly, or it has been determined that natural gas may pose a hazard.

Ablation - the process by which a glacier decays; the zone of ablation is the part of a glacier where melting exceeds accumulation of snow and ice.

Absorption – a physical or chemical process in which atoms, molecules or ions enter a solid, liquid or gas bulk phase.

Activity - includes a land use.

Aeolian - pertaining to the erosive and transporting action of the wind or to sediments that have been transported and deposited by wind action.

Aggregate - refers to gravel which is any loose rock that is at least two millimeters in its largest dimension and no more than 75 millimeters. Sand is the smallest size class in geology at 0.063 millimeters to two millimeters in size. Sometimes gravel is restricted to rock in the two to four millimeter range, with pebble being reserved for rock four to 75 millimeters. Cobble is the next larger size is at 75 millimetres to 256 millimetres.

Agricultural Managed Land - managed land that is used for agricultural production purposes including areas of cropland, fallow land and improved pasture where agricultural source material (ASM), commercial fertilizer or non-agricultural source material (NASM) is applied or may be**.**

Agricultural Source Material - has the same meaning as in Section 1 of Ontario Regulation 276/03 (General) made under the "Nutrient Management Act, 2002".

Glossary

Alteration to a Watercourse - any watercourse, whether flowing all year or not, requires a Conservation Authority permit to be altered. Typical alterations include bridge or culvert installations, channelization and diversion.

Alluvial – A soil developed on a flood plain or delta having only the characteristics of the alluvium (clay, silt, sand, gravel or similar detritus material deposited by running water) of which it is composed.

Alluvium - unconsolidated material, such as gravel, sand, silt, clay and various mixtures of these, deposited on land by running water.

Anthropogenic - influenced by human activity or of human origin.

Aphotic Zone - the depth of a waterbody that is not exposed to sunlight. The depth of the aphotic zone can be greatly affected by such things as turbidity and the season of the year. The benthic layer is located here. The aphotic zone generally underlies the photic zone, which is that portion of the waterbody directly affected by sunlight.

Apiary - a place where honey bees are kept, usually for the purpose of breeding and honey production, but sometimes to aid the pollination of seed and fruit crops.

Application - has the same meaning as in Ontario Regulation 267/03 (General) made under the "Nutrient Management Act, 2002".

Aquifer - a water-bearing layer (or several layers) of rock or sediment capable of yielding supplies of water; typically consists of unconsolidated deposits of sandstone, limestone or granite, and can be classified as confined, unconfined or perched. The water in an aquifer is called groundwater.

Aquifer System – is a group of two or more aquifers that are separated by aquitards.

Aquifer Vulnerability Index (AVI) - a numerical indicator of an aquifer's intrinsic or inherent vulnerability to contamination expressed as a function of the thickness and permeability of overlying layers.

Aquifuge - a geologic formation which has no interconnected openings and cannot hold or transmit water.

Aquitard - a confining bed and/or formation composed of rock or sediment that retards but does not prevent the flow of water to or from an adjacent aquifer. It does not readily yield water to wells or springs, but stores ground water.

Archean Volcanics - older Precambrian rocks formed from ancient volcanic activity.

Area of Influence of a Well - the area covered by the drawdown curves of a given well or combination of wells at a given time when pumped.

Aromatic Hydrocarbons - the major group of cyclic petroleum hydrocarbons such as benzene and toluene that are moderately soluble in water and are generally highly toxic to aquatic organisms.

Glossary

Artesian Aquifer - an aquifer that contains water under pressure resulting in a hydrostatic head, which stands above the local water table or above the ground level. For artesian conditions to exist, an aquifer must be overlain by a confining material and receive a supply of water.

Artesian Well – a well located in an artesian aquifer that will flow upwards without the need for pumping.

Assessment Report - an Assessment Report is a science-based report generated locally for each Source Protection Area to comply with the "Clean Water Act, 2006". The Assessment Report will identify the watersheds and the vulnerable areas within the Source Protection Area. Threats to the vulnerable areas will be assessed and determined whether they pose a significant threat to municipal residential drinking water systems. The report identifies the local watersheds in the Source Protection Area, the vulnerable areas within the Source Protection Area, and assesses potential drinking water threats in each vulnerable area in order to determine which threats constitute significant drinking water threats. An Assessment Report looks at an entire watershed and the factors influencing the quality and amount of water (quantity) found there. Assessment Reports are a key requirement of the "Clean Water Act, 2006". They include information such as the physical characteristics of the land, land uses, where drinking water supplies are located, how much water is being used and how much is available for future uses, where vulnerable water supply areas are located, what issues already compromise drinking water sources and what threatens drinking water sources from overuse and contamination. Assessment Reports provide Source Protection Committees with information that will help determine how best to protect the quality and supply of their local water resources. They are the basis for developing Source Protection Plans and making local policy decisions for protecting drinking water. An Assessment Report is a technical document that is prepared by a Source Protection Committee under Section 15 Ontario Regulation 284/07 Source Protection Area and to rank risks to drinking water within that area. Each Assessment Report is approved by the Ontario Minister of the Environment.

Attenuation - the soil's ability to lessen the amount of or reduce the severity of groundwater contamination. During attenuation, the soil holds essential plant nutrients for uptake by agronomic crops, immobilizes metals that might be contained in Municipal sewage sludge, and removes bacteria contained in animal or human wastes.

B

Band - has the same meaning as in the "Indian Act" (Canada).

Barite - A yellow, white, or colorless crystalline mineral of barium sulfate, $BaSO_4$.

Baseflow - the sustained flow (amount of water) in a stream that comes from groundwater discharge or seepage. Groundwater flows underground until the water table intersects the land surface and the flowing water becomes surface water in the form of springs, streams/rivers, lakes and wetlands. Baseflow is the continual contribution of groundwater to watercourses and is important for maintaining flow in streams and rivers between rainstorms and in winter conditions.

Basin - the area drained by a river or a watershed with a common outlet.

Beach - a geological formation consisting of loose rock particles such as sand, gravel, shingle, pebbles, cobble, or even shell along the shoreline of a body of water.

Bedrock - solid or fractured rock usually underlying unconsolidated geologic materials; bedrock may be exposed at the land surface.

Bedrock Geology - bedrock geology is the study of the solid rock underlying unconsolidated surface material. Also refers to description of bedrock types.

Benthic - benthic means occurring at the base of bodies of water: lakes, oceans and seas.

Benthic Invertebrates - benthic invertebrates are mall aquatic organisms that live in stream sediments and are a good indicator of water quality and stream health.

Benthic Region - the bottom of a body of water, supporting the benthos.

Benthos - the plant and animal life whose habitat is the bottom of a body of water.

Berm - a narrow shelf or ledge can be used at the bottom of a slope to reinforce and stabilize it against slumping and erosion or to direct overland flow.

Best Management Practices (BMPs) - structural, non-structural and managerial techniques that are recognized to be the most effective and practical means to control non-point source pollutants yet are compatible with the productive use of the resource to which they are applied. Best Management Practices are used in both urban and agricultural areas. Can also be called Beneficial Management Practices.

Biochemical Oxygen Demand (BOD) - is a measure of the quantity of oxygen used by micro-organisms (e.g. aerobic bacteria) in the decomposition (oxidation) of organic solids.

Bluff (Great Lakes-St. Lawrence River system and large inland lakes) - those actions of the shoreline formed in non-cohesive or cohesive sediments where the land rises steeply away from the water such that the elevation of the top of the slope above the base or toe of the slope is greater than two metres and the average slope angle exceeds 1:3 (=18 degrees).

Bog - peatland with the water table at or near the surface. The surface of the bog may often be raised above the surrounding terrain. Bogs are isolated from mineral-rich soil waters, therefore nutrient input is from atmospheric deposition. They are strongly acidic and nutrient poor. Peat is usually greater than 40 centimetres deep. Groundcover is usually moss, *Sphagnum spp*. and ericaceous shrubs and may be treed or treeless. Bog water is derived from groundwater or precipitation.

Bored Well - a well drilled with a large rig-mounted boring auger, usually 3658 millimetres or more in diameter and seldom deeper than 30 metres.

Boulder - a sedimentary rock fragment that is usually rounded and has a diameter over 256 millimetres.

C

Calcareous - soil, chalky in appearance, containing calcium carbonate or magnesium carbonate.

Glossary

Calcite - a vein and rock-forming mineral having the composition of calcium carbonate.

Calibration - the process whereby a numerical model is adjusted so that the calculated and observed parameters converge. When the parameters converge, the calibration process is complete.

Capture Zone - a term used to represent an area where water originates and moves to a water well. Typically, capture zones are a two dimensional representation of a three dimensional space.

Carbonate - a compound(s) containing $CO_3(2)$, also known as a salt of carbonic acid. When heated, yields the gas carbon dioxide (calcite, dolomite and siderite are examples of carbonates).

Carbonate Rock - a rock made up largely of carbonate minerals.

Chalcopyrite - an ore mineral of copper, the chemical formula for which is $CuFeS_2$.

Chemical Contaminant - a substance used in conjunction with, or associated with, a land use activity or a particular entity, and with the potential to adversely affect water quality.

Chert - when qualifying as mineral, a chert is considered a cryptocrystalline type of quartz whose matrix is indiscernible under the microscope. As rocks, cherts are silicon-based and have different colors made of micro-organisms or precipitated silica grains.

Chert-Carbonate - a sedimentary rock in which layers of carbonate minerals alternate with layers of chert.

Chlorite - a rock-forming mineral, usually greenish in colour and platy (like mica). A hydrous silicate of aluminium, iron and magnesium.

"Clean Water Act" - the "Clean Water Act, 2006" was passed as Bill 43 to protect drinking water at the source. The Act requires the development of a watershed based Source Protection Plan. A key focus of the legislation is the preparation of locally developed, terms of reference, science based assessment reports and source protection plans. While it is not possible to completely remove all risks to our drinking water, the "Clean Water Act, 2006" will help reduce risks by addressing threats to drinking water quantity and quality. The Act is designed to promote voluntary initiatives but requires mandatory action where needed.

Cliff - those sections of the shoreline normally formed in bedrock where the land rises steeply away from the water such that the elevation of the top of the slope above the base or toe of the slope is greater than two metres and the average slope angle exceeds 1:3 (=18 degrees).

Coliform - bacteria found only in human and animal wastes; presence in a river may indicate pollution by sewage or farmyard runoff.

Commercial Fertilizer - has the same meaning as in Ontario Regulation 267/03 (General) made under the "Nutrient Management Act, 2002".

Conceptual Water Budget - a written description of the overall system flow dynamics for each watershed in the Source Protection Area, taking into consideration surface water and groundwater features, land cover (e.g. proportion of urban vs. rural uses), man-made structures (e.g. dams, channel diversions, water crossings) and water takings.

Condensation - the process by which water or other liquids change from gas vapour to a liquid; process that occurs when water droplets form on surfaces or around the nuclei of a particle.

Conditions - are defined as a result of past activities. If the source protection committee is aware of conditions that are results from past activities, the committee shall list it as a drinking water threat under clause 15(2)(g)(ii) of the "Clean Water Act".

Cone of Influence - 'cone of influence' means:

(a) in respect of one or more wells that draw water from a unconfined aquifer, the area within the depression created in the water table when the wells are pumped at a rate equivalent to their allocated quantity of water.

(b) in respect of one or more wells that draw water from a confined or semi-confined aquifer, the area within the depression created in the potentiometric surface when the wells are pumped at a rate equivalent to their allocated quantity of water.

Confined Aquifer - also commonly called an artesian aquifer. A confined aquifer is bounded above and perhaps below by layers of geological material that do not transmit water readily. It is the saturated formation between impermeable layers that restrict movement of water vertically into or out of the saturated formation. In this layer, water is confined under pressure, similar to water in a pipeline. Drilling a well into this type of aquifer is similar to puncturing a pressurized pipeline. If the pressure is great enough, the well will flow, and this is called a flowing artesian well.

Confining Layer (aquitard) - a layer of geologic material with little to no permeability or hydraulic conductivity that functions as a container for an aquifer. Water does not rapidly pass through this layer or the rate of movement is extremely slow.

Conglomerate (also referred to as Puddingstone) - the hard compacted equivalent of a sedimentary deposit, made up of pebbles and boulders in a matrix of sand, silt or clay.

Conservation - the wise use of natural resources.

Conservation Authorities - local watershed management agencies that deliver services and programs that protect and manage water and other natural resources in partnership with government, landowners and other organizations.

Conservation Lands - lands which are considered to be regionally significant, such as valleys or environmentally sensitive areas, and are best managed by a public agency to retain their natural characteristics.

Consumptive Use - the portion of water withdrawn or withheld from the water source and assumed to be lost or otherwise not returned to the water source due to evaporation, incorporation into products, or other processes.

Contaminant (pollutant) - an undesirable substance that makes water unfit for a given use when found in sufficient concentration.

Contaminant of Concern - a chemical or pathogen that is or may be discharged from a Drinking Water Threat, a chemical or pathogen that is or may become a Drinking Water Threat as identified by the Ontario Ministry of Environment.

Contaminant Plume - a term used to describe a mass of contamination moving underground.

Control Structure - a structure that serves to control the flow of water, generally a dam or weir.

Corrective Action - steps that must be taken following an adverse water quality incident as specified by Ontario Regulation 170/03, Schedules 17 & 18, or Ontario Regulation 252/05, Schedule 5 and/or as directed by the local Medical Officer of Health or drinking water inspector that are necessary to protect human health.

"Cosmetic Pesticide Ban Act" - the "Cosmetic Pesticide Ban Act, 2008" recognizes that the cosmetic use of pesticides to improve the appearance of lawns and gardens presents health and environmental risks. The Act restricts the use and sale of specific pesticides for cosmetic purposes on specific land uses.

Cubic Feet per Second (cfs) - the volume of water in cubic feet (one foot X one foot X one foot) that passes a given point in one second of time; United States Geological Survey uses this measurement in reporting stream flow values. Cubic meters per second are commonly used in countries employing the metric system.

Cumulative Effects (water quality) - the consequence of multiple threats sources, in space and time, which affect the quality of drinking water sources.

Cumulative Effects (water quantity) - the consequence of multiple threats sources, in space and time, which affect the quantity of drinking water sources.

D

DDE(dichlorodiphenyldichloroethylene) and DDD(dichlorodiphenyldichloro-ethane) - chemicals similar to DDT. DDE has no commercial use. DDD was used to kill pests, but its use as a pesticide has since been banned in North America.

DDT (dichlorodiphenyltrichloroethane) - a pesticide once widely used to control insects in agriculture and insects that carry diseases such as malaria. DDT is a white, crystalline solid with no odour or taste. Since the 1970's, use of DDT as a pesticide has been banned in North America.

Dam - structure used to hold back water.

Data Gaps - the lack of site specific information for a geological area and/or specific type of information.

Decommissioned Wells - decommissioned wells are capped, plugged and sealed in compliance with regulatory requirements by the Ontario Ministry of the Environment.

Delta - a low, nearly flat accumulation of sediment deposited at the mouth of a river or stream, commonly triangular or fan-shaped.

Deltaic - an alluvial deposit formed where a stream or river drops its sediment load upon entering a quieter body of water.

Deltaic or Stratified Drift Deposits - all drift deposits originate as an accumulation of glacial material. Deltaic drift deposits originate as an alluvial deposit, usually triangular in shape, at the mouth of a river. Stratified drift exhibits both sorting and stratification, implying deposition from a fluid medium such as water and air. An alluvial deposit formed where a stream or river drops sediment load upon entering a quieter body of water.

Dendritic ("treelike") - resembles the pattern of branches and twigs that you can see in any deciduous tree, such as a maple or an elm. This pattern develops when streams flow over rocks that are fairly uniform in their resistance to erosion. Because streams can cut as easily in one place as another, their actual network pattern is the result of random flow.

Dense Non-Aqueous Phase Liquid (DNAPL) - an organic chemical in concentrations greater than its aqueous solubility and more dense than water. Such a chemical will sink in groundwater and accumulate in aquifer depressions.

Designated System - a drinking water system that is included in a Terms of Reference, pursuant to resolution passed by a municipal council under subsection 8(3) of the proposed "Clean Water Act, 2006".

Detritus – particulate organic material suspended in water or intermixed with soil.

Developed / Developable - reference to the useable portion of a parcel of land that meets the regulatory zoning provisions, particularly those pertaining to defining the area of occupation for buildings, structures, facilities and infrastructure.

Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation - a set of provincially-approved laws administered by the Conservation Authority which restrict the filling, construction of buildings or alterations to the waterways within the identified flood plain.

Diabase - a slightly metamorphosed medium-grained basic igneous rock having the composition of gabbro and usually characterized by the presence of lath-shaped feldspar crystals.

Dike (Dyke) - a tabular mass of igneous rock extending obliquely or transversely across older rocks. Can also be a manmade structure, either a wall or earth mound built around a low-lying area to prevent flooding.

Discharge - the flow of surface water in a stream or canal, or the outflow of groundwater to a well, ditch or spring. It is the volume of water in cubic metres per second (m3/s) running in a watercourse.

Discharge Area - an area where groundwater emerges at the surface; an area where upward pressure or hydraulic head moves groundwater towards the surface to escape as a spring, seep, or base flow of a stream.

Disposal Well - a well used for the disposal of waste into a subsurface stratum.

Diversion - a redirection of water from one drainage or watercourse to another.

Dolomite - a vein and rock-forming mineral having the composition of calcium, magnesium and carbonate. Also a sedimentary rock made up largely of the mineral dolomite.

Downgradient - a term used in hydrogeology to describe a point at a lower hydraulic head.

Drainage Area - the area which supplies water to a particular point.

Drainage Basin - the area of land, surrounded by divides, that provides runoff to a fluvial network that converges to a single channel or lake at the outlet.

Drainage Water - water which has been collected by a gravity drainage or dewatering system.

Drainage Well - a well pumped in order to lower the water table; a vertical shaft to a permeable substratum into which surface and subsurface drainage is channeled.

Drawdown - lowering of the water level of a lake or reservoir.

Drilled Well - a well usually 10 inches or less in diameter, drilled with a drilling rig and cased with steel or plastic pipe. Drilled wells can be of varying depth.

Drinking Water –

a) Water intended for human consumption.
b) Water that is required by an Act, regulation, order, municipal by-law or other document issued under the authority of an Act, (i) to be potable, or (ii) to meet or exceed the requirements of the prescribed drinking water quality standards.

Drinking Water Concern - a purported drinking water issue that has not at this time been substantiated by monitoring, or other verification methods. Concerns may be identified through consultations with the public, stakeholder groups, and technical experts (e.g. water treatment plant operators).

Drinking Water Issue - a substantiated condition relating to the quality or quantity of water that interferes or is anticipated to soon interfere with the use of a drinking water source by a Municipality. As defined in the "Clean Water Act" Director's Technical Rule 114, regarding the quality of water in a vulnerable area: 1) The presence of a parameter in water at a surface water intake or well, at a concentration that may result in deterioration of the water quality or where there is a trend of increasing concentrations of a parameter. 2) The presence of a pathogen at a concentration that may result in deterioration of the water quality or there is a trend of increasing concentrations of the pathogen.

Drinking Water Quality Threats Analysis - the drinking water quality threats analysis examines existing water quality issues in a drinking water system and identifies and describes threats that contribute to, or have the potential to impact, municipal drinking water sources. It also identifies what activities would pose a threat to drinking water if they were located in a vulnerable area in the future. For the drinking water quality threats analysis, drinking water threats are classified as significant, moderate or low. In order for a threat to be included in the assessment report, it must first be recognized by the provincial government in the official threats table. Threats not listed by the provincial government can be included with proper approval. To add a threat, it must be proven, using science and professional experience, that the threat has the ability to impact human health.

