2.0 Regional Overview

2.1 Watershed Characterization

The North Bay-Mattawa Source Protection Area (SP Area) is located in northeastern Ontario approximately 350 km north of Toronto and a similar distance west of Ottawa (Fig. 2-1).

It covers approximately 4,000 km^2 extending from the Town of Mattawa in the east to the City of North Bay in the west and south to the Village of South River (Fig. 2-3).

A major divide cuts through the area from north to south directing water flow either towards the Mattawa River and the Ottawa, or to Lake Nipissing and the Great Lakes.

To more easily study drainage patterns these two large watersheds are subdivided into a total of 14 subwatersheds as illustrated in Figure 2-2 and discussed in Section 2.2 Conceptual Water Budget as part of the detailed examination of how water flows through the SP Area.

Figure 2-1. North Bay-Mattawa Source Protection Area in Northeastern Ontario

Human Geography

Historic settlement and development of the area was driven by the nature of the landscape – directing access routes, limiting agricultural activities, challenging road construction. The Mattawa River extends from west to east across the northern portion. It provided a major transportation link from Lake Nipissing in the Great Lakes watershed across to the Ottawa River, traditionally for First Nations and later for European fur traders. Much of the terrain is rugged and otherwise difficult to navigate. The City of North Bay was established on the divide at the only point east of Lake Nipissing where road and (eventual) rail access from south to north was possible without a major bridge.

The total population residing within the SP Area is estimated at 74,500 (Statistics Canada, 2007). Population distribution and changes within the SP Area for the period 1996 to 2006 are indicated in Table 2-1. Note that since population data is reported based on political boundaries (municipalities, etc.) while the SP Area is defined by watershed boundaries, the total population for the SP Area is an estimate.

Municipal boundaries and population centres serviced by municipal drinking water are also illustrated in Figure 2-3. Jurisdictional considerations regarding applicability of provincial legislation to federal lands requires consideration, so the extent of federal lands and First Nation Reserve lands, mostly within the northwest portion of SP Area, are also shown in Fig. 2-3.

Figure 2-2. North Bay-Mattawa Source Protection Area Subwatersheds

Figure 2-3. Municipalities in the North Bay-Mattawa Source Protection Area

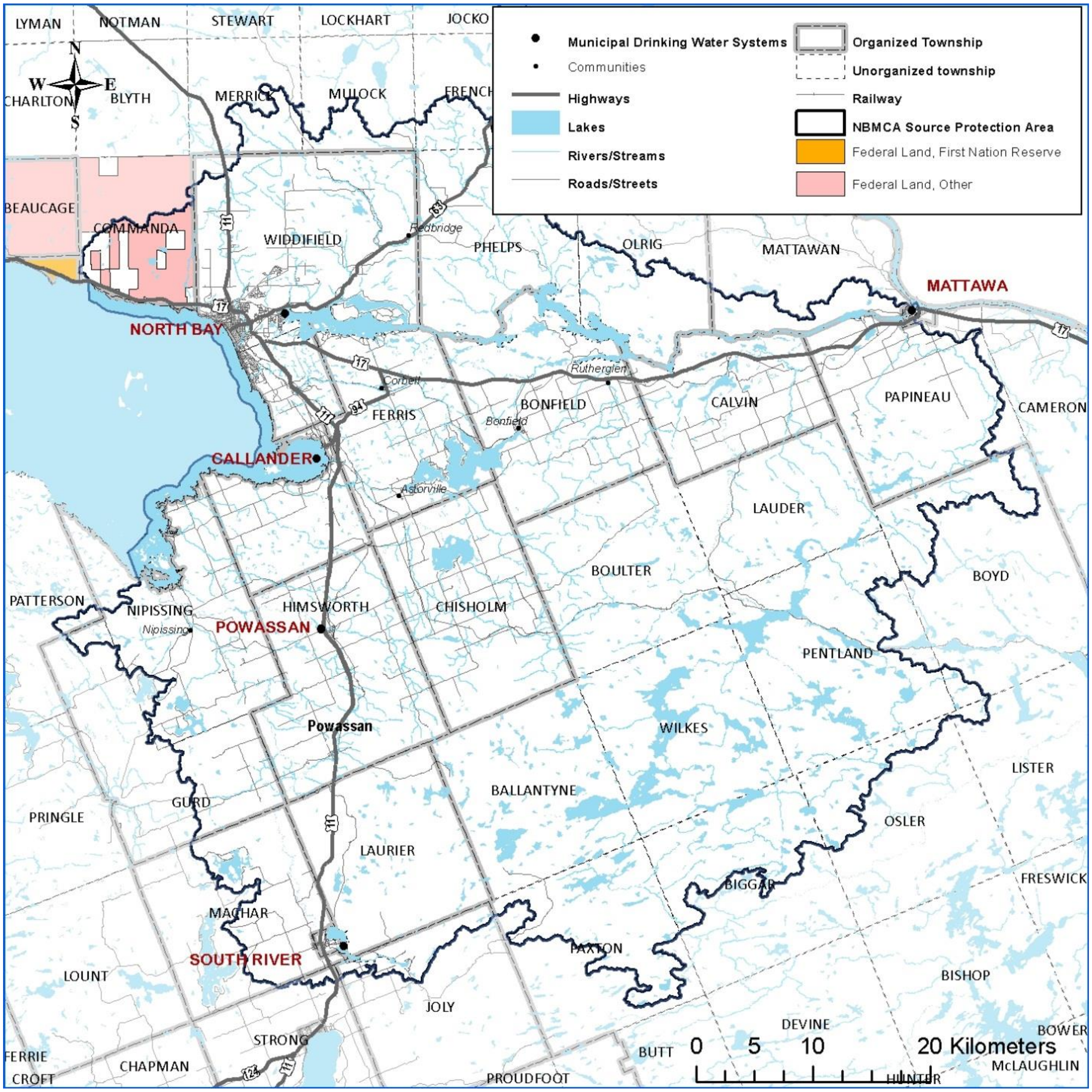


Table 2-1. Population Distribution and Change within the North Bay-Mattawa SP Area