Drinking Water Risk - Risk means the likelihood of a drinking water threat (a) rendering a drinking water source impaired, unusable or unsustainable, or (b) compromising the effectiveness of a drinking water treatment process, resulting in the potential for adverse human health effects.

Drinking Water Source Protection - Protecting surface water sources such as lakes, rivers and streams, and groundwater sources from contamination or overuse, particularly through the planning process under the "Clean Water Act, 2006". It is the first step in the multi-barrier approach to protecting drinking water. Other barriers include water testing and monitoring, reliable water treatment and distribution systems and training of water managers and staff. At this time, the emphasis of the project is to identify and address existing or potential threats to Municipal Residential Drinking Water Supplies by concentrating on zones immediately surrounding Municipal wellheads and surface water intakes.

Drinking Water System - has the same meaning as in the "Safe Drinking Water Act, 2002". A system of works, excluding plumbing, that is established for the purpose of providing users of the system with drinking water and that includes, (a) anything used for the collection, production, treatment, storage, supply or distribution of water, (b) anything related to the management of residue from the treatment process or the management of the discharge of a substance into the natural environment from the treatment system, and (c) a well or intake that serves as the source or entry point of raw water supply for the system. **Type I, Type II and Type III Systems** - water supply systems as described in the "Clean Water Act, 2006". Type I systems are municipal residential drinking water systems that serve a major residential development (15(2)(e)(ii)). Type II systems are water supply systems that have been included in the Source Protection Planning process by Municipal or Band Council Resolution (15(2)(e)(iii)). Type III systems are water supply systems that are included in the Source Protection Process by the Ontario Minister of Environment (15(2)(e)(iv)).

Drinking Water Threat - has the same meaning as in the "Clean Water Act, 2006". An existing activity, possible future activity or existing condition that results from a past activity, (a) that adversely affects or has the potential to adversely affect the quality or quantity of any water that is or may be used as a source of drinking water, or (b) that results in or has the potential to result in the raw water supply of an existing or planned drinking-water system failing to meet any standards prescribed by the regulations respecting the quality or quantity of water, and includes an activity or condition that is prescribed by the Regulations as a drinking water threat.

Drinking Water Works Permit (DWWP) - permit to establish or alter a Municipal Residential Drinking Water System (the Drinking Water Works Permit and licence will replace the certificates of approval).

Drought - drought is a complex term that has various definitions, depending on individual perceptions. For the purposes of low water management, drought is defined as weather and low water conditions characterized by one or more of the following: a) below normal precipitation for an extended period of time (for instance three months or more), potentially combined with high rates of evaporation that result in lower lake levels, streamflows or baseflow, or reduced soil moisture or groundwater storage; b) streamflows at the minimum required to sustain aquatic life while only meeting high priority demands for water, water wells becoming dry, surface water in storage allocated to maintain minimum streamflows; c) socio-economic effects occurring on individual properties and extending to larger areas of a watershed or beyond. As larger areas are affected and as low water and precipitation conditions worsen, the effects usually become more severe.

Drumlin - an elongated mound of glacial sediment deposited parallel to ice flow.

Dug Well - a large diameter well dug by hand, excavator or by an auguring machine, often caused by concrete or hand-laid bricks.

E

Ecology - an interdependent community of plants and animals living in a recognizable area; humans are a major part of most Ontario ecosystems.

Effective Precipitation - the part of precipitation which produces runoff; a weighted average of current and past precipitation correlating with runoff. It is also that part of the precipitation falling on an irrigated area which is effective in meeting the requirements of consumptive use.

Effluent - the discharge of a pollutant in a liquid form, often from a pipe into a stream or river.

End Moraine (Terminal Moraine) - a linear, slightly curved ridge of rocky debris deposited at the front end, or snout, of a glacier. It represents the furthest point of advance of a glacier, being formed when deposited material (till), which was pushed ahead of the snout as it advanced, became left behind as the glacier retreated.

Entity - one or a series of related objects, natural or anthropogenic, that may be related to a specific process. Examples: storage tank, bird colony, abandoned well, mine tailing, natural radiation source.

"Environmental Bill of Rights, 1993" - a statute of Ontario that provides a number of legal rights and formal procedures for the public to participate in environmental decision-making.

Environmental Commissioner of Ontario - an Officer of the Legislative Assembly of Ontario with responsibility for monitoring government compliance with the Environmental Bill of Rights, 1993.

"Environmental Protection Act" - the purpose of this Act is to provide for the protection and conservation of the natural environment. R.S.O. 1990, c. E.19, s. *3*.

Environmentally Sound - refers to those principles, methods and procedures involved in addressing the protection, management and enhancement of an ecosystem which are used in disciplines such as geology, geomorphology, hydrology, botany and zoology.

Erosion - a physical process causing the deterioration and transport of soil surfaces and river channel materials by the force of flowing water or wind, ice or other geological agents, including such processes as gravitational creep. Geological erosion is naturally occurring erosion over long periods of time.

Era - a division of geological time of the highest order.

Esker - a ridge of glacial sediment deposited by a stream flowing in and under a melting glacier.

Evaporation - the process by which water or other liquids change from liquid to vapour; evaporation can return infiltrated water to the atmosphere from upper soil layers before it reaches groundwater or surface water, and occur from leaf surfaces (interception), water bodies (lakes, streams, wetlands, oceans), and small puddled depressions in the landscape.

Evapotranspiration - the combined loss of water from a given area and during a specific period of time by evaporation from the soil surface and by transpiration from plants.

Event - an occurrence of an incident (isolated or frequent) with the potential to promote the introduction of a threat into the environment. An event can be intentional, as in the case of licensed discharge or accidental, as in the case of a spill.

Existing Drinking Water Source - the aquifer or surface water body from which municipal residential systems or other designated systems currently obtain their drinking water. This includes the aquifer or surface water body from which back-up wells or intakes for municipal residential systems or other designated systems obtain their drinking water when their current source is unavailable or an emergency occurs.

Exposure - the extent to which a contaminant or pathogen reaches a water resource. Exposure, like a drinking water threat, can be quantified based on the intensity, frequency, duration and scale. The degree of exposure will differ from that of a drinking water threat dependent on the nature of the pathway or barrier between the source (threat) and the target (receptor) and is largely dependent on the vulnerability of the resource.

Extreme Event - (a) a period of heavy precipitation or winds up to a 100 year storm event; (b) a freshet, or; (c) a surface water body exceeding its high water mark.

F

Feldspar - common rock-forming minerals (e.g. orthoclase, microline, plagioclase). Aluminum silicates of one or more of calcium, sodium and potassium.

Felsic - a term used to describe a characteristically light-coloured silicate mineral such as quartz or feldspar.

Fen - peatland with the water table at or just above the surface. Very slow internal drainage by seepage and usually enriched by nutrients from upslope mineral water, therefore more nutrient- and oxygen-rich than bogs. Peat substrate is usually greater than 40 centimetres deep. Can sometimes be a floating mat, with vegetation consisting of sedges, mosses, shrubs and sometimes a sparse tree layer.

Field Capacity - the capacity of soil to hold water at atmospheric pressure. It is measured by soil scientists as the ratio of the weight of water retained by the soil to the weight of the dry soil.

Fill - rubble, earth, rocks or other imported material that is used to raise or alter the existing elevation.

Fill Line - now referred to as the Approximate Regulated Area as noted in the "Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation". It is a line that may take into account the flood line and any characteristic of the adjacent lands which makes them inappropriate for traditional development (e.g. unstable slopes or soils, environmentally sensitive areas, unique habitats, etc.).

Filtering - the soil's ability to attenuate substances, which includes retaining chemicals or dissolved substances on the soil particle surface, transforming chemicals through microbial biological processing, retarding movement and capturing solid particles.

Flood - an overflow or inundation that comes from a river or other body of water and causes or threatens damage. It can be any relatively high streamflow overtopping the natural or artificial banks in any reach of a stream. It is also a relatively high flow as measured by either gauge height or discharge quantity.

Floodplain - a strip of relatively level land bordering a stream or river. It is built of sediment carried by the stream and dropped when the water has flooded the area. It is called a water floodplain if it is overflowed in times of high water, or a fossil floodplain if it is beyond the reach of the highest flood.

Floodway - the channel of a river and those parts of the adjacent floodplain which are required to carry and discharge flood water.

Flow - the volumetric rate of water discharged from a source, given in volume with respect to time. Measured in cubic metres per second (m3/s); see also “discharge”.

Flow System - groundwater flow from the recharge area to a discharge area; three levels - regional, intermediate, and local. In a regional flow system, the recharge area is at the basin or watershed divide and the discharge area is at a river in the valley bottom. In a local flow system, the recharge area is at a topographical high spot and the discharge area is at a nearby topographical low spot.

Fluoride - Fluoride is a chemical ion of the element fluorine, in that fluoride has one extra electron that gives it a negative charge. Fluoride is found naturally in water, foods, soil and several minerals such as fluorite and fluorapatite.

Fluorite - A mineral, essentially CaF_2, that is often fluorescent in ultraviolet light and occurs in light green, blue, yellow, brown, and colorless forms.

Fluvial - pertaining to rivers and streams or to features produced by the actions of rivers and streams.

Forage - herbaceous plants or plant parts fed to domestic animals.

Forest Management - the intelligent use and control of the forest and its products for a specific purpose; may be for wood production, wildlife habitat, maple syrup, nature trails or any combination of these uses and others.

Fractures - cracks in bedrock that may result in high permeability values.

“Freedom of Information and Protection of Privacy Act” - the “Freedom of Information and Protection of Privacy Act” (FIPPA) was created for the following purposes: To provide a right of access to information under the control of institutions in accordance with the principals that information should be available to the public, necessary exemptions from the right of access should be limited and specific, and decisions on the disclosure of government information should be reviewed independently of the government. To protect the privacy of individuals with respect to personal information about themselves held by institutions and to provide individuals with a right of access to that information (R.S.O. 1990, c.F31, s1.)

Fresh Water - water that contains less than 1,000 milligrams per litre of dissolved solids; generally more than 500 milligrams per litre is undesirable for drinking and many industrial uses.

Freshet - the occurrence of a water flow resulting from sudden rain or melting snow. Most commonly used to describe a spring thaw resulting from snow and ice melt.

Future Municipal Water Supply Areas - an area corresponding to a wellhead protection area or a surface water intake protection zone, or an aquifer or groundwater area identified for future municipal water supply infrastructure (either a well or a surface water intake pipe).

G

Gabbro - a course textured igneous rock, having the same composition as basalt but occurring as dikes and sills.

Galena - a gray mineral, essentially PbS, the principal ore of lead.

Gauge Station - a site on a stream, lake or canal where hydrologic data is collected.

Geology - the study of science dealing with the origin, history, materials and structure of the earth, together with the forces and processes operating to produce change within and on the earth.

GIS (Geographic Information System) - an electronic map-based database management system which uses a spatial reference system for analysis and mapping purposes.

Glacial Drift - all material transported and deposited by glacial ice and glacial meltwater.

Glacial Lake - a lake created when glacial meltwaters are ponded in a basin scoured out by glacial ice, or from the damming of natural drainage by glacial materials such as till.

Glacial Outwash - well-sorted sand, or sand and gravel deposited by water melting from a glacier.

Glacial Till - nonsorted, nonstratitified sediment deposited or transported by glacial activity.

Glaciofluvial - pertaining to rivers and streams flowing from, on or under melting glacial ice, or to sediments deposited by such rivers and streams.

Glaciolacustrine - a term used to describe fine-grained glacial materials deposited in glacial lake environments.

Gneiss - a type of rock containing bands rich in granular materials alternating with bands rich in platy or micaceous minerals.

Goals - high-level achievements for which to aim (e.g. to protect drinking water sources).

Gradient - the rate of change of elevation between one section of a river and another section further downstream.

Granite - a course-textured igneous rock made up of quartz, feldspar, and one or both of mica and hornblende; usually found in batholiths. It is an acid rock with a high content of silica.

Great Lakes - the Great Lakes are the five large lakes located in Canada and United States: Lake Ontario, Lake Superior, Lake Huron, Lake Michigan and Lake Erie.

Great Lakes Agreement – is an agreement to which subsection 14(1) of the "Clean Water Act" applies.

Great Lakes Basin - refers to the watershed of the Great Lakes and the St. Lawrence River upstream from Trois-Rivieres, Quebec.

Great Lakes Basin Water Resources - refers to the Great Lakes and all other bodies of water (streams, rivers, lakes, connecting channels, tributary groundwater) within the Great Lakes Basin.

Greenstone - an altered or metamorphosed basic igneous rock, usually basalt, rich in greenish minerals such as chlorite and some amphiboles.

Greywacke - a variety of sandstone with tiny fragments of rock and rock minerals (quartz and feldspar), resulting from rapid erosion and sedimentation.

Groundwater - the water below the water table contained in void spaces (pore spaces between rock and soil particles, or bedrock fractures). Water occurring in the zone of saturation in an aquifer or soil.

Groundwater Flow - the rate of groundwater movement through the subsurface.

Groundwater Recharge - inflow of water to a ground water reservoir from the surface. Infiltration of precipitation and its movement to the water table is one form of natural recharge.

Groundwater Recharge Area - the area where an aquifer is replenished from: (a) natural processes, such as the infiltration of rainfall and snowmelt and the seepage of surface water from lakes, streams and wetlands, (b) from human interventions, such as the use of storm water management systems, and; (c) whose recharge rate exceeds a specified threshold.

Groundwater Storage - the storage of water in groundwater reservoirs or aquifers.

Groundwater Vulnerability – assesses the probability of contaminants reaching a specified region in the groundwater system after introduction at some location above the uppermost aquifer. A groundwater vulnerability analysis looks at underground sources of drinking water. Areas that are vulnerable to contamination include wellhead protection areas, highly vulnerable aquifers and significant recharge areas. This study identifies and maps these vulnerable areas and assigns vulnerability scores. An uncertainty assessment is also conducted to identify where improvement of the science in the assessment report may be necessary in future source protection planning cycles. To determine the vulnerability score for a well, the researchers answers the questions, 'How quickly does water move horizontally through the aquifer to the well?' and 'How quickly does water move vertically from the surface down to the aquifer?'

H

Habitat - habitat is the environment of an organism; the place where it is usually found.

Hardness - a characteristic of water that contains various dissolved salts, calcium, magnesium and iron (e.g. bicarbonates, sulfates, chlorides and nitrates).

Hazard - a contaminant and/or pathogen threat.

Hazard Lands - areas designated unsuitable for commercial or residential development because of some natural limitation such as flooding, unstable soil or high ground water levels.

Hazard Rating - the numeric value which represents the relative potential for a contaminant of concern to impact drinking water sources at concentrations significant enough to cause human illness. This numeric value is determined for each contaminant of concern in the Threats Inventory and Issues Evaluation of the Assessment Report.

Headwater - the source of a river or water immediately upstream of a structure. The source waters of a stream or river.

Heavy Metals - a general term used to describe more than a dozen metallic elements. Some heavy metals, such as zinc, copper and iron, although harmful at high concentrations are essential parts of our diets at trace levels. Others, like lead and mercury, have no known health benefits and can have harmful effects on human health and the environment at very low concentrations.

Herbicide - chemicals used to kill undesirable vegetation.

Highly Vulnerable Aquifer - an aquifer on which external sources have or are likely to have a significant adverse effect, and includes the land above the aquifer.

Humic - highly decomposed organic material with small amounts of vegetative fibres present, which can be identified as to their biological origin.

Hummocky - landscape terrain that is characterized by numerous small hills and ridges. Frequently found at the edges of glaciers or in areas of landslide deposits or glacial deposition.

Hydraulic Gradient - rate of change of pressure head per unit of distance of flow at a given point and in a given direction.

Hydraulic Head (Head) - the energy that causes groundwater to flow; the total mechanical energy per unit weight; the sum of the elevation head and the pressure head.

Hydrogeologist - a person who works with and studies groundwater.

Hydrogeology - the study of the interrelationships of geologic materials and hydraulic processes.

Hydrologic Cycle - the cycle of water movement from the atmosphere to the earth and its return to the atmosphere through various stages, such as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.

Hydrology - Scientific study of the properties, distribution and effects of water on the Earth's surface, in the soil, underlying rocks and in the atmosphere.

HYMO - a computer model that computes runoff and soil loss from precipitation and basin characteristics.

I

Igneous - rocks produced under intense heat associated with volcanic activity and formed by the crystallization of molten or partially molten matter or magna.

Igneous Rock - is rock formed by the crystallization of molten or partially molten matter or magna.

Imminent Threat to Health - a contaminant of concern that can affect human health in a short period of time.

Impact - often considered the consequence or effect. The impact should be measurable and based on an agreed set of parameters. In the case of Drinking Water Source Protection, the parameters may be an acceptable list of standards which identify maximum raw water levels of contaminants and pathogens of concern. In the case of water quantity, the levels may relate to a minimum annual flow, piezometric head or lake level.

Impermeable - not allowing water to pass through.

Impervious - a term denoting the resistance to penetration by water or plant roots.

Implementation - is the process of carrying out the policies, measures and best management practices outlined in Source Protection Plans that will come into force with their completion in 2012. It is expected that Municipalities will play a central role in the implementation of Source Protection Plans.

Impoundment - a body of water, such as a pond, confined by a dam, dyke, floodgate or other barrier. It is used to collect and store water for future use or treatment.

Infiltration - the process of water moving from the ground surface vertically downward into the soil.

Infiltration Rate - the quantity of water that enters the soil surface in a specified time interval. Often expressed in volume of water per unit of soil surface area per unit of time (e.g. centimetres per hour, cm/hr).

Inflow - the water that flows into a lake, reservoir or forebay.

Intake Protection Zone (IPZ) - is one of four types of vulnerable areas identified in the Ontario “Clean Water Act, 2006”. Intake Protection Zone (IPZ) means the area of land and water that contributes source water to a drinking water system intake within a specified distance, period of flow time (for example, two hours), and/or watershed area. River and lake intakes can be contaminated when dangerous materials are spilled into the water or on nearby land and make their way to the intake. Intake protection zones are areas where dangerous materials may get to an intake so quickly the operators of the municipal water treatment plant may not have enough time to shut down the intake before the pollutant reaches it.

Integrated Resource Management - management of natural resources (water, trees, soil, wildlife) in a comprehensive, coordinated, cost effective way; usually done on a watershed basis with the goal of ensuring that the resource base does not deteriorate.

Interbedded Argillites - argillite is a type of rock having a higher degree of induration (cementation of hardness) than mudstone but less than shale.

Interflow (subsurface stormflow) - water that travels laterally or horizontally through the zone of aeration (vadose zone) during or immediately after a precipitation event and discharges into a stream or other body of water.

Interlobate Moraine - if large glaciers and continental ice sheets advance irregularly so that their margins are lobate, when the margins retreat by melting the resulting terminal moraines of boulders, clay and sand simulate the original interlobate shape of the glacier or glaciers, therefore such moraines are called interlobate moraine.

Intermittent - stopping and beginning again, pausing at intervals. An intermittent stream is a watercourse that does not flow permanently year-round.

Intrinsic - innate, inherent, inseparable from the thing itself, essential; comprising, being part of a whole.

Intrinsic Susceptibility - a measure of the natural protection of an aquifer from overlying layers with low permeability.

Intrinsic Susceptibility Index (ISI) - is a calculated value that estimates the susceptibility of a given groundwater aquifer to contamination by activity or water on the surface at a given point. It is a numerical indicator of an aquifer's intrinsic susceptibility to contamination expressed as a function of the thickness and permeability of overlying layers.

Intrinsic Vulnerability - the potential for the movement of a contaminant(s) through the subsurface based on the properties of natural geological materials. How quickly does water move vertically from the surface down to the aquifer? - This is called 'intrinsic vulnerability.

Intrusive Rocks – a type of igneous rock which is formed by the crystallization of magma at a depth below the Earth's surface.

Irrigation - the controlled application of water for agricultural purposes through man-made systems to supply water requirements not satisfied by rain or snowfall.

Irrigation Return Flow - the part of artificially applied water that is not consumed by evapotranspiration and that migrates to an aquifer or surface water body.

J

K

Kame - a steep-sided hill of stratified glacial force, distinguished from a drumlin by lack of unique shape and by stratification.

Kame-like - like a conical hill or short irregular ridge of gravel or sand deposited in contact with glacial ice.

L

Lacustrine - pertaining to lakes, or to sediments that have either settled from suspension in standing bodies of fresh water or have accumulated at their margins through wave action.

Lagoon - water impoundment in which organic wastes are stored or stabilized, or both.

Landbase - a general term for the environment of the earth not covered completely by water, often referring to a geographic area with common characteristics or defined boundaries.

Land Use - a particular use of space at or near the earth's surface with associated activities, substances and events related to the particular land use designation.

Leachate - liquid formed by water percolating through contaminated soil or soluble waste as in a landfill.

Limestone - a sedimentary rock made up largely of the carbonate mineral calcite.

Limnetic Zone - the open water area away from the shore of a lake or pond. In this zone, there is less light penetration and fewer producers.

Lithification - includes all the processes which convert unconsolidated sediments into solid sedimentary rocks. Essentially, lithification is a process of porosity destruction through compaction and cementation.

Littoral - along and close to the shore, particularly describing aquatic plants, animals, currents and water deposits.

Livestock - has the same meaning as in Ontario Regulation 267/03 (General) made under the "Nutrient Management Act, 2002".

Livestock Density - Livestock density means the number of farm animals grown, produced or raised per square kilometre of an area, separated by type of farm animals specified in Section 3.1 of the Nutrient Management Protocol. It is the number of nutrient units over a given area, and is expressed by dividing the nutrient units by the number of acres in the same area, where,

(a) in respect of land used for the application of nutrients, the number of acres of agricultural managed land in the vulnerable area, and;

(b) in respect of land that is part of a farm unit and that is used for livestock, grazing or pasturing, the number of acres that is used for those purposes.

Loam - a rich soil containing sand, silt, and clay.

Local Area - Local area means:

(a) in respect of a surface water intake, the drainage area that contributes surface water to the intake and the area that provides recharge to an aquifer that contributes groundwater discharge to the drainage area.

(b) in respect of a well, the area that is created by combining the following areas:

(i) the cone of influence of the well.

(ii) the cones of influence resulting from other water takings where those cones of influence intersect that of the well.

(iii) the areas where a reduction in recharge would have a measurable impact on the cone of influence of the well.

M

Mafic - term used to describe a characteristically dark-coloured subsilicic mineral, usually contrasted to felsic.

Magmatic – rock that is formed from a hot mass of molten or partially molten rock constituents formed at high temperatures within the earth.

Managed Land - land to which agricultural source material, commercial fertilizer or non-agricultural source material is applied.

Management - with respect to agricultural source material, the collection, handling, treatment, transportation or disposal of agricultural source material.

Manganese - a gray-white or silvery brittle, metallic element which resembles iron but is not magnetic. It is found abundantly in the ores pyrolusite, manganite, and rhodochrosite and in nodules on the ocean floor. Manganese is alloyed with iron to form ferromanganese, which is used to increase strength, hardness, and wear resistance of steel.

Marsh - standing or slow-moving water with emergent plants covering greater than 25%. Permanently flooded, intermittently exposed, or seasonally flooded. Nutrient-rich water generally remains within the rooting zone for most of the growing season. Substrate is mineral soil or well-decomposed sedimentary organic material, often held together by a root mat.

Maximum Acceptable Concentration (MAC) - the term used for limits applied to substances above which there are known or suspected adverse health effects.

Measure - a tangible direction or course of action. For example, a measure associated with the Risk Management Plan policy approach may be one of the specific required actions set out in the risk management plan. In the education and outreach policy approach, a measure may be an educational pamphlet or training course that sets out best practices. In incentive programs a measure may be the financial incentives are provided for those incorporating water conservation methods or activities.

Mesa - a flat-topped hill bounded on one or more sides by steep cliffs.

Mesic - organic material in an intermediate stage of decomposition. It contains intermediate amounts of organic fibre that can be identified as to its biological origin.

Metamorphic Rock - a rock that has undergone chemical or structural changes. Heat, pressure, or a chemical reaction may cause such changes.

Metasedimentary (Metasediments) - partly metamorphosed sedimentary rock.

Metavolcanics - partly metamorphosed volcanic rocks.

Migmatite - the same material as gneiss, but has been brought to melting or near-melting so that the veins and layers of minerals have become warped. In many cases the darker rock has been intruded by veins of lighter rock consisting of quartz and feldspar. This rock is classified as metamorphic.

Milligrams per Litre (mg/l) - a measure of the amount of dissolved solids in a solution in terms of milligrams of solid per litre of solution; equivalent to part per million in water or 1µg/l=1ppm .

Minimum Streamflow - the specific amount of water required to support aquatic life, minimize pollution and support recreational use.

Mirex – is a chlorinated hydrocarbon that was commercialized as an insecticide and later banned because of its impact on the environment. This white crystalline odorless solid was popularized to control fire ants but by virtue of its chemical. It was recognized as a bio-accumulative pollutant (does not break down easily in the environment).

Model - an assembly of concepts in the form of mathematical equations or statistical terms that portrays the behaviour of an object, process or natural phenomenon.

Moisture - water diffused in the atmosphere or the ground.

Monitoring Well - a non-pumping well, generally of small diameter, that is used to measure the elevation of a water table or water quality. A piezometer is one type of monitoring well.

Moraine - an accumulation of earth and stones carried by a glacier which is usually deposited into a high point like a ridge.

Multi-barrier Approach - the multi-barrier approach creates several barriers of protection, beginning with drinking water protection at the source. This preventive approach to risk reduction also includes treatment, testing, monitoring and training.

Municipal Residential Drinking Water System – a Municipality owned drinking water system that serves or is planned to serve a major residential development (i.e. six or more private residences).

Municipal Well – a Municipality owned pumping well that provides drinking water to five or more residences.

N

Nitrate (NO_3) - a chemical formed when nitrogen from ammonia (NH_3), ammonium (NH_4) and other nitrogen sources combine with oxygenated water. An important plant nutrient and type of inorganic fertilizer (most highly oxidized phase in the nitrogen cycle). In water, the major sources of nitrates are septic tanks, livestock feed lots and fertilizers.

Nitrite (NO_2) - product in the first step of the two-step process of conversion of ammonium (NH_4) to nitrate (NO_3).

Non-Agricultural Source Materials - used to apply to land as nutrients that do not originate from agricultural activities. Includes pulp and paper biosolids, sewage biosolids, non-agricultural compost and any other material capable of being applied to land as a nutrient that is not from an agricultural source (see "Nutrient Management Act, 2002" for legal description).

Non-Municipal Year-Round Residential Systems - non-municipal drinking water systems that serve a major residential development (more than five private residences) or a trailer park or campground that has more than five service connections.

Non-Point Source Pollution - pollution of the water from numerous locations that are hard to identify as point source, like agricultural activities, urban runoff and atmospheric deposition.

"Nutrient Management Act, 2002" - the purpose of this Act is to provide for the management of materials containing nutrients in ways that will enhance protection of the natural environment and provide a sustainable future for agricultural operations and rural development.

Nutrients - chemicals (particularly phosphorus) which stimulate the growth of aquatic plants; the nutrients act as fertilizers and contribute to heavy weed growth and algae blooms.

Nutrient Unit - the amount of nutrients that give the fertilizer replacement value of the lower of 43 kilograms of nitrogen or 55 kilograms of phosphate as nutrient as established by reference to the Nutrient Management Protocol ("Nutrient Management Act, 2002").

O

Official Plan (OP) - is a policy document prepared by a Municipality, which states in broad terms the municipality's strategic vision for community development and land use. The primary role of the Official Plan is to establish a series of Municipal policies to manage physical change and the effects on the social, economic and natural environment within the Municipality.

Ontario Drinking Water Quality Standards - regulated standards made under the "Safe Drinking Water Act, 2002", Ontario Regulation 169/03 for microbiological, chemical and radiological parameters that, when present above certain concentrations in drinking water, have known or suspected adverse health effects and require corrective action.

Ontario Ministry of the Environment (MOE) - is the provincial Ministry that is spearheading Drinking Water Source Protection in the Province of Ontario. The "Clean Water Act, 2006", legislated in July 2007, ensures that communities are able to identify potential risks to their supply of drinking water and take action to reduce or eliminate these risks.

Operational Plan - a document based on the requirements of the Drinking Water Quality Management Standard. The plan will document the owner and operating authority's quality management system.

Organic Soil - soil materials that have developed predominately from organic deposition (i.e. containing greater than 17 percent organic carbon or approximately 30 percent organic matter by weight).

Organism - an individual form of life that includes bacteria, protozoa, fungi, viruses and algae.

Outdoor Confinement Area - has the same meaning as in Ontario Regulation 267/03 (General) made under the "Nutrient Management Act, 2002".

Outflow - the flow out of or through a waterpower facility, control structure, pond, reservoir or lake.

Outwash Deposits - sediments deposited by glacial meltwater creating stratified layers of gravel, sand and fines. The terms fluvial and outwash are used interchangeably.

Outwash Sand - sand drift, which becomes deposited by melt-water streams.

Overburden - used to describe the soil and other material that lies above a specific geologic feature.

Oxbow - a crescent-shaped lake or slough formed in an abandoned stream bend that has become separate from the main stream by a change in its course.

P

Pathogen - an organism capable of producing disease.

Pathogenic Contaminant - a microscopic organism that is capable of producing infection or infectious disease in humans.

Peak Flow - the greatest rate of flow of water (highest recorded level) in a river within a defined time interval (e.g. annual peak flow, daily peak flow).

Percolation - the actual movement of subsurface water either horizontally or vertically; lateral movement of water in the soil subsurface toward a nearby surface drainage feature (e.g., stream) or vertical movement through the soil to the groundwater zone.

Permeable - a porous surface through which water passes quickly.

Permeability - the property or capacity of a soil or rock for transmitting a fluid, usually water; the rate at which a fluid can move through a medium. The definition only considers the properties of the soil or rock, not the fluid.

Permit To Take Water (PTTW) - any person that takes more than 50,000 litres of water per day from any source requires a permit issued by the Ministry of the Environment under the "Ontario Water Resources Act", unless they meet the criteria for certain exempted water takings.

Pesticides - chemicals including insecticides, fungicides, and herbicides that are used to kill living organisms.

pH - a numerical measure of acidity, or hydrogen ion activity used to express acidity or alkalinity. Neutral value is pH 7.0, values below pH 7.0 are acid, and above pH 7.0 are alkaline.

Physiography - the study of the physical features of the Earth's surface.

Piezometer - a type of monitoring well that is used to measure the height of a column of fluid which is open only at the top and bottom of its casing.

Piezometric Surface - the imaginary surface that coincides with the head of the water in an aquifer.

Piping - the internal erosion and carrying away of fine material from within a soil as the result of a flow of water. It refers to the pipe-shaped discharge channel left by erosion which starts at the point of exit of a flow line which exits on the ground surface, typically beneath embankments or on slopes where perched groundwater may seep out.

Planned - with respect to a drinking water system, a drinking water system that is to be established, or a part of a drinking water system that is to be established, if,

(a) approval to proceed with the establishment of the system or part has been given under Part II of the "Environmental Assessment Act".

(b) the establishment of the system or part has been identified as the preferred solution within a completed planning process conducted in accordance with an approved class environmental assessment under Part II.1 of the "Environmental Assessment Act" and no order has been issued under subsection 16 (1) of that Act.

(c) the system or part would serve a reserve as defined in the "Indian Act" (Canada).

Point Source Pollution - pollution from a distinct source, such as an industrial discharge pipe, underground storage tank, septic system, or spills.

Policy - a statement of intention. A policy may be designed to guide current and future actions and decisions, and to achieve a desired goal or outcome. A policy may refer to the policy approaches or the measures that will be used to achieve it.

Policy Approach - the approach a threat policy relies upon to reduce the risk posed by drinking water threats. The various policy approaches provided in the Act are: education and outreach activities; incentive programs; land use planning approaches (e.g., official plans, zoning by-laws, site plan controls); new or amended provincial instruments (e.g., Certificates of Approval); risk management plans; prohibition; restricted land uses.

Porosity - the ratio of the volume of void or air spaces in a rock or sediment to the total volume of the rock or sediment.

Potable Water - water that is safe for drinking.

Potentiometric Contour - elevation at the potentiometric surface.

Glossary

Potentiometric Surface - a theoretical surface to which water in an aquifer can rise by hydrostatic pressure.

Provincial Risk Management Measures Catalogue – is a comprehensive database that will contain information on risk management measures (RMM) to guide the development and implementation of source protection plan policies aimed at managing threats to water quality. The catalogue will describe appropriate risk management measures that reduce the risk posed by prescribed drinking water threats to source water, along with guidance on how to take local factors into account when choosing measures to address each type of threat. The catalogue will also provide a relative ranking of the effectiveness of each measure.

Precambrian Era - an informal name for the eons of the geologic timescale that came before the current Phanerozoic eon. It spans from the formation of Earth around 450 million years ago to the evolution of abundant macroscopic hard-shelled fossils, which marked the beginning of the Cambrian, the first period of the first era of the Phanerozoic eon, some 542 million years ago.

Precambrian Shield - rocks formed during the Precambrian era of earth's history, which have become exposed to the surface in what are called shield areas.

Precipitation - moisture falling from the atmosphere in the form of rain, snow, sleet or hail.

Preferential Pathway (now referred to as a Transport Pathway) - any structure of land alteration or condition resulting from a naturally occurring process or human activity which would increase the probability of a contaminant reaching a drinking water source.

Prescribed Drinking Water Threats - The following activities are prescribed as drinking water threats for the purpose of the definition of "drinking water threat" in subsection 2 (1) of the "Clean Water Act":

1. 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.
3. The application of agricultural source material to land.
4. The storage of agricultural source material.
5. The management of agricultural source material.
6. The application of non-agricultural source material to land.
7. The handling and storage of non-agricultural source material.
8. The application of commercial fertilizer to land.
9. The handling and storage of commercial fertilizer.
10. The application of pesticide to land.
11. The handling and storage of pesticide.
12. The application of road salt.
13. The handling and storage of road salt.
14. The storage of snow.

15. The handling and storage of fuel.
16. The handling and storage of a dense non-aqueous phase liquid.
17. The handling and storage of an organic solvent.
18. The management of runoff that contains chemicals used in the de-icing of aircraft.
19. An activity that takes water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body.
20. An activity that reduces the recharge of an aquifer.
21. The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard. Ontario Regulation 385/08, Section 3.

Private Well - groundwater that serves one home or is maintained by a private owner.

Pulse Crops - crops grown for food for human or animal consumption and include field beans, field peas, lentils, soybeans and fababeans.

Pyrite - A brass-coloured mineral, FeS_2 , occurring widely and used as an iron ore and in producing sulphur dioxide for sulphuric acid. Often referred to as fool's gold.

Pyrrhotite - A brownish-bronze iron sulfide mineral, FeS, characterized by weak magnetic properties and used as an iron ore and in the manufacture of sulfuric acid. Also called magnetic pyrites.

Q

Quaternary Geology - the study of all geologic activity and events which took place during the Quaternary geologic period (the last 1.8 million years).

R

Rainfall - the quantity of water that falls as rain only.

Rain Gauge - any instrument used for recording and measuring time, distribution and the amount of rainfall .

Raw Water - water in its natural state, prior to any treatment; not the same as 'pure' water which does not exist in nature. Raw water is water that is in a drinking-water system or in plumbing that has not been treated in accordance with: (a) the prescribed standards and requirements that apply to the system, or (b) such additional treatment requirements that are imposed by the license or approval for the system.

Raw Water Supply - water outside a drinking water system that is a source of water for the system (see source water).

Reach (river and streams) - a length of channel over which the channel characteristics are stable or similar. All geomorphological features and types of aquatic habitat should be proportionately represented in the section of the river or stream being assessed.

Recharge Area - an area in which water infiltrates and moves downward into the zone of saturation of an aquifer; area that replenishes groundwater.

Recharge Zone - the area of land, including caves, sinkholes, faults, fractures and other permeable features, that allows water to replenish an aquifer. This process occurs naturally when rainfall filters down through the soil or rock into an aquifer.

Regional Storm - the Regional Storm refers to a storm centred event on record that has the potential to occur over other watersheds in the general area. The Timmins Storm, which was an actual storm that occurred in 1961, that resulted in 193 millimetres of rainfall in 12 hours is considered the Regional Storm in the Lakehead Source Protection Area.

Regulated Area - is the area near a watercourse which is subject to Conservation Authority Regulations ("Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation").

Regulatory Limit - the area defined by the Conservation Authority for floodplain mapping purposes. Regulated areas are those areas for which Conservation Authorities delineate and restrict land uses by making regulations under subsection 28(1) of the "Conservation Authority Act". This subsection applies to water courses, streams, lakes, valleys, flood plains and wetlands in Ontario.

Reserve - has the same meaning as in the "Indian Act" (Canada).

Reservoir - a water body, either natural or artificial, for the storage, regulation and control of water. Large bodies of groundwater are called groundwater reservoirs or aquifers; water behind a dam is also called a reservoir.

Riparian - situated along the bank of a stream or other body of water.

Riparian Area - the area that lies as a transition zone between upland areas such as fields and streams, wetlands, lakes, rivers, etc. The zone is intermittently inundated and usually supports wet meadow, marshy or swampy vegetation.

Riparian Areas - a relatively narrow strip of land that borders a stream or river often coincides with the maximum water surface elevation of the one-hundred year storm.

Risk – the likelihood of a drinking water threat:

(a) rendering an existing or planned drinking water source impaired, unusable or unsustainable
(b) compromising the effectiveness of a drinking water treatment process, resulting in the potential for adverse human health effects.

River - a natural stream of water of considerable volume.

River and Stream System - a system that includes all watercourses, rivers, streams and small inland lakes (lakes with a surface area of less than 100 square kilometres) that have a measurable and predictable response to a single runoff event.

River Basin - a term used to designate the area drained by a river and its tributaries.

Runoff - the portion of precipitation which is not absorbed by the ground surface and finds its way into surface stream channels and becomes the flow of water from the land to oceans or interior basins by overland flow and stream channels.

"Safe Drinking Water Act, 2002" - provides for the protection of human health and prevention of drinking water health hazards through the control and regulation of drinking water systems and drinking water testing.

Saturation - occurs when all pore spaces in a soil are filled with water.

Saturation Zone - the portion that's saturated with water is called the zone of saturation. The upper surface of this zone, open to atmospheric pressure, is known as the water table.

Scour - removal of soil material by waves and currents especially at the base or toe of a shore structure or bluff.