Name	Municipal Designation	1996 Population	2001 Population	2006 Population	% Change 1996-2006
Bonfield	Township	1,765	2,064	2,009	13.8
Callander	Municipality	3,168	3,177	3,249	2.6
Calvin	Township	562	603	608	8.2
Chisholm	Township	1,197	1,230	1,318	10.1
East Ferris	Municipality[1]	4,139	4,291	4,200	1.5
Mattawa	Town	2,281	2,270	2,003	-12.2
North Bay	City	54,332	52,771	53,966	-0.7
Papineau-Cameron	Township	973	997	1,058	8.7
Powassan	Municipality	3,311	3,252	3,309	-0.1
South River	Village	1,098	1,040	1,069	-2.6
Subtotal:		72,826	71,695	72,789	-0.1
Townships & First Nations Reserve only partially within SP Area (population of entire territory)					
Joly	Township	311	290	280	-10.0
Machar	Township	835	849	866	3.7
Mattawan	Township	115	114	147	27.8
Nipissing	Township	1,524	1,553	1,642	7.7
Nipissing 10	First Nation Reserve	1,381	1,378	1,413	2.3
Strong	Township	1,393	1,369	1,327	-4.7
Subtotal:		5,559	5,553	5,675	2.1
Total:		78,385	77,248	78,464	0.1

1. During preparation of this report, the Township of East Ferris made an administrative name change and is now called the Municipality of East Ferris. This is simply for administrative purposes and does not affect the geographic area.

Approximately 75% of the population is located in the City of North Bay which is the only major urban centre in the SP Area. Most of the rest live in the towns and hamlets, but depending on the municipality, there may be a significant portion of the population on rural properties. A large portion of the SP Area is virtually uninhabited. Population distribution and density is indicated on Table 2-2.

Table 2-2. Population Density within the North Bay-Mattawa SP Area (2006)

Name	Municipal Designation	2006 Population	Density 2006 (pop/km^2)	Census Calculated Land Area (km^2)
Municipalities Located Completely within the SP Area				
Bonfield	Township	2,009	9.8	205.75
*Callander	Municipality	3,249	32.2	100.96
Calvin	Township	608	4.4	139.17
Chisholm	Township	1,318	6.4	205.26
East Ferris	Municipality[1]	4,200	28	149.76
*Mattawa	Town	2,003	548	3.66

Name	Municipal Designation	2006 Population	Density 2006 (pop/km^2)	Census Calculated Land Area (km^2)
*North Bay	City	53,966	171.4	314.91
Papineau-Cameron	Township	1,058	1.9	561.37
*Powassan	Municipality	3,309	14.9	222.75
*South River	Village	1,069	264.5	4.04
Subtotal:		72,789		
Municipalities Located Partially within the SP Area				
Joly	Township	280	1.4	193.82
Machar	Township	866	4.7	184.38
Mattawan	Township	147	0.7	199.52
Nipissing	Township	1,642	4.2	387.4
Nipissing 10	First Nation Reserve	1,413	23.1	61.22
Strong	Township	1,327	8.4	158.73
Subtotal:		5,675		
Total:		78,464		

1. During preparation of this report, the Township of East Ferris made an administrative name change and is now called the Municipality of East Ferris. This is simply for administrative purposes and does not affect the geographic area.

Drinking Water Systems

Five centres in this SP Area have municipal drinking water systems classified as large municipal residential systems under O.Reg 170/03 (indicated in Fig 2-2 as DWSP municipalities). The source for two of these systems is groundwater and the remaining three from surface water. Details for all five systems are summarized in Table 2-3 below. Information on pumping rates for each system can be found in Section 2.5.

Table 2-3. Municipal Drinking Water Systems in the North Bay-Mattawa SP Area

Municipality	Drinking Water System Name	Drinking Water Source	Drinking Water System Location	Population Serviced	Intake/Well Location	
					Easting	Northing
Callander	Callander Water Treatment Plant	Surface Water (Callander Bay)	100 Nipissing St., Callander	1,700	625480	5119098
North Bay	North Bay Water Treatment Plant	Surface Water (Trout Lake)	248 Lakeside Dr., North Bay	53,000	622779	5131488
South River	South River Water Treatment Plant	Surface Water (South River Reservoir)	28 Howard St., South River	1,000	627817	5077532
Mattawa	Mattawa Well Supply	Groundwater (Well x2)	400 Bissett St., Mattawa	2,251	676227	5131742
Powassan	Powassan Well Supply	Groundwater (Well x2)	Fairview Lane, Powassan	1,000	625874 625890	5104525 5104592

Many people are serviced by other systems subject to regulation under O.Reg 170/03 under the Safe Drinking Water Act, 2002. These are all listed in the Table 2-10 below. The abbreviated types of systems listed below represent the following (Note that there are other types of systems listed under O. Reg 170/03 which are not mentioned in this report, since there are none known to the SP Area):

- LMRS: Large Municipal Residential System (mentioned above)
- LNMNRS: Large Non Municipal Non Residential System
- NMYRRS: Non Municipal Year-Round Residential System
- SNMNRS: Small Non Municipal Non Residential System

Most of the remaining residents get their water from private residential wells or surface water intakes.

Table 2-4. Non-Municipal Drinking Water Systems in the North Bay-Mattawa SP Area

Municipality	Type	Drinking Water System Name	Number	DWS Location	Population Serviced	Capacity (L/s)	Maximum Annual Capacity (L/year)
Callander	NMYRRS	Green Road Cottages	260048347	80 Green Road, Callander		.5	15,768,000
Callander	NMYRRS	Keeling Apartments	260077701	244 Hwy 654 West, Callander	18	1	63,072,000
Callander	NMYRRS	Lagassie Trailer Park	260072228	128 Rivers East Road, Callander	60	1.11	35,004,960
Calvin	NMYRRS	Canadian Ecology Centre (Main Building)	260061022	6905 Highway 17, Mattawa	180	2	94,608,000
North Bay	NMYRRS	Blue Sky Apartments	260084669	5429 Hwy 11 North, North Bay	10	.5	15,768,000
North Bay	NMYRRS	Fairview Trailer Park And Campground	260044525	395 Riverbend Road, North Bay		1.4	44,150,400
North Bay	NMYRRS	Oasis Trailer Park	260063089			.7	22,075,200
North Bay	NMYRRS	Parkwood Villa	260074542	5887 Hwy 11 North, North Bay		2.8	88,300,800
Powassan	NMYRRS	Trout Creek Apartments	260048672	105 Main Street, Trout Creek	19	.8	25,228,800
Bonfield	SNMNRS	Camp Caritou	260038675	63 Development Road, Bonfield		0.3	9,460,800
Bonfield	SNMNRS	Ecole Lorrain	260014729	245 Yonge Street, Bonfield		1.0	63,072,000
East Ferris	SNMNRS	Ferris Glen Public School	260009607	30 Voyer Road, Corbeil		1.3	40,996,800
Callander	SNMNRS	North Bay Rotary's Camp Tillicum	260031512	Callander		2.8	88,300,800

Municipality	Type	Drinking Water System Name	Number	DWS Location	Population Serviced	Capacity (L/s)	Maximum Annual Capacity (L/year)
East Ferris	SNMNRS	Ecole St-Thomas D'Aquin	260014755	1392 Village Road, Astorville		1.0	63,072,000
East Ferris	SNMNRS	Nipissing Manor Nursing Care Centre	260016445	1202 Hwy 94, Corbeil		2.6	81,993,600
Nipissing Twp	SNMNRS	South Shore Education Centre	260009672	60 Beatty St, Nipissing Township		0.6	18,921,600
North Bay	SNMNRS	Birchs Residence	260009282	168 Birchs Road, North Bay		2.8	88,300,800
North Bay	SNMNRS	Cedarview Residence	260009295	105 Larocque Road, North Bay		2.8	88,300,800
Powassan	SNMNRS	Almaguin Highlands Community Living	260021476	8 Glendale Heights Dr, Powassan		0.8	25,228,800
Powassan	SNMNRS	Lady Isabelle Nursing Home	260016432	102 Corkery Street, Trout Creek		0.2	6,307,200
Powassan	SNMNRS	Mapleridge Public School	260018642	171 Edward St. S, Powassan		0.3	9,460,800
Powassan	SNMNRS	Rutledge Residential Home	260023946	Box 542, Powassan		0.8	25,228,800
South River	SNMNRS	Almaguin Highlands Secondary School	260009555	309 Hwy 11 North Highway, South River		0.6	18,921,600
South River	SNMNRS	Project D.A.R.E.	260024739	PO Box 2000. Lot 4, Con 9, South River		1.1	34,689,600
South River	SNMNRS	Southwind Retirement Home	260067340	8 Highway 11 South, South River		2.8	88,300,800
Unorganized	SNMNRS	Phelps Central School	260009659	19 Glenvale Drive, Redbridge		1.1	34,689,600

Physical Geography

Topography and Physiography

Topographically the area consists of three distinct regions; the Northern Uplands, the Algonquin Highlands, and the Nipissing-Mattawa Lowland (Figure 2-4). Faulting activities during the preglacial period resulted in a substantial scarp formation on the north side of the Mattawa River with relief of approximately 100 m. Similar scarps are seen west of Powassan. Relief of up to 260 m is found in the Algonquin Highlands. Both the Northern Uplands and Algonquin Highlands are characterized by rolling bedrock, thinly covered with glacial tills. Rock knob terrain is common throughout the SP Area. The Nipissing-Mattawa Lowland, lying mainly to the south of the Mattawa River and across the centre of the SP Area, is associated with extensive lake sediments around and between bedrock outcrops. Such lake sediments consist chiefly of varved clays with some rhythmically banded sands (Harrison, 1972). Minor ridges and several large end moraine segments, drumlins and eskers are important elements.