Sediment - transported and deposited particles derived from rocks, soil or biological material. Sediment is also referred to as the layer of soil, sand and minerals at the bottom of surface water, such as streams, lakes and rivers.

Sedimentary Rock – is the type of rock that is formed by sedimentation of material at the Earth's surface and within bodies of water. Shale and limestone are the most common sedimentary rock occurring in the province of Ontario.

Sedimentary Peat - peat that is formed beneath a body of standing water. It is primarily derived from aquatic mosses, plant and algae. The material is slightly sticky, dark brown to black and is usually well decomposed (humic).

Sedimentation - silt and other suspended particles in a stream settling to the bottom. A natural river line process that creates point bars.

Seepage - the appearance and disappearance of water at the ground surface. Seepage designates the type of movement of water in saturated material. It is different from percolation, which is the predominant type of movement of water in unsaturated material.

Semi-Permeable - partially permeable.

Septic System (Conventional) - used to treat household sewage and wastewater by allowing solids to decompose and settle in a tank, then flow by gravity or pump/siphon to a drainage or tile field for soil absorption.

Sewage - has the same meaning as in the "Ontario Water Resources Act".

Significant Groundwater Recharge Area - an area within which it is desirable to regulate or monitor drinking water threats that may affect the recharge of an aquifer.

Significant Threat Policy - (a) a policy set out in a source protection plan that, for an area identified in the assessment report as an area where an activity is or would be a significant drinking water threat, is intended to achieve an objective referred to in paragraph 2 of subsection 22 (2), or (b) a policy set out in a source protection plan that, for an area identified in the assessment report as an area where a condition that results from a past activity is a significant drinking water threat, is intended to achieve the objective of ensuring that the condition ceases to be a significant drinking water threat.

Snow Course - an established, standard course of stations where the water content of the average snowpack can be determined; used to forecast spring flooding potential.

Snow Cover - a general term for the presence of snow on the surface of a watershed. Use of the term should include acknowledgement of the area and temporal variation of snowpack amounts on the watershed surface.

Snow Depth - the vertical distance between the upper surface of a snowpack and the ground surface beneath.

Snowfall - the amount of snow, hail, sleet or other precipitation occurring in solid form which reaches the earth's surface. It may be expressed in depth in inches after it falls, or in terms of inches or millimetres in depth of the equivalent amount of water.

Snowmelt - conversion of water from solid (ice) to liquid in the snowpack.

Snowpack - the seasonal accumulation of snow on the ground surface.

Snow Water Equivalent (also equivalent water content, or total water content) - depth of water layer produced, after melting of snow at a given place.

Soil Moisture - water diffused in the soil and remaining as a measurable quantity, as the volume of water divided by the total volume.

Soil Moisture Storage - water diffused in the soil. It is found in the upper part of the zone of aeration from which water is discharged by transpiration from plants or by soil evaporation.

Source Area - an area of land which absorbs and transmits surface and groundwater into nearby streams.

Source Protection - a program of education, stewardship, planning, infrastructure, and regulation activities that together serve to help prevent the contamination or overuse of source water.

Source Protection Area - areas are based on the existing 36 Conservation Authority boundaries (however there are exceptions). For administrative efficiency, some Source Protection Areas (SPAs) have been grouped together to form Source Protection Regions. Source Protection Areas and Regions have been defined in Ontario Regulation 284/07. Source Protection Area means those lands and waters that have been defined under Ontario Regulation 284/07 as the 'study area' for an Assessment Report and Source Protection Plan under the "Clean Water Act, 2006".

Source Protection Authority - a Conservation Authority or other person or body that is required to exercise powers and duties under the "Clean Water Act, 2006". Source Protection Authority refers to the role that Conservation Authorities play in Drinking Water Source Protection. Generally, where a Conservation Authority exists it becomes the Source Protection Authority for the area, but they have additional roles and responsibilities as laid out in the "Clean Water Act, 2006". Ontario Regulation 284/07 establishes Source Protection Authorities across Ontario.

Source Protection Committee - a group of individuals who have been appointed under the "Clean Water Act" by a Source Protection Authority to coordinate Source Protection Planning activities for a Source Protection Area. The Lakehead Source Protection Committee is composed of a provincially appointed Chair plus nine other members who were appointed from within the watershed by the Lakehead Source Protection Authority. The nine members of the Committee represent the watershed as the following: three municipal representatives - the City of Thunder Bay (2) and Municipality of Oliver Paipoonge (1); three economic/industry sector representatives - Thunder Bay Port Authority (1), forest industry(1) and agriculture industry (1); and three public members who represent education (1), tourism (1) and the general public (1). The Lakehead Source Protection Committee also includes one non-voting liaison representative from each of the following: the Lakehead Source Protection Authority, Thunder Bay District Health Unit and Ontario Ministry of the Environment. A First Nations Representative seat for an individual from Fort William First Nation remains vacant to date.

Source Protection Plan - the Source Protection Plan for each Source Protection Area (watershed) must set out policies intended to ensure that all significant drinking water threats cease to be significant and that potential threats are managed in such a way that they will never become significant drinking water threats. The Source Protection Committee must consult with Municipalities/public and make the Source Protection Plans available to the public. The Source Protection Committee will create a plan in 2012 for their Source Protection Area. In general, a Source Protection Plan builds on the information collected in the Assessment Report to establish policies to protect drinking water supplies. The "Clean Water Act, 2006" states that the Plans must address significant threats to drinking water. There are various tools and approaches that may be included in a Source Protection Plan. Many of these are already available to people who manage land uses and activities, such as Municipalities, for the protection of drinking water. Some of these will be familiar to people, such as land-use planning (by-laws and zoning), Regulations (e.g., you may need a Nutrient Management Plan to apply animal waste), and stewardship (e.g., education and Best Management Practices). Others may be less familiar, such as monitoring water quality to make sure an activity is not impacting the local area in a way that would negatively impact the drinking water supply. Each Plan is approved by the Ontario Ministry of the Environment. The Plan will outline policies and programs to eliminate significant threats to the water supply as well as reduce the opportunity for low and moderate threats to become significant. The Plan will be a document which specifies the actions required to protect and enhance drinking water sources in the Source Protection Area (watershed). The Source Protection Committee will establish criteria for policy development, priority areas based on the Assessment Report, along with monitoring and implementation requirements. Source Protection Plans will outline the steps that must be taken in a watershed to reduce the risk posed by significant threats. They could propose a variety of approaches such as incentive programs, monitoring activities, Risk Management Plans, changes to Municipal land use policies and others.

Source Protection Region - two or more Source Protection Areas that have been grouped together under Ontario Regulation 284/07.

Source Water - untreated water in streams, rivers, lakes or underground aquifers which is used for the supply of raw water for drinking water systems (see raw water supply).

Glossary

Source Water Protection - action taken to prevent the pollution and overuse of municipal drinking water sources, including groundwater, lakes, rivers and streams. Source water protection involves developing and implementing a plan to manage land uses and potential contaminants.

Sphalerite – The primary ore of zinc, occurring in usually yellow-brown or brownish-black crystals or cleavage masses, essentially ZnS with some cadmium, iron, and manganese. Also called blende or zinc blende.

Spring - a place where groundwater naturally comes to the surface, resulting from the water table meeting the land surface.

Spring Runoff - snow melting in the spring causes water bodies to rise. This, in streams and rivers, is called "spring runoff".

Static Water Level - the water level in a well that is not being pumped or influenced by pumping.

Stem Flow - water that is intercepted by vegetation and then runs down plant stems or tree trunks to the soil surface.

Storm - a change in the ordinary conditions of the atmosphere, which may include any or all meteorological disturbances such as wind, rain, snow, hail or thunder.

Stormwater Management - planning for the effective discharge of storm water without causing harmful effects on surface features, river levels or water quality.

Stratigraphy - the branch of geology that deals with the definition and interpretation of stratified rocks; the conditions of their formations; their character, arrangement, sequence, age and distribution; and especially their correlation by the use of fossils and other means. The term is applied both to the sum of the characteristics listed and a study of these characteristics.

Stream - a general term for a body of flowing water. In hydrology , the term is generally applied to the water flowing in a natural channel as distinct from a canal. More generally, it is applied to the water flowing in any channel, natural or artificial. Some types of streams are:

1. Ephemeral: A stream which flows only in direct response to precipitation, and whose channel is at all times above the water table.
2. Intermittent or seasonal: A stream which flows only at certain times of the year when it receives water from spring(s) or rainfall, or from surface sources such as melting snow.
3. Perennial: A stream which flows continuously.
4. Gaining: A stream or reach of a stream that receives water from the zone of saturation .
5. Insulated: A stream or reach of a stream that neither contributes water to the zone of saturation nor receives water from it.

Stream Flow - the discharge that occurs in a natural channel. The term streamflow is more general than runoff , as streamflow may be applied to discharge whether or not it is affected by diversion or regulation.

Stream Flow Indicators - gauges in streams measure stream flow and are used to provide indicators to show there is enough stream flow in the river to meet basic needs of the ecosystem and to show that water is available for other uses such as recreation, hydropower generation or irrigation. One stream flow indicator will be used, percentage of lowest average summer month flow. The average monthly flow for July, August and September for the stream flow station is determined and the lowest of these three values is the lowest average summer month flow. Monthly flow for each stream-gauge station will be compared with the lowest average summer month flow for the station to determine the stream flow indicator.

Stream Flow Indicator Graph - each month the average flow in cubic meters per second (m3/sec) for that month is plotted on a one year graph.

Stream Gauge - a measuring device for water elevation at selected points; the water elevation is then changed into flow measurements by the use of a conversion table.

Sub-Catchment - secondary or subordinate area for catching water, reservoir or basin developed for flood control or water management.

Subwatershed - a watershed subdivision of unspecified size that forms a convenient natural unit.

Surface Runoff (overland flow) - precipitation that cannot be absorbed by the soil because the soil is already saturated with water (soil capacity); precipitation that exceeds infiltration; the portion of rain, snow melt, irrigation water, or other water that moves across the land surface and enters a wetland, stream, or other body of water (overland flow). Overland flow usually occurs in urban settings (pavement, roofs, etc.) or where the soils are very fine textured or heavily compacted.

Surface to Well Advection Time (SWAT) - the average time required by a water particle to travel from a point at the ground surface to the well, including both vertical and horizontal movement.

Surface Water - all water above the surface of the ground including, but not limited to lakes, ponds, reservoirs, artificial impoundments, streams, rivers, springs, seeps and wetlands.

Surface Water Intake Protection Zone (IPZ) - A surface water intake protection zone is means an area that is related to a surface water intake and within which it is desirable to regulate or monitor drinking water threats. Intake protection zones were drawn around the intakes and assigned vulnerability scores on a 10-point scale:

IPZ-1: For a lake intake, a one-kilometre circle around the intake except where it meets shore – at which point it is drawn 120 metres from shore or the extent of the regulation limit, whichever is greater.

IPZ-2: The area where water can reach the intake in a specified time, usually two to six hours.

IPZ-3: Areas where there are activities further away from the intake which could have an impact on water quality.

The contiguous area of land and water immediately surrounding a surface water intake, which includes: the distance from the intake; a minimum travel time of the water associated with the intake of a municipal residential system or other designated systems, based on the minimum response time for the water treatment plant operator to respond to adverse conditions or an emergency; the remaining watershed area upstream of the minimum travel time area (also referred to as the Total Water Contributing Area) applicable to inland water courses and inland lakes only.

Surface Water Vulnerability Analysis - is the vulnerability analysis includes looking at both surface water and groundwater vulnerability. Because it is above ground, surface water, or water that is found in lakes, rivers and streams, is vulnerable to many types of contaminants. The surface water vulnerability analysis is the part of the assessment reports that looks at the likelihood that surface water will become contaminated, especially in the areas around drinking water intake pipes. The surface water vulnerability analysis requires that vulnerable areas around intake pipes (also known as Intake Protection Zones) be identified, mapped and given vulnerability scores. An uncertainty assessment is also done to identify where the science may need to be improved in future source protection planning cycles. Researchers studied how water moves in the area around each intake. For a river intake, they looked at how quickly it gets to the intake during high and low flows. For a lake intake, they studied how the movement of water is affected by currents and winds. For both types of intakes they identified streams, municipal storm sewers and rural drains that enter the river or lake near the intake. Intake protection zones were drawn around the intakes and assigned vulnerability scores on a 10-point scale.

Surficial geology - deals with the study and description of the forms on the outer layer of the Earth.

Susceptibility
Susceptibility is the likelihood of water in an area to be contaminated by a potential source of contamination based on factors including hydrogeologic sensitivity.

Swamp - wooded mineral wetland or peatland with standing or gently flowing water in pools or channels, or subsurface flow. The water table may drop below the rooting zone of vegetation, creating aerated conditions at the surface. The substrate is often woody, well decomposed peat, or a mixture of mineral and organic material. Vegetation includes deciduous or coniferous trees or shrubs, herbs and mosses.

Systems Serving Designated Facilities - drinking water systems that serve designated facilities such as schools (elementary and public), universities, colleges, children and youth care facilities (including day nurseries), health care facilities, children's camps and delivery agent care facilities (including certain hostels).

T

Table of Drinking Water Threats - the Ontario Ministry of the Environment publication "Table of Drinking Water Threats: *Clean Water Act, 2006*".

Targets – are objectives or goals to be met for water quality and water quantity to protect sources of drinking water as outlined in Source Protection Plans. In the context of draft technical guidance documents, targets are detailed goals that are often expressed as numeric values (e.g., to reduce contaminant X in this aquifer by X per cent by 2112). In the context of a Great Lakes target, the Minister of Environment under the "Clean Water Act, 2006" may establish objectives related to the quality and quantity of Great Lakes waters as a source of drinking water to be met by Source Protection Plans.

Terms of Reference - the work plan and budget, as approved by the Minister of Environment, for the preparation of Assessment Report and Source Protection, as defined by the "Clean Water Act". The Terms of Reference outlines the responsibilities assigned to the Source Protection Committee, Source Protection Authority, Conservation Authority and Member Municipalities in each Source Protection Area, in order to produce the Assessment Report and Source Protection Plan.

Thornthwaite Method - a method to estimate soil water budget, based on air temperature, latitude and date.

Threat Assessment –

> **Tier 1** - preliminary examination of drinking water threats based on readily accessible information.
> **Tier 2** - advanced examination of drinking water threats through accessing more detailed information, interviews and perhaps when warranted, additional monitoring, modeling or studies.

Threat Policies - policies in a source protection plan that address a drinking water threat of any risk level (significant, moderate or low), including policies that address activities and conditions.

Till - glacial deposits composed primarily of unsorted sand, silt, clay and boulders laid down directly by the melting ice.

Time of Travel - is an estimate of the time required for a particle of water to move in the saturated zone from a specific point in an aquifer into the well or intake. 'Time of Travel' means:

(a) in respect of groundwater, the length of time that is required for groundwater to travel a specified horizontal distance in the saturated zone, and;
(b) in respect of surface water, the length of time that is required for surface water to travel a specified distance within a surface water body.

For the purposes of Source Protection Planning, a timeframe of two, five and 25 years is used for groundwater and a two hour timeframe is used for surface water.

Topography - the configuration of the land surface including its relief and the position of its natural and man-made features.

Total Water Contributing Area - the area around a water source that includes all the surface and groundwater that provides recharge to that water source. The total water contributing area can be calculated for an entire watershed or on a sub-watershed basis.

Toxic - a substance which is poisonous to an organism.

Toxicity - the quality or degree of being poisonous or harmful to plant, animal or human life.

Transpiration - the process by which plants take up water through their roots and then give off water vapour through their leaves (open stomata). This water then enters the atmosphere.

Transport Pathway (formerly referred to as a Preferential Pathway) - any structure of land alteration or condition resulting from a naturally occurring process or human activity which would increase the probability of a contaminant reaching a drinking water source.

Tributary - any stream that contributes water to another water body.

Turbidity - a measure of water cloudiness caused by suspended solids.

U

Unconfined Aquifer (water table aquifer) - an aquifer with continuous layers of permeable soil and rock that extends from the land surface to the base of the aquifer. The water table forms the upper boundary of the aquifer and is directly affected by atmospheric pressure.

Undercutting - erosion of material at the foot of a cliff or bank.

V

Varved - any form of repetitive layered sediment that was deposited within a one-year time period. This annual deposit may comprise paired contrasting laminations of alternately finer and coarser silt or clay, reflecting seasonal sedimentation (summer and winter) within the year.

Vugs - small cavities inside rock that are formed when crystals form inside a rock matrix and are later removed through erosive processes, leaving behind voids. A common cause of vugs is minerals precipitating from solution in water and then later being dissolved again by less saturated water. The inner surfaces of vugs are often coated with some of the mineral matter that formed them. Fine crystals are often found in vugs where the open space allows the free development of external crystal form. Goeodes are a common vug formed rock.

Vulnerability - describes how easily a well or intake can become polluted with a dangerous material. Researchers have studied each municipal well and intake to determine how vulnerable they are.

Vulnerable Area - areas related to a water supply source that are susceptible to contamination and for which it is desirable to regulate or monitor drinking water threats that may affect the water supply source. Vulnerable areas under the "Clean Water Act, 2006" are a: significant groundwater recharge area, highly vulnerable aquifer, surface water intake protection zone or wellhead protection area.

W

Washoff - storm water runoff at surface level.

Waste Disposal Site - any land upon, into, in or through which, or building or structure in which waste is deposited, disposed of, handled, stored, transferred, treated or processed, and any operation carried out or machinery or equipment used in connection with the depositing, disposal, handling, storage, transfer, treatment or processing of the waste ("Environmental Protection Act", R.S.O. 1990).

Water Balance - the accounting of water input and output and change in storage of the various components of the hydrologic cycle .

Water Budget - a description and analysis of the overall movement of water within each watershed in the Source Protection Area, taking into consideration surface water and groundwater features, land cover (e.g. proportion of urban versus rural uses), human-made structures (e.g. dams, channel diversions, water crossings), and water takings.

Tier 1 Water Budget
A water budget developed using a geographical information system or equivalent to assess groundwater flows and levels, surface water flows and levels, and the interactions between them.

Tier 2 Water Budget
A water budget developed using computer based three dimensional groundwater flow models and computer based continuous surface water flow models to assess groundwater flows and levels, surface water flows and levels, and the interactions between them.

Tier 3 Water Budget
A water budget developed using computer based three dimensional groundwater flow models and computer based continuous surface water flow models to assess groundwater flows and levels, surface water flows and levels, and the interactions between them, and that includes consideration of the following circumstances:

(a) current and future land cover within the area;
(b) hydraulic flow controls within the area;
(c) water taken by the surface water intakes and wells related to the area;
(d) other uses of water within and downstream of the area;
(e) steady and transient states in groundwater;
(f) drought conditions;
(g) the average daily supply and demand for surface water within the area; and
(h) average monthly supply and average monthly demand for groundwater within the area.

Water Control Structure - a man-made dam, weir or other structure used to regulate the natural flow of water.

Watercourses - depressions formed by runoff moving over the surface of the earth; any natural course that carries water.

Water Cycle (Hydrologic Cycle) - the continuous circulation of water from the atmosphere to the earth and back to the atmosphere including condensation, precipitation, runoff, groundwater, evaporation, and transpiration.

Water Diversion - redirecting part of a stream flow to a location where the water will be used (e.g. to a site where it is convenient to build a water treatment plant).

Water Pollution - industrial and institutional waste and other harmful or objectionable material in sufficient quantities to result in a measurable degradation of the water quality.

Water Quality - a term used to describe the chemical, physical and biological characteristics of water, usually in respect to its suitability for a particular purpose, such as drinking.

Watershed - the land area from which surface water and groundwater drains into a stream system; the area of land that generates total runoff (surface flow, interflow, and baseflow) for a particular stream system. Also referred to as drainage area, basin or catchment area for a watercourse.

Watershed Characterization - a characterization of the physical geography and human geography of the watershed and the characterization of the interactions between the physical geography and human geography.

Water Soluble Fraction (WSF) - the portion of an oil that is soluble in water under equilibrium conditions. The water-soluble fraction of petroleum hydrocarbons is composed mostly of aromatic hydrocarbons such as benzene or toluene.

Water Supply - any quantity of available water.

Water Table - the point where the unsaturated zone meets the zone of saturation is known as the water table. Water table levels fluctuate naturally throughout the year based on seasonal variations and are the reason why some wells go dry in the summer. In addition, the depth to the water table varies. For example, in (select an area in the watershed or community) the water table is "X" metres below the surface. The water table is the surface below which the soil is saturated with water.

Water Table Aquifer - an aquifer whose upper boundary is the water table; also known as an unconfined aquifer.

Water Table Contour - a line in a groundwater map that connects points of equal groundwater elevation.

Water Table Well - a well whose water is supplied by a water table or unconfined aquifer**.**

Weir - a small dam, often temporary and removable, which raises the water level upstream for aesthetic, recreational or industrial uses.

Well - a vertical bore hole in which a pipe-like structure is inserted into the ground in order to discharge (pump) water from an aquifer.

Wellhead - the structure built above a well.

Wellhead Protection Area (WHPA) - means an area that is related to a wellhead and within which it is desirable to regulate or monitor drinking water threats. Ontario Regulation 385/08, Section 2.

Well Yield - the volume of water that can be pumped from a well during a specific period.

Wetlands - lands such as a swamp, marsh, bog or fen (not including land that is being used for agricultural purposes and no longer exhibits wetland characteristics) that,

a) is seasonally or permanently covered by shallow water or has the water table close to or at the surface.
b) Has saturated soils and vegetation dominated by aquatic or water-tolerant plants.
c) has been further identified, by the Ontario Ministry of Natural Resources (MNR) or by any other person, according to evaluation procedures established by the Ontario Ministry of Natural Resources.

Wetland Complex - an area consisting of several kinds of wetlands potentially including open water marsh, marsh, swamp, bogs and fens.

White Paper - the term commonly applied to official documents presented by Ministers of the Crown which state and explain the government's proposed policy on a certain issue, usually to provide opportunity for stakeholder consultations.

Windbreak - one or more rows of trees planted around buildings or fields to reduce the force of winds; rows are planted at right angles to the direction of the prevailing winds; an energy conservation measure.

Withdrawal - the removal or taking of water from surface water bodies or groundwater sources.

Winter Drawdown - the water level reduction in a lake or reservoir during the winter.

Wollastonite - a common mineral in skarns or contact metamorphic rocks. Skarns can sometimes produce some wonderfully rare and exotic minerals with very unusual chemistries. Wollastonite forms from the interaction of limestones, that contain calcite with the silica, SiO_2, in hot magmas. This happens when hot magmas intrude into and/or around limestones or from limestone chunks that are broken off into the magma tubes under volcanoes and then blown out of them.

Yield - the quantity of water expressed either as a continuous rate of flow (cubic feet per second, etc.) or as a volume per unit of time. It can be controlled for a given use, or uses, from surface water or groundwater sources in a watershed.

Zone of Aeration (vadose zone or unsaturated zone) - the zone between the land surface and the water table in which the pore spaces between soil and rock particles contain water, air, and/or other gases.

Zone of Saturation (saturated zone) - the zone in which the pore spaces between soil and rock particles are completely filled with water. The water table is the top of the zone of saturation. Water in the zone of saturation is called groundwater.

Appendix 1 - List of Non-Municipal Drinking Water Systems within the Lakehead Source Protection Area

Appendix I - List of Non-Municipal Drinking Water Systems within the Lakehead Source Protection Area

Drinking WS Number	DWS Name	Category	Municipality
260004501	R252 Kakabeka Falls Provincial Park - Main Pumphouse Well Supply	Large Non-Municipal Non-Residential	Oliver Paipoonge
260004878	Copenhagen Trailer Park Well Supply	Non-Municipal Year-Round Residential	Thunder Bay
260005541	Kakabeka Legion Seniors Home Well Supply	Non-Municipal Year-Round Residential	Oliver Paipoonge
260006646	Silver Springs Estates Trailer Park Well Supply	Non-Municipal Year-Round Residential	Thunder Bay
260007504	Pine Tree Estates Mobile Home Park Well Supply	Non-Municipal Year-Round Residential	Thunder Bay
260009854	Crestview Public School Well Supply	Small Non-Municipal Non-Residential	Oliver Paipoonge
260009867	Five Mile Public School Well Supply	Small Non-Municipal Non-Residential	Thunder Bay
260009880	Gorham-Ware Public School Well Supply	Small Non-Municipal Non-Residential	Thunder Bay
260009893	Kakabeka Falls Public School Well Supply	Small Non-Municipal Non-Residential	Oliver Paipoonge
260009919	Kingfisher Outdoor School Well Supply	Small Non-Municipal Non-Residential	Thunder Bay
260009932	McKenzie Public School Well Supply	Small Non-Municipal Non-Residential	Shuniah
260009945	Valley Central Public School Well Supply	Small Non-Municipal Non-Residential	Thunder Bay
260009971	Whitefish Valley Public School Well Supply	Small Non-Municipal Non-Residential	Thunder Bay
260016458	Franklin Manor/ Northern Linkage Well Supply	Small Non-Municipal Non-Residential	Thunder Bay
260016497	Three C's Center Well Supply	Small Non-Municipal Non-Residential	Thunder Bay
260016848	Options Northwest Group Home Well Supply	Small Non-Municipal Non-Residential	Oliver Paipoonge
260018395	Thunder Bay Christian School Well Supply	Small Non-Municipal Non-Residential	Oliver Paipoonge
260023244	Thunder Bay Aboriginal Head Start (Shkoday) Well Supply	Small Non-Municipal Non-Residential	Thunder Bay
260024089 *	Enchanted Garden Residence Well Supply	Non-Municipal Year-Round Residential	Thunder Bay
260024271	Alice Avenue Home Well Supply	Small Non-Municipal Non-Residential	Thunder Bay
260026871	K-O-A Kampground Well Supply	Non-Municipal Seasonal Residential	Shuniah
260026884	R252 Pigeon River Border Crossing Water Treatment Plant	Small Non-Municipal Non-Residential	Thunder Bay
260028769	Smart's Mobile Home Park Well Supply	Non-Municipal Year-Round Residential	Thunder Bay
260035373	R252 Murillo Complex Well Supply	Small Municipal Non-Residential	Oliver Paipoonge
260035386	R252 Rosslyn Community Centre Well Supply	Small Municipal Non-Residential	Oliver Paipoonge
260035399	R252 Norwest Recreation Centre Well Supply	Small Municipal Non-Residential	Oliver Paipoonge
260035932 *	Springdale Inc. Well Supply	Non-Municipal Year-Round Residential	Oliver Paipoonge

Appendix I - List of Non-Municipal Drinking Water Systems within the Lakehead Source Protection Area

DWS Number	DWS Name	Category	Municipality
260037154	R252 Wilderness Discovery Family Resort And Conference Centre Well Supply	Small Non-Municipal Non-Residential	Thunder Bay City
260038298	Happyland Park Well Supply	Non-Municipal Year-Round Residential	Summer Resort Location, Sf21, Lake Shebandowan, Conacher
260038311	Aurora Lutheran Bible Camp Well Supply	Non-Municipal Seasonal Residential	Oliver Paipoonge
260041561	R252 Lac Des Iles Mines Water Treatment Plant	Large Non-Municipal Non-Residential	Thunder Bay
260041717	R252 Conmee Community Centre Well Supply	Non-Municipal Year-Round Residential	Thunder Bay
260042562	Longhouse Village Trailer Park Well Supply	Small Municipal Non-Residential	Shuniah
260048776	R252 Macgregor Recreation Centre Well Supply	Small Non-Municipal Non-Residential	Shuniah
260051103	R252 Kakabeka Falls Provincial Park - Group Camp Well Supply	Small Non-Municipal Non-Residential	Shuniah
260052143	R252 Slate River Baptist Church Well Supply	Small Non-Municipal Non-Residential	Kakabeka Falls
260056732	R252 Emerald Greens Golf Course Well Supply	Small Municipal Non-Residential	Thunder Bay
260061750	R252 Dorion Municipal Office/Library Building Well Supply	Small Municipal Non-Residential	Thunder Bay
260061763	R252 Dorion Public Works Garage Well Supply	Small Municipal Non-Residential	Dorion
260061776	R252 Dorion Centennial Building Well Supply	Small Non-Municipal Non-Residential	Dorion
260061945	R252 Dragon Hills Golf Course And Driving Range Well Supply	Small Non-Municipal Non-Residential	Thunder Bay
260064038	Dorion Bible Camp Well Supply	Small Non-Municipal Non-Residential	Dorion
260067249	Intola Baptist School Well Supply	Non-Municipal Year-Round Residential	Dorion
260069836	Duke's Trailer Court Well Supply	Small Non-Municipal Non-Residential	Shuniah
260070395 *	R252 Bay-Lee-Mac Camp Water Treatment Plant	Non-Municipal Seasonal Residential	Thunder Bay
260074256	Wild Rose Park Well Supply	Small Non-Municipal Non-Residential	Nolalu
260075842	R252 Dorion Bible Conference Centre Well Supply	Small Non-Municipal Non-Residential	Thunder Bay
260078260	R252 Kakabeka Falls Congregation Of Jehovah's Witnesses Well Supply	Small Non-Municipal Non-Residential	Dorion
260079300	R252 Thunder Bay Seventh-Day Adventist Church Well Supply	Small Non-Municipal Non-Residential	Conmee
UNR - 100000019253	UNR -Wild Rose Park		Shuniah
UNR	UNR - Thunder Bay Correctional Centre		Thunder Bay
260016991	Lakehead University Nordic Sports Centre Well Supply		Thunder Bay
UNR - 100000018772	UNR -252 Dragon Hills Golf Course		Galway-Cavendish-Harvey

Appendix I - List of Non-Municipal Drinking Water Systems within the Lakehead Source Protection Area

*Unable to confirm if located within the Lakehead Source Protection Area

DWS Number	DWS Name	Category	Municipality
UNR – 100000019952*	UNR -Canadian Operators Petroleum Well Supply		Thunder Bay
UNR - 100000021258	UNR -R 252- Neebing Municipal Office		Kenora
UNR - 100000021301	UNR -Thunder Bay Adventist School		Thunder Bay
UNR - 100000025998	UNR -O.Reg.243 McKellar Park (7589)		Thunder Bay
UNR - 100000048061	UNR -Mapleward Fire Station		Thunder Bay
UNR - 100000051156	UNR -Pine Grove United Church		Thunder Bay

Appendix II –Livestock Density Worksheet

Livestock Density for Thunder Bay Census District

	# of units	Conversion Factor # livestock/NU	# of NUs
Cattle	7609	0.85	8951.764706
Pigs	206	8.165	25.2296387
Poultry	33901	245	138.3714286
Sheep	753	8	94.125
Horses	526	1	526
Goats	273	8	34.125
Llamas	28	6.5	4.307692308
		Total	**9773.923465**

Livestock numbers from Statistics Canada, 2006 Census of Agriculture, *Farm Data and Farm Operator Data,* catalogue no. 95-629-XWE.

Livestock to NU conversion factors are averages from Conversion Factors presented in Ministry of Environment, Technical Bulletin: Proposed Methodology for Calculating Percentage of Managed Lands and Livestock Density for Land Application of Agricultural Source of Material, Non-Agricultural Source of Material, December 2009.

Total Acreage of Managed Lands within LSPA = 30095.91 Acres

Acreage taken from MPAC parcels with codes corresponding to managed lands within the LSPA

Average Nutrient Units across LSPA = 0.324759194 NU/acre

Appendix III - List of Known Lakes within the Lakehead Source Protection Area

Appendix III: List of Named Lakes within the Lakehead Source Protection Area

Tertiary Watershed	Lake Name	Thermal Property
Arrow	Bearpad Lake	Warm Water
Arrow	Bell Lake	Cold Water
Arrow	Caldwell Lake	Warm Water
Arrow	Cloud Lake	Cool Water
Arrow	Crescent Lake	Unknown
Arrow	Crystal Lake	Warm Water
Arrow	Fallingsnow Lake	Cold Water
Arrow	Johnson Lake	Unknown
Arrow	Lenore Lake	Cool Water
Arrow	Loch Lomond	Cold Water
Arrow	Matson Lake	Cold Water
Arrow	McQuaig Lake	Unknown
Arrow	Moon Lake	Unknown
Arrow	Pine Lake	Unknown
Arrow	Sawdust Lake	Unknown
Arrow	Ward Lake	Unknown
Black Sturgeon	Abigogami Lake	Cold Water
Black Sturgeon	Ada Lake	Unknown
Black Sturgeon	Allan Lake	Cold Water
Black Sturgeon	Ancliff Lake	Cold Water
Black Sturgeon	Andersen Lake	Unknown
Black Sturgeon	Anderson Lake	Cold Water
Black Sturgeon	Bare Lake	Unknown
Black Sturgeon	Bass Lake	Cold Water
Black Sturgeon	Bat Lake	Unknown
Black Sturgeon	Beatty Lake	Unknown
Black Sturgeon	Beaver Lake	Unknown
Black Sturgeon	Beaverhide Lake	Cold Water
Black Sturgeon	Big Pearl Lake	Cool Water
Black Sturgeon	Big Trout Lake	Warm Water
Black Sturgeon	Bigger Lake	Cold Water
Black Sturgeon	Billy Lake	Cold Water
Black Sturgeon	Bisect Lake	Cold Water
Black Sturgeon	Bishops Lake	Cold Water
Black Sturgeon	Bittern Lake	Cool Water
Black Sturgeon	Blende Lake	Unknown
Black Sturgeon	Breezy Lake	Unknown
Black Sturgeon	Cannon Lake	Unknown
Black Sturgeon	Caribou Lake	Unknown
Black Sturgeon	Cavern Lake	Cold Water
Black Sturgeon	Clegge Lake	Cold Water
Black Sturgeon	Cliff Lake	Cold Water
Black Sturgeon	Crag Lake	Unknown
Black Sturgeon	Crow Lake	Cold Water

Black Sturgeon	D'Arcy Lake	Unknown
Black Sturgeon	Deception Lake	Cold Water
Black Sturgeon	Deer Lake	Unknown
Black Sturgeon	Demuth Lake	Unknown
Black Sturgeon	Dick Lake	Unknown
Black Sturgeon	Dot Pond	Unknown
Black Sturgeon	Fall Lake	Cold Water
Black Sturgeon	Fisher Lake	Unknown
Black Sturgeon	Five Minute Lake	Unknown
Black Sturgeon	Furcate Lake	Cold Water
Black Sturgeon	Golden Gate Lake	Cool Water
Black Sturgeon	Goodmorning Lakes	Cold Water
Black Sturgeon	Grande Lake	Cold Water
Black Sturgeon	Granite Lake	Unknown
Black Sturgeon	Grassy Lake	Unknown
Black Sturgeon	Gray Lake	Unknown
Black Sturgeon	Greenwich Lake	Cold Water
Black Sturgeon	Gulch Lake	Cold Water
Black Sturgeon	Hades Lake	Warm Water
Black Sturgeon	Harris Lake	Warm Water
Black Sturgeon	Henderson Lake	Unknown
Black Sturgeon	Hicky Lake	Unknown
Black Sturgeon	Hilma Lake	Cold Water
Black Sturgeon	Himdick Lake	Cold Water
Black Sturgeon	Hogan's Lake	Unknown
Black Sturgeon	Hunters Lake	Cold Water
Black Sturgeon	Innes Lake	Cold Water
Black Sturgeon	Iron Lake	Unknown
Black Sturgeon	Jeff Lake	Cold Water
Black Sturgeon	Johnnies Lake	Unknown
Black Sturgeon	Knobel Lake	Cold Water
Black Sturgeon	Little Hicky Lake	Unknown
Black Sturgeon	Little Hilma Lake	Unknown
Black Sturgeon	Little Moraine Lake	Cold Water
Black Sturgeon	Long Lake	Cold Water
Black Sturgeon	Loon Lake	Cold Water
Black Sturgeon	Lost Lake	Cold Water
Black Sturgeon	Lower Clearwater Lake	Unknown
Black Sturgeon	Luck Lake	Unknown
Black Sturgeon	Lynch Lake	Unknown
Black Sturgeon	MacDonalds Lake	Unknown
Black Sturgeon	MacIntosh Lake	Cold Water
Black Sturgeon	MacKenzie Lake	Cold Water
Black Sturgeon	Mac's Lake	Unknown
Black Sturgeon	Magone Lake	Cold Water
Black Sturgeon	Mason Lake	Unknown

Appendix III: List of Named Lakes within the Lakehead Source Protection Area

Black Sturgeon	Milkshake Lake	Cool Water
Black Sturgeon	Miner Lake	Cold Water
Black Sturgeon	Mirror Lake	Cold Water
Black Sturgeon	Moonshine Lake	Unknown
Black Sturgeon	Moose Lake	Cold Water
Black Sturgeon	Moosehorn Lake	Unknown
Black Sturgeon	Moraine Lake	Cold Water
Black Sturgeon	Mountain Lake	Unknown
Black Sturgeon	Mutt Lake	Cold Water
Black Sturgeon	Nalla Lake	Cold Water
Black Sturgeon	Nolan Lake	Cold Water
Black Sturgeon	Nybergs Lake	Unknown
Black Sturgeon	Paradise Lake	Cold Water
Black Sturgeon	Pass Lake	Cool Water
Black Sturgeon	Pearl Lake	Warm Water
Black Sturgeon	Pearson Lake	Cold Water
Black Sturgeon	Penassen Lakes	Cold Water
Black Sturgeon	Pickett's Lake	Unknown
Black Sturgeon	Picture Lake	Unknown
Black Sturgeon	Pike Lake	Warm Water
Black Sturgeon	Pine Lake	Unknown
Black Sturgeon	Pocket Lake	Cold Water
Black Sturgeon	Pounsford Lake	Cool Water
Black Sturgeon	Pratt Lake	Unknown
Black Sturgeon	Pringle Lake	Cold Water
Black Sturgeon	Question Mark Lake	Cold Water
Black Sturgeon	Rainbow Lake	Unknown
Black Sturgeon	Rat Lake	Unknown
Black Sturgeon	Ring Lakes	Unknown
Black Sturgeon	Roll Lake	Unknown
Black Sturgeon	Samick's Lake	Unknown
Black Sturgeon	Sandybeach Lake	Cold Water
Black Sturgeon	Scarp Lake	Unknown
Black Sturgeon	Schmoo Lake	Unknown
Black Sturgeon	Shale Lake	Unknown
Black Sturgeon	Sibleymount Lake	Unknown
Black Sturgeon	Silver Lake	Cold Water
Black Sturgeon	Single Lake	Unknown
Black Sturgeon	Sirecho Lake	Unknown
Black Sturgeon	Sparks Lake	Unknown
Black Sturgeon	Sprat Lake	Cold Water
Black Sturgeon	Spring Lake	Unknown
Black Sturgeon	Springlet Lake	Unknown
Black Sturgeon	Sunset Lake	Unknown
Black Sturgeon	Sward Lake	Cool Water
Black Sturgeon	Tartan Lake	Cold Water