Figure 2-4. Topography in the North Bay-Mattawa SP Area

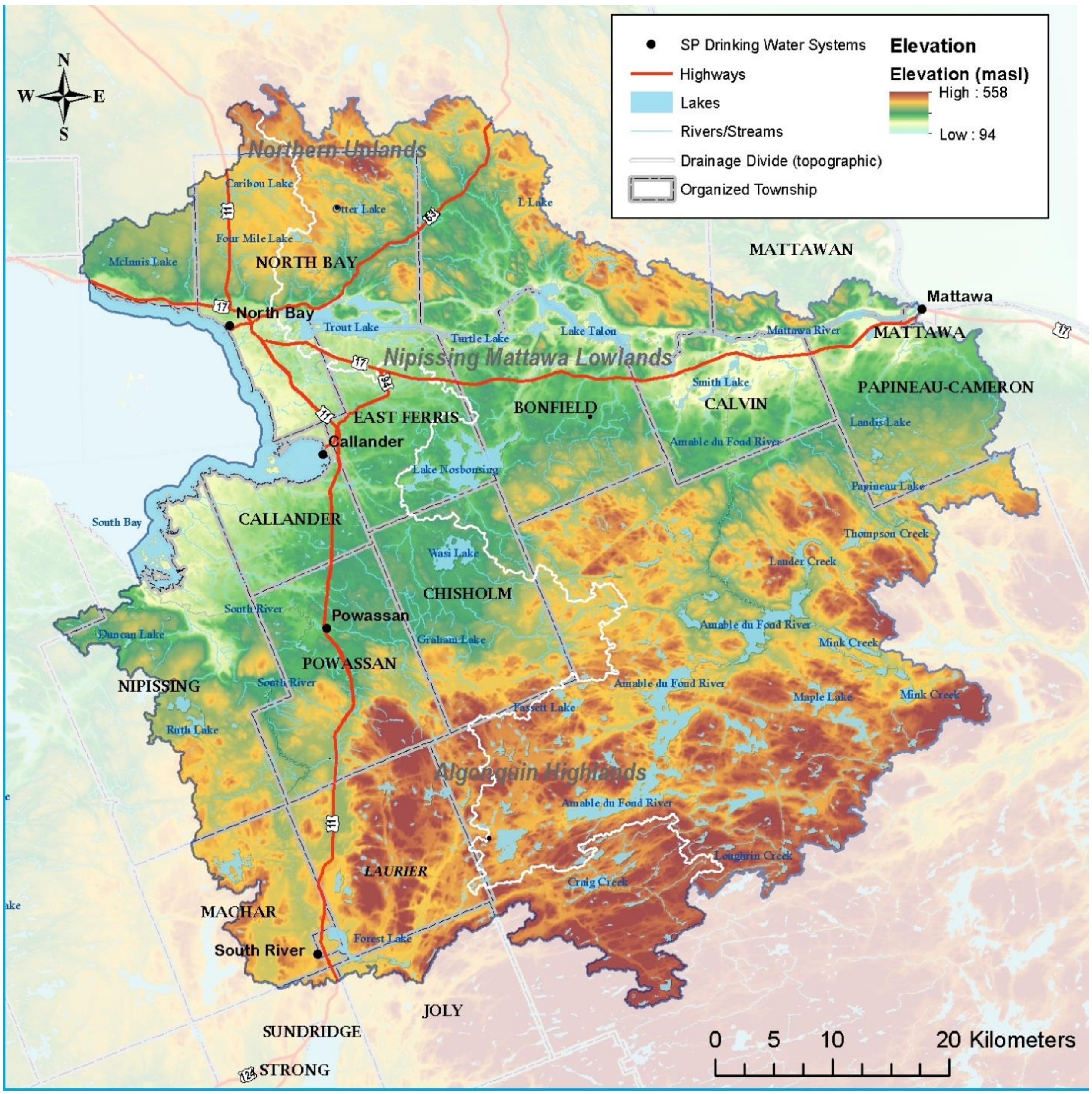
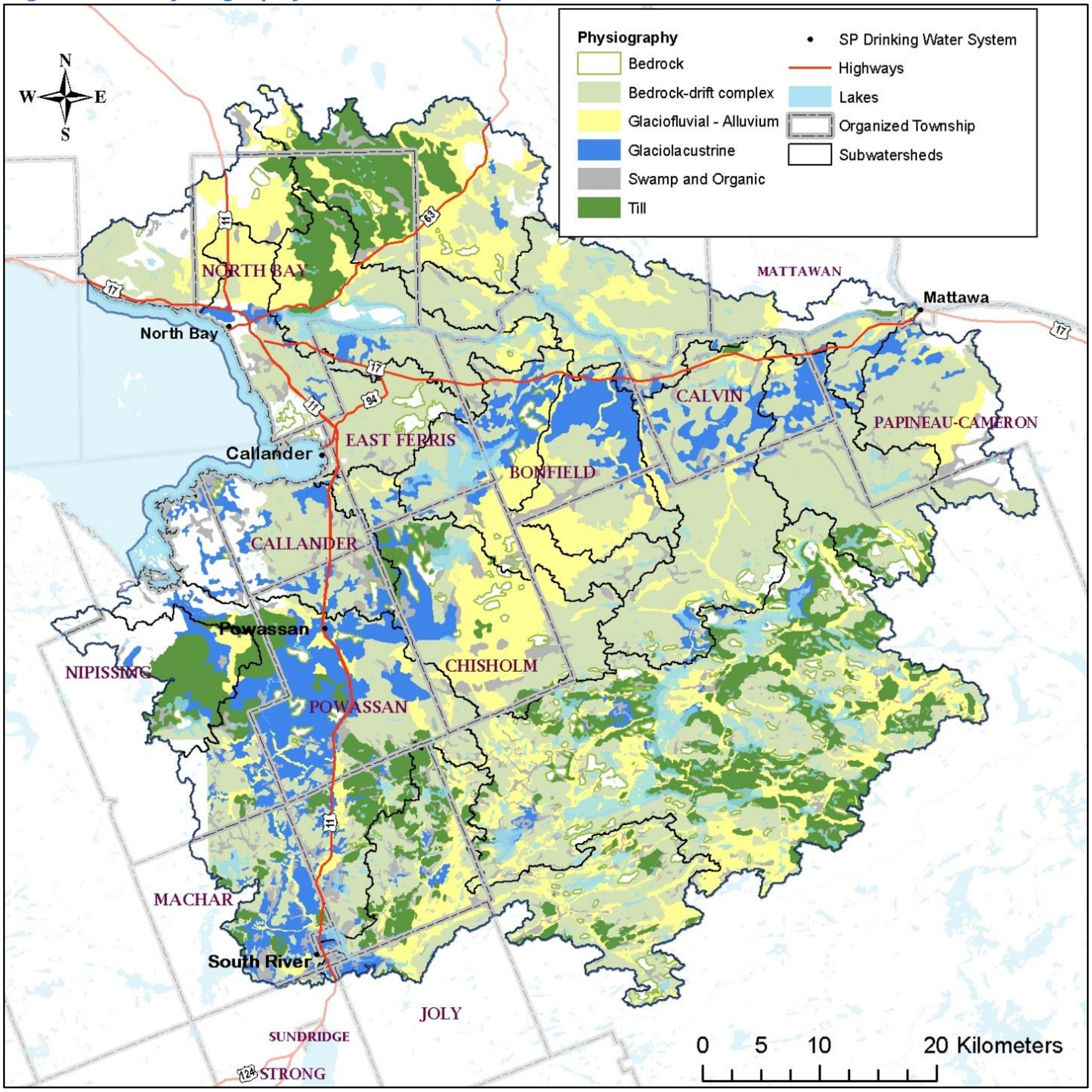