Black Sturgeon	Tastan Lake	Cold Water
Black Sturgeon	Thruline Lake	Unknown
Black Sturgeon	Twenty Minute Lake	Cold Water
Black Sturgeon	Twinredblox Lake	Cool Water
Black Sturgeon	Two Pound Lake	Cold Water
Black Sturgeon	Unknown Lake	Cool Water
Black Sturgeon	Upper Clearwater Lake	Unknown
Black Sturgeon	Upper Hunters Lake	Cold Water
Black Sturgeon	Upper Pass Lake	Cold Water
Black Sturgeon	Upper Wolf Lake	Unknown
Black Sturgeon	Venice Lake	Cool Water
Black Sturgeon	Walkinshaw Lake	Cool Water
Black Sturgeon	Welburn Lake	Cold Water
Black Sturgeon	White Granite Lake	Unknown
Black Sturgeon	White Horse Lake	Cold Water
Black Sturgeon	Wideman Lake	Cold Water
Black Sturgeon	Wiggins Lake	Cold Water
Black Sturgeon	Wiswell Lake	Unknown
Black Sturgeon	Wolf Lake	Cool Water
Black Sturgeon	Wolfpup Lake	Cool Water
Black Sturgeon	Yea Lake	Cold Water
Black Sturgeon	Young Lake	Cold Water
Dog	Adair Lake	Unknown
Dog	Adrian Lake	Cold Water
Dog	Alpha Lake	Unknown
Dog	Amethyst Lake	Cool Water
Dog	Amp Lake	Cool Water
Dog	Andy Lake	Unknown
Dog	Anne Lake	Unknown
Dog	Arundel Lake	Unknown
Dog	Athelstane Lake	Cold Water
Dog	Barnum Lake	Cool Water
Dog	Basher Lake	Unknown
Dog	Bass Lake	Unknown
Dog	Batwing Lake	Cool Water
Dog	Beaver Lake	Unknown
Dog	Beaverkit Lake	Unknown
Dog	Beaverlodge Lake	Cool Water
Dog	Beeney Lake	Unknown
Dog	Bentley Lake	Unknown
Dog	Beth Lake	Unknown
Dog	Binabick Lake	Unknown
Dog	Block Lake	Unknown
Dog	Blossom Lake	Cool Water
Dog	Bloxham Lake	Unknown
Dog	Blunder Lake	Cool Water

Dog	Bolduc Lake	Unknown
Dog	Boulevard Lake	Cool Water
Dog	Bowes Lake	Unknown
Dog	Boyd Lake	Unknown
Dog	Brink Lake	Unknown
Dog	Buck Lake	Cool Water
Dog	Burbidge Lake	Unknown
Dog	Burk Lake	Cool Water
Dog	Buzzer Lake	Unknown
Dog	Camp Lake	Cold Water
Dog	Carlson lake	Unknown
Dog	Carson Lake	Unknown
Dog	Cascade Lake	Unknown
Dog	Cedarlimb Lake	Unknown
Dog	Chambers Lake	Cool Water
Dog	Chub Lake	Unknown
Dog	Clearwater Lake	Unknown
Dog	Clements Lake	Unknown
Dog	Clovenhoof Lake	Unknown
Dog	Coldwater Lake	Cold Water
Dog	Combe Lake	Unknown
Dog	Conklin Lake	Unknown
Dog	Coons Lake	Unknown
Dog	Cowles Lake	Unknown
Dog	Crayfish Lake	Unknown
Dog	Creighton Lake	Unknown
Dog	Creppy Lake	Unknown
Dog	Crock Lake	Cool Water
Dog	Croskery Lake	Unknown
Dog	Cummins Lake	Unknown
Dog	Current Lake	Cool Water
Dog	Curzon Lake	Unknown
Dog	Dakota Lake	Cold Water
Dog	Damocles Lake	Unknown
Dog	Davison Lake	Unknown
Dog	Deman Lake	Unknown
Dog	Demars Lake	Unknown
Dog	Dog Lake	Cool Water
Dog	Dolores Lake	Unknown
Dog	Drift Lake	Unknown
Dog	Dufault Lake	Unknown
Dog	East Divide Lake	Cold Water
Dog	East Dog Lake	Cool Water
Dog	Eayrs Lake	Cool Water
Dog	Echo Lake	Cold Water
Dog	Egg Lake	Unknown

Dog	Eleph Lake	Unknown
Dog	Elgin Lake	Cold Water
Dog	Empey Lake	Unknown
Dog	Errey Lake	Unknown
Dog	Escape Lake	Cool Water
Dog	Fall Lake	Unknown
Dog	Far Lake	Unknown
Dog	Fenson Lake	Unknown
Dog	Fire Lake	Unknown
Dog	Firefly Lake	Unknown
Dog	Fitzpatrick Lake	Cool Water
Dog	Fiveash Lake	Unknown
Dog	Float Lake	Cold Water
Dog	Florence Lake	Unknown
Dog	Flossie Lake	Unknown
Dog	Flower Lake	Unknown
Dog	Fodder Lake	Unknown
Dog	Fork Lake	Cold Water
Dog	Fraser Lake	Unknown
Dog	Freed Lake	Unknown
Dog	Gall Lake	Unknown
Dog	Gandier Lake	Unknown
Dog	Gilby Lake	Unknown
Dog	Gilt Lake	Unknown
Dog	Glen Lake	Unknown
Dog	Gold Lake	Cool Water
Dog	Golding Lake	Cold Water
Dog	Goodman Lake	Unknown
Dog	Graham Lake	Unknown
Dog	Grassy Narrows Lake	Unknown
Dog	Greenhue Lake	Unknown
Dog	Greenpike Lake	Cool Water
Dog	Greenwater Lake	Cold Water
Dog	Gunderson Lake	Unknown
Dog	Gutteridge Lake	Cool Water
Dog	Hackl Lake	Unknown
Dog	Hadwen Lake	Unknown
Dog	Halfway Lake	Unknown
Dog	Ham Lake	Unknown
Dog	Hardwicke Lake	Cool Water
Dog	Harju's Lake	Unknown
Dog	Harnden Lake	Unknown
Dog	Hasson Lake	Unknown
Dog	Hawkeye Lake	Cold Water
Dog	Hawkshaw Lake	Unknown
Dog	Hazelwood Lake	Cool Water

Dog	Hettrick Lake	Unknown
Dog	Hicks Lake	Cool Water
Dog	High Lake	Unknown
Dog	Highcliff Lake	Cold Water
Dog	Hitch Lake	Unknown
Dog	Holstrom Lake	Unknown
Dog	Home Lake	Cold Water
Dog	Hoof Lake	Unknown
Dog	Hornet Lake	Unknown
Dog	Horseshoe Lake	Unknown
Dog	Horseshoe Lake	Unknown
Dog	Howcum Lake	Unknown
Dog	Hunkin Lake	Unknown
Dog	Huronian Lake	Cold Water
Dog	Island Lake	Cool Water
Dog	Jack Lake	Unknown
Dog	Jackfish Lake	Unknown
Dog	Jig Lake	Cool Water
Dog	Jordain Lake	Unknown
Dog	Kabaigon Lake	Unknown
Dog	Kashabowie Lake	Cold Water
Dog	Kawene Lake	Cool Water
Dog	Keego Lake	Unknown
Dog	Kegmus Lake	Cool Water
Dog	Kekekuab Lake	Cool Water
Dog	Keni Lake	Unknown
Dog	Kerfoot Lake	Unknown
Dog	Kingfisher Lake	Cool Water
Dog	Knocker Lake	Unknown
Dog	Lac des Iles	Cold Water
Dog	Lackie Lake	Unknown
Dog	Lasseter Lake	Unknown
Dog	Lassie Lake	Cool Water
Dog	Length Lake	Unknown
Dog	Lily Lake	Unknown
Dog	Little Amethyst Lake	Unknown
Dog	Little Athelstane Lake	Cold Water
Dog	Little Dog Lake	Cool Water
Dog	Little Greenwater Lake	Unknown
Dog	Little Hawkeye Lake	Cold Water
Dog	Little Kabaigon Lake	Unknown
Dog	Little Max Lake	Unknown
Dog	Livermore Lake	Unknown
Dog	Lob Lake	Unknown
Dog	Loch Erne	Cold Water
Dog	Loch Macdougall	Cool Water

Dog	Loch McLean	Cold Water
Dog	Loch Muich	Cold Water
Dog	Loch Smith	Cold Water
Dog	Lone Island Lake	Unknown
Dog	Long Lake	Unknown
Dog	Lottit Lake	Unknown
Dog	Lower Kaogomok Lake	Unknown
Dog	Lower Sabrina Lake	Unknown
Dog	Lower Shebandowan Lake	Cold Water
Dog	Macauley Lake	Cool Water
Dog	MacCormack Lake	Unknown
Dog	Makins Lake	Unknown
Dog	Marble Lake	Unknown
Dog	Maria Lake	Unknown
Dog	Marks Lake	Cold Water
Dog	Mary Lake	Cool Water
Dog	Mason Lake	Unknown
Dog	Mathe Lake	Unknown
Dog	McCrimmon Lake	Unknown
Dog	McGrath Lake	Cool Water
Dog	McLeish Lake	Cool Water
Dog	McNall Lake	Unknown
Dog	Middle Shebandowan Lake	Cold Water
Dog	Minnow Lake	Unknown
Dog	Mirage Lake	Unknown
Dog	Missing Lake	Unknown
Dog	Mittay Lake	Unknown
Dog	Modo Lake	Unknown
Dog	Mokomon Lake	Unknown
Dog	Monday Lake	Cool Water
Dog	Mud Lake	Unknown
Dog	Mug Lake	Unknown
Dog	Muise Lake	Unknown
Dog	Murphy Lake	Unknown
Dog	Muskeg Lake	Unknown
Dog	Nancy's Lake	Unknown
Dog	No Name Lake	Unknown
Dog	Odette Lake	Cool Water
Dog	Oliver Lake	Cold Water
Dog	One Island Lake	Cool Water
Dog	Onion Lake	Cool Water
Dog	Orbit Lake	Unknown
Dog	Orth Lake	Unknown
Dog	Otto Lake	Unknown
Dog	Paul Lake	Unknown
Dog	Peewatai Lake	Unknown

Dog	Pencil Lake	Unknown
Dog	Peridotite Lake	Cold Water
Dog	Pete Lake	Cold Water
Dog	Pete's Pond	Unknown
Dog	Phair Lake	Unknown
Dog	Pictured Lake	Unknown
Dog	Pistol Lake	Unknown
Dog	Postans Lake	Unknown
Dog	Prain Lake	Unknown
Dog	Prophet Lake	Unknown
Dog	Quilp Lake	Unknown
Dog	Ray Lake	Cool Water
Dog	Rescue Lake	Unknown
Dog	Retto Lake	Cold Water
Dog	Ricestalk Lake	Unknown
Dog	Rockstone Lake	Cold Water
Dog	Rolling Lake	Unknown
Dog	Rosvall Lake	Unknown
Dog	Roundrock Lake	Unknown
Dog	Rousseau Lake	Cool Water
Dog	Rudge Lake	Cold Water
Dog	Ruston Lake	Unknown
Dog	Ruthann Lake	Unknown
Dog	Sallows Lake	Unknown
Dog	Senga Lake	Unknown
Dog	Shabb Lake	Cool Water
Dog	Shafton Lake	Unknown
Dog	Shallownest Lake	Cool Water
Dog	Sharp Lake	Unknown
Dog	Shelby Lake	Unknown
Dog	Shorty Lake	Unknown
Dog	Sitches Lake	Cold Water
Dog	Skimpole Lake	Unknown
Dog	Skram Lake	Unknown
Dog	Skrum Lake	Unknown
Dog	Skut Lake	Unknown
Dog	Span Lake	Unknown
Dog	Spereman Lake	Unknown
Dog	Spike lake	Cold Water
Dog	Spirit Lake	Cool Water
Dog	Spoon Lake	Unknown
Dog	Squires Lake	Unknown
Dog	Star Lake	Unknown
Dog	Stennett Lake	Unknown
Dog	Stephens Lake	Cold Water
Dog	Stern Lake	Unknown

Dog	Stetham Lake	Cold Water
Dog	Stonefish Lake	Unknown
Dog	Sun Lake	Unknown
Dog	Sunday Lake	Unknown
Dog	Surprise Lake	Cool Water
Dog	Swallow Lake	Cool Water
Dog	Swamp Lake	Unknown
Dog	Swarbrick Lake	Cool Water
Dog	Tackle Lake	Unknown
Dog	Taman Lake	Unknown
Dog	Tapio Lake	Unknown
Dog	Teardrop Lake	Unknown
Dog	Tetlock Lake	Unknown
Dog	Thunder Lake	Cold Water
Dog	Tib Lake	Unknown
Dog	Timmus Lake	Cool Water
Dog	Tinto Lake	Cold Water
Dog	Ton Lake	Cool Water
Dog	Toole Lake	Unknown
Dog	Topaz Lake	Cool Water
Dog	Tornroos Lake	Unknown
Dog	Toulouse Lake	Unknown
Dog	Tower Lake	Unknown
Dog	Towle Lake	Unknown
Dog	Town Lake	Unknown
Dog	Tribble Lake	Unknown
Dog	Trout Lake	Cold Water
Dog	Trumper Lake	Unknown
Dog	Tuesday Lake	Unknown
Dog	Turn Lake	Cold Water
Dog	Twin Birch Lake	Cold Water
Dog	Twist Lake	Unknown
Dog	Two Island Lake	Cool Water
Dog	Two Mile Lake	Unknown
Dog	Upper Kaogomok Lake	Unknown
Dog	Upper Ricestalk Lake	Unknown
Dog	Upper Sabrina Lake	Unknown
Dog	Vande Lake	Unknown
Dog	Varris Lake	Unknown
Dog	Vester Lake	Unknown
Dog	Vivian Lake	Unknown
Dog	Voutilainen Lake	Unknown
Dog	Wakinoo Lake	Unknown
Dog	Waller Lake	Cold Water
Dog	Walnut Lake	Unknown
Dog	Warnica Lake	Cool Water

Dog	Wartman Lake	Cool Water
Dog	Wasp Lake	Unknown
Dog	Wearn Lake	Unknown
Dog	Whalen Lake	Unknown
Dog	White Pine Lake	Unknown
Dog	Whitefin Lake	Cool Water
Dog	Whitefish Lake	Unknown
Dog	Whitelily Lake	Cool Water
Dog	Wishart Lake	Unknown
Dog	Yoho Lake	Unknown
Dog	Yorky Lake	Cool Water
Dog	Young Lake	Unknown
Dog	Zero Lake	Unknown

Appendix IV - List of Named Rivers and Streams within the Lakehead Source Protection Area

Tertiary Watershed	Tributary Name	Thermal Property
Arrow	Cloud River	Cold water
Arrow	Crystal Creek	Unknown
Arrow	Jarvis River	Cold Water
Arrow	Little Pine River	Unknown
Arrow	Little Whitefish River	Cold Water
Arrow	Lomond River	Cold Water
Arrow	McQuaig Creek	Unknown
Arrow	Pine River	Cold Water
Arrow	Sawdust Creek	Unknown
Arrow	Sunset Creek	Cold Water
Arrow	Whiskyjack Creek	Unknown
Black Sturgeon	Abigogami Creek	Unknown
Black Sturgeon	Anderson Creek	Unknown
Black Sturgeon	Beaverhide Creek	Unknown
Black Sturgeon	Beck Creek	Unknown
Black Sturgeon	Blende River	Unknown
Black Sturgeon	Blind Creek	Unknown
Black Sturgeon	Boulter's Creek	Unknown
Black Sturgeon	Cavern Creek	Unknown
Black Sturgeon	Cold Creek	Unknown
Black Sturgeon	Coldwater Creek	Unknown
Black Sturgeon	D'arcy Creek	Unknown
Black Sturgeon	Furcate Creek	Cold Water
Black Sturgeon	Green Bay Creek	Unknown
Black Sturgeon	Greenwich Creek	Cold Water
Black Sturgeon	Gulch Creek	Cold Water
Black Sturgeon	Henderson Creek	Unknown
Black Sturgeon	Hicky Creek	Unknown
Black Sturgeon	Hilma Creek	Unknown
Black Sturgeon	Himdick Creek	Unknown
Black Sturgeon	Ishkibbible Creek	Unknown
Black Sturgeon	Joe Creek	Unknown
Black Sturgeon	MacIntosh Creek	Unknown
Black Sturgeon	MacKenzie Creek	Cold Water
Black Sturgeon	MacKenzie River	Cold Water
Black Sturgeon	McGaw Creek	Unknown
Black Sturgeon	Moraine Creek	Unknown
Black Sturgeon	Nivilus Creek	Unknown
Black Sturgeon	Northstar Creek	Unknown
Black Sturgeon	Pearl River	Cold Water

Black Sturgeon	Pickerel Creek	Unknown
Black Sturgeon	Portage Creek	Unknown
Black Sturgeon	Sawbill Creek	Unknown
Black Sturgeon	Sibley Creek	Unknown
Black Sturgeon	Spring Creek	Unknown
Black Sturgeon	Springlet Creek	Unknown
Black Sturgeon	Swan Creek	Unknown
Black Sturgeon	Tastan Creek	Unknown
Black Sturgeon	Unknown Creek	Unknown
Black Sturgeon	Walkinshaw Creek	Cold Water
Black Sturgeon	Welch Creek	Unknown
Black Sturgeon	Wildgoose Creek	Cold Water
Black Sturgeon	Wolf River	Unknown
Black Sturgeon	Wolfpup Creek	Unknown
Dog	Aberdeen Creek	Unknown
Dog	Athelstane Creek	Unknown
Dog	Barnum Creek	Unknown
Dog	Batwing Creek	Unknown
Dog	Beaver Creek	Unknown
Dog	Bentley Creek	Unknown
Dog	Block Creek	Unknown
Dog	Bloxham Creek	Unknown
Dog	Brule Creek	Cold Water
Dog	Buck Creek	Unknown
Dog	Carson Creek	Unknown
Dog	Cedar Creek	Cold Water
Dog	Corbett Creek	Cold Water
Dog	Crayfish Creek	Unknown
Dog	Crock Creek	Unknown
Dog	Current River	Cold Water
Dog	Depot Creek	Unknown
Dog	Dolores Creek	Unknown
Dog	Drift Creek	Unknown
Dog	East Dog River	Unknown
Dog	East Oskondaga River	Cold Water
Dog	Eayrs Creek	Unknown
Dog	Escape Creek	Cold Water
Dog	Ferguson Creek	Cold Water
Dog	Firefly Creek	Unknown
Dog	Gall Creek	Unknown
Dog	Gold Creek	Unknown

Dog	Greenwater Creek	Unknown
Dog	Gutteridge Creek	Unknown
Dog	Hawkeye Creek	Unknown
Dog	Hoof Creek	Unknown
Dog	Jack Creek	Unknown
Dog	Jig Creek	Unknown
Dog	Jordain Creek	Unknown
Dog	Kekek Creek	Unknown
Dog	McIntyre River	Cold Water
Dog	McVicar Creek	Cold Water
Dog	Mirage Creek	Unknown
Dog	Mosquito Creek	Warm Water
Dog	Muise Creek	Unknown
Dog	Muskeg Creek	Unknown
Dog	Neebing River	Unknown
Dog	Newton Creek	Unknown
Dog	North Current River	Cold Water
Dog	North River	Cold Water
Dog	Oliver Creek	Cold Water
Dog	Orchid Creek	Unknown
Dog	Oskondaga River	Cold Water
Dog	Otter Creek	Unknown
Dog	Penassen Creek	Unknown
Dog	Pennock Creek	Unknown
Dog	Pinecone Creek	Unknown
Dog	Pitch Creek	Cold Water
Dog	Riviere des Iles	Unknown
Dog	Sabrina Creek	Unknown
Dog	Sabrina Creek	Unknown
Dog	Sackville Creek	Unknown
Dog	Savigny Creek	Unknown
Dog	Senga Creek	Unknown
Dog	Serpent Creek	Cold Water
Dog	Shackers Creek	Unknown
Dog	Sharp Creek	Unknown
Dog	Shebandowan River	Unknown
Dog	Shelby Creek	Unknown
Dog	Silver Creek	Cold Water
Dog	Silver Falls Creek	Unknown
Dog	Sitch Creek	Unknown
Dog	Slate River	Cold Water

Dog	South Cedar Creek	Cold Water
Dog	Spereman Creek	Unknown
Dog	Strawberry Creek	Unknown
Dog	Sunday Creek	Unknown
Dog	Sunshine Creek	Unknown
Dog	Swamp River	Unknown
Dog	Swamp River	Unknown
Dog	Tinpail Creek	Unknown
Dog	Ton Creek	Unknown
Dog	Topaz Creek	Unknown
Dog	Trumper Creek	Unknown
Dog	Twin Birch Creek	Unknown
Dog	Wakinoo Creek	Unknown
Dog	Wasp Creek	Unknown
Dog	Whitefin Creek	Unknown
Dog	Whitefish River	Cold Water
Dog	Whitewood Creek	Cold Water
Dog	Wiegant River	Unknown
Dog	Yoho Creek	Unknown
Dog	Young Creek	Unknown

Appendix V – Ontario Ministry of Environment Certificates of Approval for Smurfit-Stone

CONTENT COPY OF ORIGINAL

Ministry of the Environment | Ministère de l'Environnement

Ontario

CERTIFICATE OF APPROVAL
INDUSTRIAL SEWAGE WORKS
NUMBER 4452-699SRC

Smurfit-Stone Container Canada Inc.
630 Rene- Levesque Blvd. West, Suite 3000
Montreal, Quebec
H3B 5C7

Site Location: Thunder Bay Mill
965 Strathcona Avenue
City of Thunder Bay, District of Thunder Bay
P7A 8A8

You have applied in accordance with Section 53 of the Ontario Water Resources Act for approval of:

establishment of a stormwater management facility to service a 13.7 ha drainage area of the existing landfill site located at the Thunder Bay Mill, City of Thunder Bay, designed to handle stormwater runoff generated during storm events with 1:100 year return frequency maintaining the maximum flow velocity below 1.01 m^3/sec, consisting of the following:

- one (1) drainage ditch approximately 590 m long, 2.0 m wide at the north end linearly increasing to 6.0 m wide at the south end, and with a constant depth of 0.3 m throughout its length, discharging through culverts described below;
- two (2) 750 mm diameter culverts crossing the landfill site access road, discharging into an existing wetland and eventually to Lake Superior; and
- including all controls and associated appurtenances.

all in accordance with the Application for Approval of Industrial Sewage Works submitted by Smurfit-Stone Container Canada Inc. dated October 21, 2004, drawings and design specifications prepared by UMA Engineering Ltd., Thunder Bay, Ontario, and the following documents:

1. Letter from Doug Steele, UMA Engineering Ltd, to the attention of Stefanos Habtom, MOE, dated February 28, 2005 providing additional information regarding the design of the proposed drainage ditch and Drawing No. 00-H-0002 - Stormwater Discharge Catchment Area and Ditch Cross Section.

For the purpose of this Certificate of Approval and the terms and conditions specified below, the following definitions apply:

"*Certificate*" means this entire certificate of approval document, issued in accordance with Section 53 of the *Ontario Water Resources Act*, and includes any schedules;

"*Director*" means any Ministry employee appointed by the Minister pursuant to section 5 of the *Ontario Water Resources Act*;

"*District Manager*" means the District Manager of the Thunder Bay District Office of the Ministry;

"*Ministry*" means the Ontario Ministry of the Environment;

"*Owner*" means Smurfit-Stone Container Canada Inc. and includes its successors and assignees; and

"*Works*" means the sewage works described in the Owner's application, this certificate and in the supporting documentation referred to herein, to the extent approved by this certificate.

You are hereby notified that this approval is issued to you subject to the terms and conditions outlined below:

CONTENT COPY OF ORIGINAL

TERMS AND CONDITIONS

1. GENERAL CONDITION

(1) Except as otherwise provided by these conditions, the *Owner* shall design, build, install, operate and maintain the works in accordance with the description given in this *Certificate*, the application for approval of the works and the submitted supporting documents and plans and specifications as listed in this *Certificate*.

(2) Where there is a conflict between a provision of any submitted document referred to in this *Certificate* and the conditions of this *Certificate*, the conditions in this *Certificate* shall take precedence, and where there is a conflict between the listed submitted documents, the document bearing the most recent date shall prevail.

2. EXPIRY OF APPROVAL

The approval issued by this *Certificate* will cease to apply to those parts of the *Works* which have not been constructed within five (5) years of the date of this *Certificate*.

3. CHANGE OF OWNER

(1) The *Owner* shall notify the *District Manager* and the *Director*, in writing, of any of the following changes within 30 days of the change occurring:

(a) change of *Owner*;
(b) change of address of the *Owner*;
(c) change of partners where the *Owner* is or at any time becomes a partnership, and a copy of the most recent declaration filed under the Business Names Act, R.S.O. 1990, c. B17 shall be included in the notification to the *District Manager*;
(d) change of name of the corporation where the *Owner* is or at any time becomes a corporation, and a copy of the most current information filed under the Corporations Information Act, R.S.O. 1990, c. C39 shall be included in the notification to the *District Manager*;

(2) In the event of any change in ownership of the *Works*, other than a change to a successor municipality, the *Owner* shall notify in writing the succeeding owner of the existence of this *Certificate*, and a copy of such notice shall be forwarded to the *District Manager* and the *Director*.

4. STORMWATER MONITORING AND RECORDING

The *Owner* shall, upon commencement of operation of the *Works*, carry out the following monitoring program:

(1) All samples and measurements taken for the purposes of this *Certificate* are to be taken at a time and in a location characteristic of the quality and quantity of the stormwater runoff being monitored.

(2) Grab samples shall be collected immediately after a rainfall event at the following sampling point during **Spring, Summer,** and **Fall**, and analyzed for each parameter listed and all results recorded:

Table 1 - Stormwater Monitoring Sampling Point: North Side of Culverts)		
Inorganics		**Field Parameters**
Alkalinity	Lead	pH
Ammonia	Mercury	Conductivity
Arsenic	Nitrate	Temperature
Barium	Nitrite	Dissolved Oxygen
Boron	Total Kjeldahl Nitrogen	
Cadmium	pH	**Other Organics**
Chloride	Total Phosphorus	Biochemical Oxygen Demand (BOD5)
Chromium	Total Suspended Solids	Chemical Oxygen Demand (COD)
Conductivity	Total Dissolved Solids	Phenol
Copper	Sulphate	
Iron	Zinc	

(3) The methods and protocols for sampling, analysis and recording shall conform, in order of precedence, to the methods and protocols specified in the following:

(a) the Ministry's Procedure F-10-1, "Procedures for Sampling and Analysis Requirements for Municipal and Private Sewage Treatment Works (Liquid Waste Streams Only), as amended from time to time by more recently published editions;

(b) the Ministry's publication "Protocol for the Sampling and Analysis of Industrial/Municipal Wastewater" (January 1999), ISBN 0-7778-1880-9, as amended from time to time by more recently published editions;

(c) the publication "Standard Methods for the Examination of Water and Wastewater" (20th edition), as amended from time to time by more recently published editions;

(4) The measurement frequencies specified in subsection (2) in respect to any parameter are minimum requirements which may, after one (1) year of monitoring in accordance with this Condition, be modified by the *District Manager* in writing from time to time.

(5) The *Owner* shall retain for a minimum of three (3) years from the date of their creation, all records and information related to or resulting from the monitoring activities required by this *Certificate.*

5. OPERATION AND MAINTENANCE

(1) The Owner shall undertake an inspection of the condition of the stormwater management ditches, at least once a year, and undertake any necessary cleaning and maintenance to prevent the excessive buildup of sediment and/or decaying vegetation.

(2) The owner shall maintain a logbook to record the results of these inspections and any cleaning and maintenance operations undertaken and shall keep the logbook at the site for inspection by the Ministry.

6. REPORTING

(1) The *Owner* shall prepare, and submit upon request to the *District Manager,* a performance report, on an annual basis, within ninety (90) days following the end of the period being reported upon. The annual report can be prepared as part of the annual report required under the Provisional Certificate of Approval - Waste Disposal Site. The first such report shall cover the first annual period following the commencement of operation of the *Works* and subsequent reports shall be submitted to cover successive annual periods following thereafter. The reports shall contain, but shall not be limited to, the following information:

(a) a summary and interpretation of all monitoring data and a comparison to the Provincial Water Quality Objectives (PWQO) including an overview of the success and adequacy of the *Works*;

(b) a description of any operating problems encountered and corrective actions taken;

(c) a summary of any effluent quality assurance or control measures undertaken in the reporting period;

The reasons for the imposition of these terms and conditions are as follows:

1. Condition 1 is imposed to ensure that the *Works* are built and operated in the manner in which they were described for review and upon which approval was granted. This condition is also included to emphasize the precedence of Conditions in the *Certificate* and the practice that the Approval is based on the most current document, if several conflicting documents are submitted for review.

2. Condition 2 is included to ensure that, when the *Works* are constructed, the *Works* will meet the standards that apply at the time of construction to ensure the ongoing protection of the environment.

3. Condition 3 is included to ensure that the *Ministry* records are kept accurate and current with respect to the approved works and to ensure that subsequent owners of the *Works* are made aware of the *Certificate* and continue to operate the *Works* in compliance with it.

4. Condition 4 is included to enable the *Owner* to evaluate and demonstrate the performance of the *Works*, on a continual basis, so that the *Works* are properly operated and maintained at a level which is consistent with the design objectives specified in the *Certificate* and that the *Works* does not cause any impairment to the receiving watercourse.

5. Condition 5 is included to ensure that any buildup of sediment and/or decaying vegetation does not impair the performance of the stormwater management facility.

6. Condition 6 is included to provide a performance record for future references, to ensure that the *Ministry* is made aware of problems as they arise, and to provide a compliance record for all the terms and conditions outlined in this *Certificate*, so that the *Ministry* can work with the *Owner* in resolving any problems in a timely manner.

In accordance with Section 100 of the Ontario Water Resources Act, R.S.O. 1990, Chapter 0.40, as amended, you may by written notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this Notice, require a hearing by the Tribunal. Section 101 of the Ontario Water Resources Act, R.S.O. 1990, Chapter 0.40, provides that the Notice requiring the hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the works are located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

CONTENT COPY OF ORIGINAL

The Secretary*
Environmental Review Tribunal
2300 Yonge St., 12th Floor
P.O. Box 2382
Toronto, Ontario
M4P 1E4

AND

The Director
Section 53, *Ontario Water Resources Act*
Ministry of the Environment
2 St. Clair Avenue West, Floor 12A
Toronto, Ontario
M4V 1L5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

The above noted sewage works are approved under Section 53 of the Ontario Water Resources Act.

DATED AT TORONTO this 29th day of March, 2005

Mohamed Dhalla, P.Eng.
Director
Section 53, *Ontario Water Resources Act*

SH/
c: District Manager, MOE Thunder Bay - District
Doug W. Steele, UMA Engineering Ltd.

CONTENT COPY OF ORIGINAL

Ministry of the Environment | Ministère de l'Environnement

Ontario

AMENDED CERTIFICATE OF APPROVAL
INDUSTRIAL SEWAGE WORKS
NUMBER 5333-6TZG2N
Issue Date: October 4, 2006

Smurfit-Stone Container Canada Inc.
630 Rene- Levesque Blvd. West, Suite 3000
Montreal, Quebec
H3B 5C7

Site Location: Thunder Bay Mill
965 Strathcona Avenue
Thunder Bay City, District Of Thunder Bay
P7A 8A8

You have applied in accordance with Section 53 of the Ontario Water Resources Act for approval of:

the establishment of stormwater diversion piping extending from the existing storm sewer system upstream of the primary lagoons to the boat slip;

all in accordance with the following submitted supporting documents:

1. Application for Approval of Industrial Sewage Works submitted by Ken Traynor of Smurfit-Stone Container Canada Inc. dated May 18, 2006;

2. Letter and attachments dated May 18, 2006 from Ken Traynor of Smurfit-Stone Container Canada Inc. to Director, Environmental Assessment and Approval Branch, Ministry of the Environment;

3. Letter and attachments dated November 25, 2005 from Doug Steele of UMA Engineering Ltd. to Wim Smits of the Ministry of the Environment;

For the purpose of this Certificate of Approval and the terms and conditions specified below, the following definitions apply:

"Certificate" means this entire certificate of approval document, issued in accordance with Section 53 of the *Ontario Water Resources Act*, and includes any schedules;

"Director" means any Ministry employee appointed by the Minister pursuant to section 5 of the *Ontario Water Resources Act*;

"District Manager" means the District Manager of the Thunder Bay District Office of the Ministry;

"Ministry" means the Ontario Ministry of the Environment;

"Owner" means Smurfit-Stone Container Canada Inc. and includes its successors and assignees; and

"works" means the sewage works described in the Owner's application, this certificate and in the supporting documentation referred to herein, to the extent approved by this certificate.

You are hereby notified that this approval is issued to you subject to the terms and conditions outlined below:

TERMS AND CONDITIONS

1. GENERAL CONDITION

(1) Except as otherwise provided by these Conditions, the Owner shall design, build, install, operate and maintain the

works in accordance with the description given in this Certificate, the application for approval of the works and the submitted supporting documents and plans and specifications as listed in this Certificate.

(2) Where there is a conflict between a provision of any submitted document referred to in this Certificate and the Conditions of this Certificate, the Conditions in this Certificate shall take precedence, and where there is a conflict between the listed submitted documents, the document bearing the most recent date shall prevail.

2. CHANGE OF OWNER

(1) The Owner shall notify the District Manager and the Director, in writing, of any of the following changes within 30 days of the change occurring:

(a) change of Owner or operating authority, or both;

(b) change of address of Owner or operating authority or address of new owner or operating authority;

(c) change of partners where the Owner or operating authority is or at any time becomes a partnership, and a copy of the most recent declaration filed under the *Partnerships Registration Act*;

(d) change of name of the corporation where the Owner or operator is or at any time becomes a corporation, and a copy of the most current "Initial Notice or Notice of Change" (Form 1, 2 or 3 of O. Reg. 189, R.R.O. 1980, as amended from time to time), filed under the *Corporations Information Act* shall be included in the notification to the District Manager;

(2) In the event of any change in ownership of the works, the Owner shall notify in writing the succeeding owner of the existence of this certificate, and a copy of such notice shall be forwarded to the District Manager.

(3) The Owner shall ensure that all communications made pursuant to this condition will refer to this certificate's number.

3. DECOMMISSIONING OF TREATMENT WORKS

The Owner shall proceed with the Decommissioning Plan outlined in the letter and attachments dated May 18, 2006 from Ken Traynor of Smurfit-Stone Container Canada Inc. to Director, Environmental Assessment and Approval Branch, Ministry of the Environment and as directed by the District Manager.

4. RESUMPTION OF INDUSTRIAL ACTIVITIES

The Owner shall, within three (3) months before any resumption of industrial activities on the site, including but not limited to the storage of materials or fuels, notify the District Manager in writing. This notification shall include a plan which identifies potential risks to runoff quality and outlines mitigation and/or treatment measures to be implemented.

The reasons for the imposition of these terms and conditions are as follows:

1. Condition 1 is imposed to ensure that the works are built and operated in the manner in which they were described for review and upon which approval was granted. This condition is also included to emphasize the precedence of Conditions in the Certificate and the practice that the Approval is based on the most current document, if several conflicting documents are submitted for review.

2. Condition 2 is included to ensure that the Ministry records are kept accurate and current with respect to approved works and to ensure that subsequent owners of the works are made aware of the certificate and continue to operate the works in compliance with it.

3. Condition 3 is included to ensure that the previously approved treatment works are decommissioned in a manner to minimize impact on the environment.

4. Condition 4 is included to ensure that appropriate measures are in place to minimize impact on the environment, in the event of any resumption of industrial activities on the site.

CONTENT COPY OF ORIGINAL

This Certificate of Approval revokes and replaces Certificate(s) of Approval No. 4-0021-95-987 issued on February 12, 1998, as amended by Notices dated February 23, 1999, May 24, 2000 and July 13, 2001.

In accordance with Section 100 of the Ontario Water Resources Act, R.S.O. 1990, Chapter 0.40, as amended, you may by written notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this Notice, require a hearing by the Tribunal. Section 101 of the Ontario Water Resources Act, R.S.O. 1990, Chapter 0.40, provides that the Notice requiring the hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the works are located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary*	AND	The Director
Environmental Review Tribunal		Section 53, *Ontario Water Resources Act*
2300 Yonge St., Suite 1700		Ministry of the Environment
P.O. Box 2382		2 St. Clair Avenue West, Floor 12A
Toronto, Ontario		Toronto, Ontario
M4P 1E4		M4V 1L5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

The above noted sewage works are approved under Section 53 of the Ontario Water Resources Act.

DATED AT TORONTO this 4th day of October, 2006

Mohamed Dhalla, P.Eng.
Director
Section 53, *Ontario Water Resources Act*

RC/
c: District Manager, MOE Thunder Bay - District
Ken Traynor, Smurfit-Stone Container Canada Inc.

CONTENT COPY OF ORIGINAL

Ministry of the Environment | Ministère de l'Environnement

Ontario

AMENDMENT TO PROVISIONAL CERTIFICATE OF APPROVAL
WASTE DISPOSAL SITE
NUMBER A590137
Notice No. 2

Smurfit-Stone Container Canada Inc.
630 Rene- Levesque Blvd. West, Suite 3000
Montreal, Quebec
H3B 5C7

Site Location: Thunder Bay Mill
965 Strathcona Avenue
Thunder Bay City, District Of Thunder Bay
P7A 8A8

You are hereby notified that I have amended Provisional Certificate of Approval No. A590137 issued on July 23, 1996 and all amendments thereafter for the use and operation of a 11.2 hectare landfill site within a total area of 31.3 hectares having a maximum capacity of 728,000 cubic meters, as follows:

I. Definitions

The following definition is hereby amended:

g) "Owner" or "Proponent" means Smurfit-Stone Container Canada Inc.

The following definition(s) are hereby added:

i) "LCS" means the leachate collection system.