Figure 2-5 depicts the physiography using soil classifications and data from the Northern Ontario Geology Terrain Study (NOGETS; Gartner & Van Dine, 1980). These classifications relate primarily to glacial processes and include the following:

- exposed bedrock,
- drift or till which is material pushed and deposited by glaciers,
- glaciofluvial material and alluvium deposited by moving streams,
- glaciolacustrine deposits formed beneath glacial lakes, and
- organic sediments formed from vegetation in poorly drained areas (including swamps).

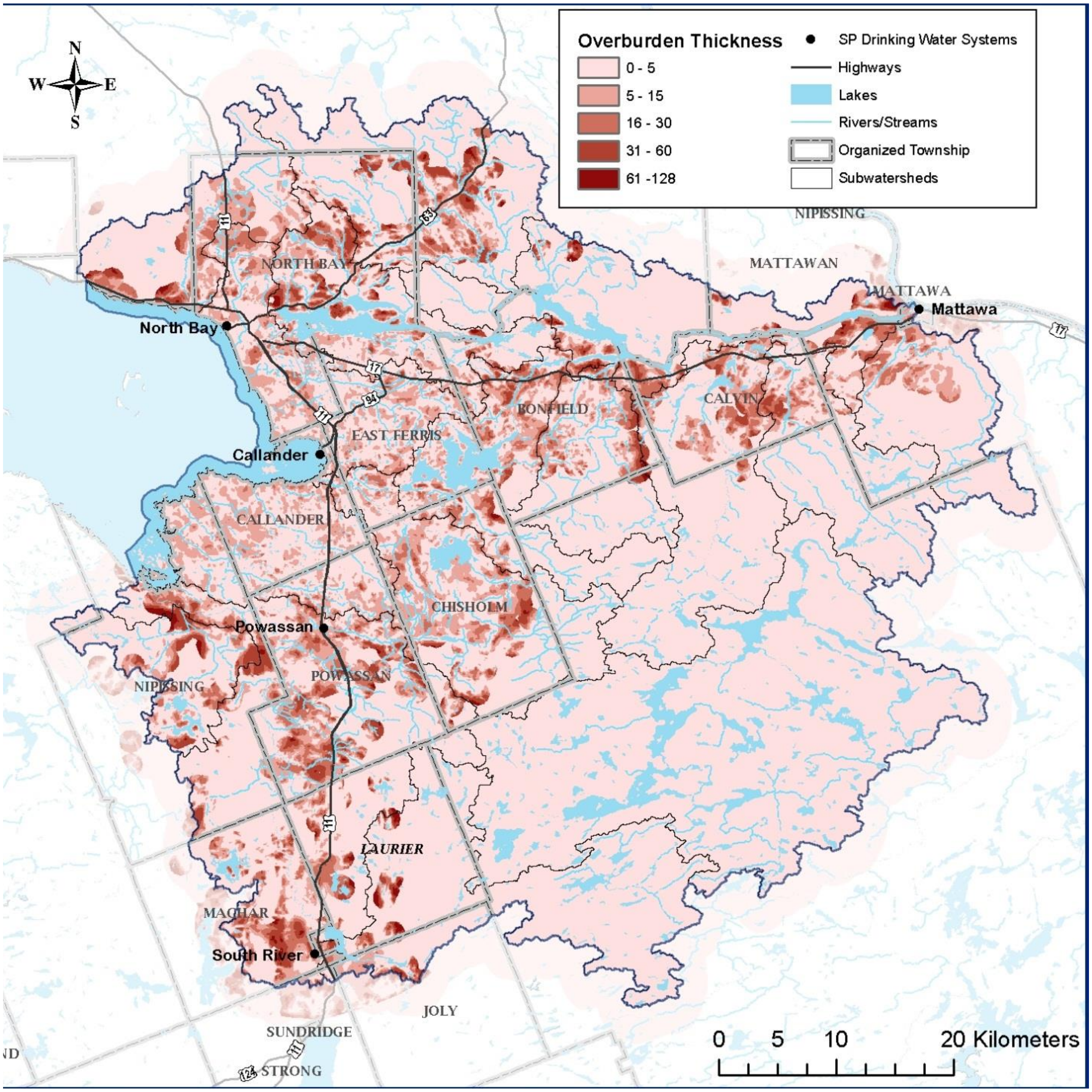
Although this classification ignores soil particle size, the coarser grained materials tend to be associated with historic areas of moving water while finer particles settled from the still waters of glacial lakes. Coarse-grained deposits are important for groundwater movement and aquifer recharge; fine-grained deposits, such as clay, impede the flow of water and often occur in a layer that protects the aquifer (water-bearing layer) from water-borne contaminants. Soil coverage throughout the area tends to be shallow (Fig. 2-6). The vast majority of the area has drift of less than 5 m in thickness. Till thickness reaches 5 to 10 m in several areas. There are occasional deep sand and gravel deposits but these are generally not extensive. Organic deposits commonly occur between the bedrock hills and in low-lying areas coupled with a high water table.

Figure 2-5. Physiography in the North Bay-Mattawa SP Area



Where soils were more substantial, settlements established; soil was necessary for agriculture and facilitated road construction. Because of the shallow rolling bedrock base, aquifers are mostly small and localized. There are very few constructed overburden wells, but this may be due as much to business practicalities in the area as to a lack of suitable geologic conditions.

Figure 2-6. Overburden Thickness in the North Bay-Mattawa SP Area



The bedrock geology of the SP Area is part of the Central Gneissic Belt of the Grenville Province of the Canadian Shield. Much of the study area consists of 1.8 to 1.6 billion year old gneisses that have been intruded by 1.4 to 1.5 billion year old granitic and monzonnitic plutons (Thurston, 1991), but also includes metamorphosed mudstones (Metagreywacke), sandstones (quartzite), and limestone (crystalline limestone/marble). From a hydrogeological perspective, these rocks are very hard and erosion resistant. However, continental tectonic forces have caused faulting, fracturing and jointing, providing minor pathways for groundwater movement. On the whole, the bedrock surface represents a relatively impermeable surface. Therefore, groundwater preferentially flows through the overlying materials. Most groundwater models in overburden aquifers consider bedrock to be a no-flow boundary and exclude it from the model. Even though it is recognized that hydraulic conductivity drops sharply with increasing penetration, the data collected when modelling the groundwater flow system below the town site of Trout Creek indicated that the uppermost zone of bedrock should be included (Waters Environmental Geosciences Ltd, 2010). Only three groundwater system locations representing about 1% of the SP Area were modeled during development of this Assessment Report and each was found to be very different from the others.

A general overview of the surficial geology of the North Bay-Mattawa SP Area is provided in the following paragraphs, taken largely from Gartner and VanDine (1980).

Glacial till deposits are the predominate characteristic the North Bay-Mattawa SP Area, with the exception of steep bedrock outcrop exposures and rock knob features. The SP Area is predominately overlain by subglacial till deposited during the last glacial ice advance (albeit thin in most places). Glacial till is a heterogeneous mixture of fine-grained and coarse-grained soils, and basically represents what is left after the glacial ice melted. The till matrix varies in texture from fine-grained silts to sands with clasts, ranging from small grains to large boulders. The till forms a thin, discontinuous veneer over the bedrock surface and thickens considerably in the valleys. As such, it represents an impediment but not a barrier to groundwater flow. End and medial moraines[1] are scattered throughout the Nipissing-Mattawa lowland area east of Lake Nipissing. These moraines consist of bouldery silty sand till, and they occur as subordinate landforms in the rock knob terrain throughout most of the area (Gartner and VanDine, 1980).

Glaciolacustrine sediments consist of well-stratified fine sand, silt and clay and are deposited in glacial lakes when melt water is trapped between the front of a glacier and a moraine or rock wall that prevents drainage. These deposits are present in a number of localities in the North Bay area and are especially concentrated along the north shore of Lake Nipissing. East of Bonfield Township the glaciolacustrine sediments range in texture from silty sand to silt and clay, and usually overlie bedrock or the till where present (Gartner and VanDine, 1980). These materials exhibit a relatively low permeability, but are flat lying and can contribute to high water table conditions. Glaciolacustrine deposits near Powassan consist of marginally more permeable sand and silt with minor clay (generally where rock knobs are less prominent) (Gartner and VanDine, 1980). In the region of Mattawa, the glaciolacustrine plains consist of clayey silt immediately south of the Mattawa and Ottawa Rivers (Gartner and VanDine, 1980).

Organic deposits are found throughout the region and have collected in low-lying areas, covering sand and gravel outwash plains, glaciolacustrine deposits, and Precambrian bedrock. Although highly permeable, they are mostly in areas of groundwater discharge and in most cases do not contribute significantly to recharge of the groundwater table other than in the summer months. In some areas they may mitigate rates of infiltration and runoff in the spring, retaining moisture like a sponge and creating reserves for drier summer months.