The following conditions are hereby added:

The following items are hereby added to Condition 14:

14. j.) A discussion on the operation of the LCS. The discussion shall include but not be limited to the following:

i. the quantity of leachate (in litres) pumped from the LCS to the City of Thunder Bay sanitary sewer system;
ii. a discussion on maintenance, inspection, non-operation time (ie. downtime); and
iii. City of Thunder Bay Sewer Use By-law compliance.

k.) Stratigraphic cross-sections which clearly illustrate the subsurface distribution of geological materials;

m.) The report shall include the calculation of major ion balances for the groundwater sample analytical results. The % difference between the sums (expressed as milliequivalents per litre) of major cations and major anions shall be calculated. The % difference is defined as:

3 cation - 3 anion
% difference = 100 x ______
3 cation + 3 anion

If the analytical result of a ground water sample has an anion-cation balance % difference of greater than ±10%, the Owner must take action to determine the cause of the imbalance, and ensure that it is addressed in future groundwater sampling and analyses;

n.) a copy of the borehole logs for the site shall be provided

II. General

18. Waste shall no longer be permitted to be landfilled at the site unless the owner receives written permission from the District Manager that waste generated from the site that are permitted to be landfilled under this Certificate can be landfilled. The owner in the request must provide the amount and type of waste to be landfilled. Upon commencement of final cover construction activities, waste shall no longer be permitted to be landfilled at the site.

19. **By September 30, 2005**, the owner shall clearly define the boundaries of the limit of waste by installing permanent markers that can be visible year-round.

III. Leachate Collection System

20. The installation and operation of the extension to the Leachate Collection System shall be completed in accordance with Item 4 through 10 in Schedule "A".

21. Within 90 days of completion of the extension of the leachate collection system, the owner shall submit to the District Manager a construction report detailing the construction activities and any design changes made to the LCS during construction. This report shall include but not be limited to the following topics:

i. drawing of the location of the system;
ii. a description of the various construction stages;
iii. quality assurance/quality control plan for the construction; and
iv. any changes to the design of the system.

22. The owner shall maintain an operations/maintenance log book for the LCS. The log book shall be a dedicated book strictly for the LCS. Items that shall be recorded in the log book shall include but not be limited to maintenance, inspection completed and flow measurements. A copy of the log book shall be kept on-site at all times.

23. The owner shall record on a monthly basis at a minimum the volume of leachate discharge to the City of Thunder Bay's sanitary sewer system from the LCS.

24. By **September 1, 2005**, the owner shall submit to the Director, with copies to the District Manager, an inspection and maintenance plan for the site. The plan shall include details of the type of inspections to be completed and a schedule (ie. daily, monthy, quarterly, yearly) for the completion of these tasks.

IV. Monitoring

25. Groundwater and leachate monitoring shall be undertaken by the Owner in accordance with the groundwater and leachate monitoring program set out in Schedule "C".

26. By **June 30, 2005**, the owner shall submit to the Director for approval, with copies to the District Manager, a surface water monitoring plan for the site. The plan shall include, but shall not be limited to the following:

i. a site plan showing the sampling locations;
ii. analytical parameters;
iii. field measurements (i.e. flow, direction, pH, temperature, conductivity);
iv. sampling protocols; and
v. sampling frequency.

27. Any proposed changes to the report/monitoring program, including the frequency of submission, shall be submitted to the District Manager in writing for approval. Approval by the District Manager is required prior to implementation of these changes.

Schedule "A"

The following items are hereby added:

4. Application for a Provisional Certificate of Approval for a Waste Disposal Site requesting an amendment to include the Final Closure Plan and Extension of the Leachate Collection System. Application was undersigned by Kenneth Traynor, Controller, Smurfit Stone Container Canada dated April 26, 2004.

5. Report and design drawings entitled *"Smurfit Stone Container Canada Inc. - Thunder Bay Landfill Site: 2004 Application for Certificate of Approval"* submitted by UMA on behalf of Smurfit Stone Canada Container Inc. dated April 2004. The report included the following sections:

i. Section 1 - Hydrogeological Assessment;
ii. Section 2 - Leachate Collection System, Design Brief;
iii. Section 3 - Landfill Closure Plan;
iv. Section 4 - Environmental Monitoring Plan; and
v. Section 5 - Leachate Contingency Plan.

6. Letter dated July 5, 2004 to Mr. Ken Traynor, Controller, Smurfit-Stone Container Canada Inc. from Mr. Dale Gable, Ministry of the Environment requesting additional information on the final closure plan and extension to leachate collection system.

7. Letter dated August 31, 2004 to Mr. Dale Gable, Senior Review Engineer, Waste Unit, Ministry of the Environment from Mr. Ken Traynor, Controller, Smurfit-Stone Container Canada Inc. providing information to additional information request pertaining to final closure and leachate collection system.

8. Memorandum dated August 17, 2004 to Mr. Wim Smits, Senior Environmental Officer, Ministry of the Environment from Mr. Jim Sutton, Surface Water Specialist, Ministry of the Environment regarding surface water comments pertaining to the amendment application.

9. Memorandum dated June 23, 2004 to Mr. Wim Smits, Senior Environmental Officer, Ministry of the Environment from Mr. Leif Nelson, Regional Hydrogeologist, Ministry of the Environment regarding ground water comments pertaining to the amendment application.

10. Letter and supporting documentation dated October 20, 2004 to the Director, EAAB, Ministry of the Environment submitting for the Section 53, OWRA Approvals for Industrial Sewage Works for the Smurfit-Stone Container Inc. Thunder Bay Landfill Site.

Schedule "C"

This Schedule forms part of the Certificate of Approval No. A590137. It describes the groundwater and leachate monitoring program referred to in Condition 22.

C.1. Groundwater and Leachate

C.1.1 Groundwater and Leachate Monitoring Program Objectives

The overall goal of the groundwater monitoring program is to detect and assess effects of the landfill on local water resources. The following objectives have been identified to achieve this goal:

a) to monitor groundwater quality in the shallow groundwater system and the deeper confined groundwater system;
b) to identify and characterize movement of leachate related contaminants in the systems;
c) to evaluate the effectiveness of the leachate collection system and attenuation zone; and
d) to determine the need for implementation of contingency plans.

C.1.2 Monitoring Plan

The groundwater and leachate monitoring plan shall be carried out by the Owner to address the stated objectives and will include:

C.1.2.1 Landfill Monitoring Frequency

The groundwater and leachate monitoring program shall be conducted three times per year during the spring, summer and fall.

C.1.2.2 Groundwater Monitor Sampling Locations

Table C1 identifies the groundwater and leachate monitors sampling locations. If a monitoring well is dry or damaged then that well does not have to be sampled that sampling event. Static water levels shall be collected in all the groundwater and leachate monitors prior to purging and sampling:

Table C1 -Sampling Locations

Well C	MW02-03	MW05-02
MW02-05	MW02-02	MW05-03
Well M6	Well 91A	MW02-01
MW02-04	MW05-01	Well M2
Well 91B	LCS Discharge	

The leachate sample from the LCS shall be collected from the sample port located within the LCS pumphouse.

C.1.2.3 Analytical Parameters

The parameters which shall be measured in the field, along with the chemical and physical laboratory analyses which shall be collected on the groundwater samples from the groundwater and leachate monitors, shall include the following:

Table C-2 Analytical Parameters

pH (field)	Magnesium	Aluminum
pH (lab)	Potassium	Boron
Temperature(field)	Sodium	Cadmium
Colour	Benzene	Chromium
Turbidity	1,4 Dichlorobenzene	Cobalt
Conductivity (field)	Dichlorobenzene	Copper
Conductivity (lab)	Toluene	Iron
Total Alkalinity (as CaCO3)	Vinyl Chloride	Lead
Total Dissolved Solids	Dissolved Organic Carbon	Manganese
Total Suspended Solids	Biological Oxygen Demand	Nickel
Hardness	Chemical Oxygen Demand	Vanadium
Chloride	Ammonia	Zinc
Sulphate	Phosphorus (Total)	VOC(1)
Nitrate	Total Kjeldhl Nitrogen	
Nitrite	Tannins and Lignins	
Calcium	Phenols	

Notes: (1) - VOC to be sampled in the fall at MW02-01, Well M2 and at MW05-01 only. The Owner can make a request to the District Manager to have the parameter removed from parameter lists. Only upon receiving written consent from the District Manager shall the parameter be removed from the parameter list.

C.1.2.4 Groundwater and Leachate Monitor Inspections

Any groundwater or leachate monitoring well found to be damaged, not functioning or otherwise improperly maintained, shall within a reasonable time be properly repaired or replaced. The District Manager shall be notified prior to any well being replaced.

C.1.2.5 Groundwater and Leachate Monitoring Protocols

Standard and/or generally accepted groundwater sampling (including well development, sample collection, storage and transport) and analytical protocols shall be adhered to during all groundwater monitoring sessions. Groundwater elevation measurements shall be of the static groundwater elevation within the groundwater monitoring well measured prior to well development.

C.1.2.6 Method Detection Limits

All laboratory analyses on groundwater samples should be performed by an accredited analytical laboratory and the detection limits (MDLs) for the specific analyses should commensurate with the standards established in the current Ontario Drinking Water Standards.

The reason(s) for this amendment to the Certificate of Approval is (are) as follows:

1. Condition 14 is amendment to include a discussion of the leachate collection system in the annual report and include additional discussions as per the District Office Request. This is to ensure the long-term health and safety of the public and the environment.

2. Condition 18 is added to reflect the landfill closing and no longer accepting waste.

3. Condition 19 is added to ensure the limit of waste for the landfill site is clearly identified.

4. Condition 20 is added to ensure the LSC extension is completed as per the design drawings and submissions submitted by UMA Engineering on behalf of Smurfit-Stone Container Inc. and to ensure the long-term health and safety of the environment and the public.

5. Condition 21 are added to ensure the owner submits a report detailing the construction activities and any changes to the District Manager.

6. Condition 22 and 23 are added to ensure the owner maintains records on the operation of the system.

7. Condition 24 is added to ensure that the owner has regularly scheduled inspections and maintenacne completed for the system. This is to ensure the long term health and safety of the environment and the public.

8. Condition 25 is to incorporate the propsoed groundwater monitoring program into the certificate and to ensure the long-term health and safety of the public and the environment.

9. Condition 26 is added to ensure the owner has an established monitoring plan in place a the site and to ensure the long-term health and safety of the public and the environment.

This Notice shall constitute part of the approval issued under Provisional Certificate of Approval No. A590137 dated July 23, 1996

In accordance with Section 139 of the Environmental Protection Act, R.S.O. 1990, Chapter E-19, as amended, you may by written Notice served upon me, the Environmental Review Tribunal and in accordance with Section 47 of the Environmental Bill of Rights, S.O. 1993, Chapter 28, the Environmental Commissioner, within 15 days after receipt of this Notice, require a hearing by the Tribunal. The Environmental Commissioner will place notice of your appeal on the Environmental Registry. Section 142 of the Environmental Protection Act, provides that the Notice requiring the hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the waste disposal site is located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary* Environmental Review Tribunal 2300 Yonge St., 12th Floor P.O. Box 2382 Toronto, Ontario M4P 1E4	AND	The Environmental Commissioner 1075 Bay Street, 6th Floor Suite 605 Toronto, Ontario M5S 2B1	AND	The Director Section 39, *Environmental Protection Act* Ministry of Environment and Energy 2 St. Clair Avenue West, Floor 12A Toronto, Ontario M4V 1L5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

This instrument is subject to Section 38 of the Environmental Bill of Rights, that allows residents of Ontario to seek leave to appeal the decision on this instrument. Residents of Ontario may seek leave to appeal within 15 days from the date this decision is placed on the Environmental Registry. By accessing the Environmental Registry at www.ene.gov.on.ca, you can determine when the leave to appeal period ends.

The above noted waste disposal site is approved under Section 39 of the Environmental Protection Act.

DATED AT TORONTO this 21st day of April, 2005

Ian Parrott, P.Eng.
Director
Section 39, *Environmental Protection Act*

DG/
c: District Manager, MOE Thunder Bay - District
Doug W. Steele, UMA Engineering Ltd.

CONTENT COPY OF ORIGINAL

Ontario

Ministry of the Environment | **Ministère de l'Environnement**

AMENDMENT TO PROVISIONAL CERTIFICATE OF APPROVAL
WASTE DISPOSAL SITE
NUMBER A590137
Notice No. 3

Smurfit-Stone Container Canada Inc.
630 Rene- Levesque Blvd. West, Suite 3000
Montreal, Quebec
H3B 5C7

Site Location: Thunder Bay Mill
965 Strathcona Avenue
Thunder Bay City, District Of Thunder Bay
P7A 8A8

You are hereby notified that I have amended Provisional Certificate of Approval No. A590137 issued on July 23, 1996 and all amendments thereafter for the use and operation of a 11.2 ha landfill site within a total area of 31.3 ha, having a maximum capacity of 728,000 cubic meters, as follows:

The following Condition(s) are hereby added:

III. Final Cover and Slopes

28. The closure and construction of the final cover and slopes of the landfill shall be completed in accordance with Item 4 through 14 in Schedule "A".

29. No later than fourteen (14) days prior to commencement of construction, the owner shall submit to the District Manager, a construction schedule for the final cover and slope construction.

30. The owner shall on a monthly basis conduct visual inspections on the integrity of the slopes and the final cover (including vegetation), vermin and vectors for the site. A written record shall be maintained at the site, which shall include but not be limited to the following:

a) the name and signature of the trained personnel conducting the inspection;
b) the date and time of the inspection;
c) lists of any impacts/items observed;
d) date, time and detailed description of remedial actions taken in order to control the nuisance; and
e) recommendations for any preventative measures that can be taken to prevent future reoccurrences.

31. Within 120 days of completion of the final cover construction, the owner shall submit to the District Manager, a construction report detailing the construction activities and any design changes made during construction. The report shall include but not be limited to the following topics:

i. drawing(s) of the "as-built" final cover;
ii. a description of the various construction stages;
iii. quality assurance/control measures for the construction; and
iv. any changes to the design.

32. By **September 1, 2006**, the owner shall submit to the District Manager, a report that describes the effectiveness of the alternative top soil mixture. The report shall discuss but not be limited to general plant growth for site, areas that require additional work (where vegetation has not taken), proposed remedial work to rectify vegetation growth issues and timetable for proposed work completion (if required).

The following item is hereby added to Schedule "A":

CONTENT COPY OF ORIGINAL

11. Letter dated February 28, 2005 to Mr. Stefanos Habtom, Ministry of the Environment from Mr. Doug Steele, UMA Engineering Ltd. providing additional detail and drawings on the ditch and the catchment area. The drawing attached is as follows:

i. Drawing No. 00-H-002 - Stormwater Discharge Catchment Area prepared by UMA Engineering Ltd. (Project No, E287-029-01)

12. Letter dated April 1, 2005 to Mr. Dale I. Gable, Ministry of the Environment from Mr. Doug Steele, UMA Engineering Ltd. providing information on proposed alternative top soil mixture for the final cover.

13. Email dated April 5, 2005 to Mr. Dale Gable, Ministry of the Environment from Mr. Doug Steele, UMA Engineering Ltd. providing case examples of proposed peat/sand mixture for use instead of top soil.

14. Email dated April 26, 2005 to Mr. Dale Gable, Ministry of the Environment from Mr. Doug Steele, UMA Engineering Ltd. providing an updated thickness of alternative top soil and soil cover.

The reason(s) for this amendment to the Certificate of Approval is (are) as follows:

1. Condition 28 is added to ensure the final cover is completed as per the design drawings, supporting documentation and communication records. This is to ensure the long-term health and safety of the public and the environment.

2. Condition 29 is added to ensure the owner has a proposed construction schedule in place prior to commencement of construction. This shall provide the Ministry a timeline of the construction.

3. Condition 30 is added to ensure the cover and slopes are inspected on a regular basis to ensure that are performing as required. This is to ensure the long-term health and safety of the public and the environment.

4. Condition 31 is added to ensure the owner submits a construction report to the District Manager which provides "as-built" drawings and details on the construction. This is to ensure the District office has a record of the activities and final construction. This is to ensure the long-term health and safety of the public and the environment.

5. Condition 32 is added to ensure the owner submits a report to the District Manager providing an update on the status of the vegetation cover for the site and any remedial actions needed to ensure vegetation growth occurs in areas where the vegetation cover has not taken.

This Notice shall constitute part of the approval issued under Provisional Certificate of Approval No. A590137 dated July 23, 1996

In accordance with Section 139 of the Environmental Protection Act, R.S.O. 1990, Chapter E-19, as amended, you may by written notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this Notice, require a hearing by the Tribunal. Section 142 of the Environmental Protection Act, provides that the Notice requiring the hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the waste disposal site is located;

And the Notice should be signed and dated by the appellant.

CONTENT COPY OF ORIGINAL

This Notice must be served upon:

The Secretary*
Environmental Review Tribunal
2300 Yonge St., 12th Floor
P.O. Box 2382
Toronto, Ontario
M4P 1E4

AND

The Director
Section 39, *Environmental Protection Act*
Ministry of Environment and Energy
2 St. Clair Avenue West, Floor 12A
Toronto, Ontario
M4V 1L5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

The above noted waste disposal site is approved under Section 39 of the Environmental Protection Act.

DATED AT TORONTO this 27th day of April, 2005

Ian Parrott, P.Eng.
Director
Section 39, *Environmental Protection Act*

DG/
c: District Manager, MOE Thunder Bay - District
Doug Steele, UMA Engineering Ltd.

CONTENT COPY OF ORIGINAL

Ministry of the Environment | Ministère de l'Environnement | Ontario

AMENDMENT TO PROVISIONAL CERTIFICATE OF APPROVAL
WASTE DISPOSAL SITE
NUMBER A590137
Notice No. 4
Issue Date: September 30, 2005

Smurfit-Stone Container Canada Inc.
630 Rene- Levesque Blvd. West, Suite 3000
Montreal, Quebec
H3B 5C7

Site Location: Thunder Bay Mill
965 Strathcona Avenue
Thunder Bay City, District Of Thunder Bay
P7A 8A8

You are hereby notified that I have amended Provisional Certificate of Approval No. A590137 issued on July 23, 1996 and all amendments thereafter for the use and operation of a 11.2 ha landfill site within a total area of 31.3 ha, having a maximum capacity of 728,000 cubic meters,, as follows:

The following item is hereby added to Schedule "A":

15. Letter dated July 5, 2005 addressed to the Director, Environmental Assessment and Approvals Branch, Ministry of the Environment from Mr. Doug Steele, UMA Engineering providing a submission to satisfy Condition 26.

The reason(s) for this amendment to the Certificate of Approval is (are) as follows:

1. The reason for the addition of Item 15 is to recognize the submission to satisfy Condition 26. The plan requiring no additional surface water monitoring beyond the existing Section 53 surface water monitoring requirements at this time is therefore incorporated into the Certificate.

This Notice shall constitute part of the approval issued under Provisional Certificate of Approval No. A590137 dated July 23, 1996

In accordance with Section 139 of the Environmental Protection Act, R.S.O. 1990, Chapter E-19, as amended, you may by written notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this Notice, require a hearing by the Tribunal. Section 142 of the Environmental Protection Act, provides that the Notice requiring the hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the waste disposal site is located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

CONTENT COPY OF ORIGINAL

The Secretary*
Environmental Review Tribunal
2300 Yonge St., 12th Floor
P.O. Box 2382
Toronto, Ontario
M4P 1E4

AND

The Director
Section 39, *Environmental Protection Act*
Ministry of Environment and Energy
2 St. Clair Avenue West, Floor 12A
Toronto, Ontario
M4V 1L5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

The above noted waste disposal site is approved under Section 39 of the Environmental Protection Act.

DATED AT TORONTO this 30th day of September, 2005

Ian Parrott, P.Eng.
Director
Section 39, *Environmental Protection Act*

DG/
c: District Manager, MOE Thunder Bay - District
Doug Steele, UMA Engineering Ltd.