Coarse-grained deposits in the region are, for the most part, comprised of sand, gravel and boulders associated with kames, eskers, and moraines. Well-rounded, and well-sorted fluvial sands and gravels form large flat areas or terraces west of the Mattawa and Ottawa valleys (Harrison, 1972). Beach sands are also well sorted and well-rounded and form raised beaches

[1] *Moraines are deposits of material left by melting ice. Medial and end moraines lie along the margin of ice sheets, whereas ground moraine is left in the footprint of the ice after melting. Moraines can either be lower permeability materials like silty sands, or sandy silts,, or they can be comprised of sand and gravel and be highly permeable, depending on the material originally entrained in the ice.*

or scarps (Harrison, 1972). These are all highly permable and serve regionally as groundwater recharge zones.

Moraines are an accumulation of earth and stones carried by glacial outwash which is usually deposited into a high point like a ridge. The Rutherglen Moraine (south of Rutherglen) and the Genesee Moraine (15 km east of Powassan) are the two major moraines formed during the last ice recession (Harrison, 1972). They formed when ice flowed from the east through the Mattawa Valley lowland. The Rutherglen Moraine extends approximately 11 km from the Mattawa River southward towards Algonquin Park. The moraine, which many consider to be an esker, consists of five segments each with unique composition ranging from sand and gravel, to till and clay (Harrison, 1972). The Genessee Moraine is a large end moraine that lies parallel to the Algonquin Highlands. This moraine is more than 8 km long and up to 3 km wide in some places, and is composed primarily of sand and gravel (Harrison, 1972).

Glacial outwash is widespread throughout the region. Immediately north of North Bay a large area of sandy gravel, gravely sand, or sand, blankets the Precambrian bedrock. In some places the overburden is over 30 m thick, but it is generally 3 to 5 m thick over the bedrock (Gartner and VanDine, 1980). Therefore, these areas can serve as local or regional aquifers, if saturated, as well as groundwater recharge features. Immediately north of the Mattawa River, outwash deposits are found along Highway 533 from the Town of Mattawa northwest into Antoine Township (Gartner and VanDine, 1980). The Town of Mattawa is underlain by a large east-west trending ground moraine on the western edge of town, and a sand and gravel outwash plain upon which most of the town is built. Larger and deeper outwash deposits have good potential for groundwater supplies (Harrison, 1972). The larger portion of the Town of Powassan is underlain by a confined sand and gravel aquifer, which is utilized by the municipal well system. The silty-clay confining layer varies in thickness, and ranges from 5 m to 6 m in the immediate vicinity of the town's two municipal wells. The confining layer may not be continuous and, in some localized areas, the confining layer is interpreted to be absent.

Kames are ice-contact deposits that are typically laid down at the front of melting glaciers, and they are also a common landform on the rock knob terrain of the study area (Harrison, 1972). Many kames extend from Lake Talon to the southern margin of the North Bay area, a distance of approximately 35 km. Kames are common in the Powassan area and southeast of Mattawa (Gartner and VanDine, 1980). Kames are recharge features and serve as local aquifers if extensive enough.

Eskers are sand and gravel deposits that are formed from melt-water channels within or below a glacier. These long ridges of sand and gravel are well developed in the study area. In the Mattawa region, the eskers trend in a southerly direction, with the largest located north of the Town of Mattawa (Gartner and VanDine, 1980). One esker located in the Bonfield Township forms a single ridge and in most places rises 10 to 15 m above the surrounding landscape (Harrison, 1972). While these are groundwater recharge features, eskers can also be the source of small streams at their base.

Mineral and aggregate resources within the SP Area, include metallic and non-metallic deposits however, current mining activity is limited to sand and gravel extraction. Historically other mining activities have taken place in the watershed, but only by relatively small operations that were involved in the extraction of surficial deposits. During the 1920s, feldspar was mined in the Mattawa area. More recently mica has been mined at several locations in the lower Mattawa valley including the Purdy Mica Mine in Mattawa Township. There are extensive aggregate extraction activities in the watershed, mainly within glaciofluvial deposits. A highly productive sand and gravel area is located north of the escarpment in North Bay.

Vegetative Land Cover

Only about 8% of the SP Area is classified as human land use in the forms of settlement infrastructure or agricultural pasture/cropland (Table 2-5). Over 80% is forested and 7% is open water. Dominant tree species include Red Pine, Eastern White Pine, Eastern Hemlock, Yellow Birch, Maple species, and Red Oak. The distribution of land cover classes is also shown in Figures 2-7 and 2-8.

Table 2-5. Vegetative Land Cover in the North Bay-Mattawa SP Area

Land Classification	Land Cover and Type	Area (km^2)	% Coverage	% Coverage by Class
Human Land Use	Settlement Infrastructure	80	2.0	8
	Pasture	252	6.3	
Forested	Mixed Forest	1479	37.3	80
	Deciduous Forest	1134	28.6	
	Coniferous Forest	378	9.5	
	Sparse Forest	170	4.3	
Wetland	Treed Bog	93	2.3	3
	Open Bog	4	0.1	
	Treed Fen	3	0.1	
Other	Other	72	1.8	2
	Cutovers	11	0.3	
	Burns	0	<1.0	
Water	Water – Deep or Clear	281	7.1	7
Bare Rock	Bedrock Outcrop	6	0.1	0
Total		**3963**	**100**	**100**

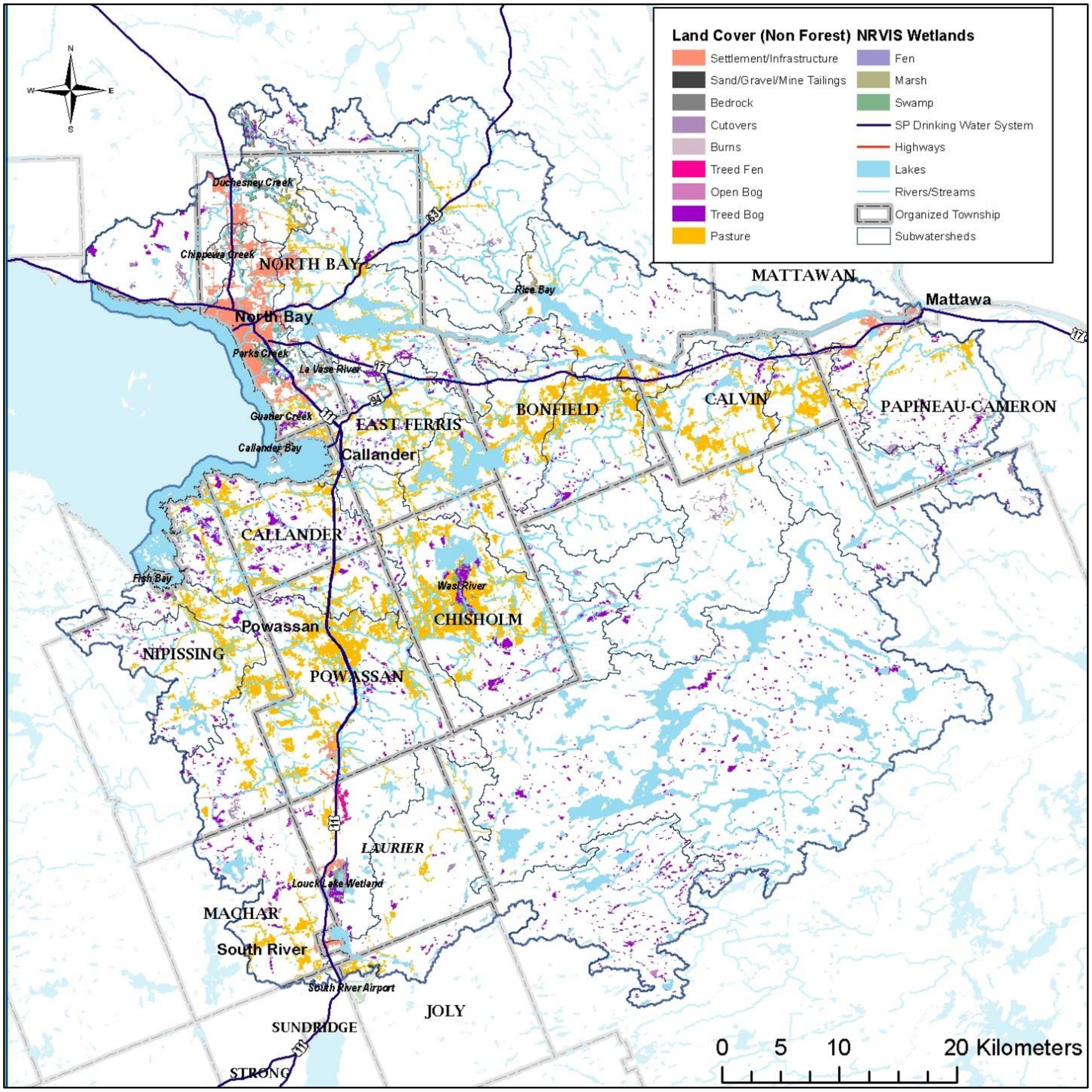
Riparian areas are the lands found along shorelines. The term refers to the transition zone between upland areas such as fields, and water features such as streams, wetlands, lakes and rivers. The zone may be intermittently inundated supporting wet meadow, marshy or swampy vegetation. They are frequently ecologically diverse, providing important habitat and physical attributes that stabilize shorelines and reduce contaminants in overland flows. Residential development or agricultural activities have often resulted in alterations to shoreline areas. Large portions of the SP Area are unpopulated with riparian areas in their natural state, but there has been little data collection or assessment of those. If a 100 m strip along every shoreline were to be identified as a riparian buffer, it would amount to almost 15% of the SP Area.

Wetland distribution is relatively uniform across the SP Area with high concentrations of treed fens and treed bogs around Lake Nipissing in the Bear-Boileau Creeks and LaVase River watersheds. Approximately 100 km^2 of wetland covers the SP Area, or 2.5%. Of the wetlands that have been evaluated, 11 are classified as Provincially Significant. They include the Callander Bay Wetland, Chippewa Creek Conservation Area Wetland, Duchesnay Creek Wetland Complex, Fish Bay Wetland, Gauthier Creek Marsh, LaVase Portage Conservation

Area, Louck Lake Wetland, Parks Creek Wetland, Rice Bay Wetland, South River Wetland, and the Upper Wasi River Swamp. In addition, locally significant wetlands have been identified in most SP Area subwatersheds.

Figure 2-7. Wooded Land Cover in the North Bay-Mattawa SP Area

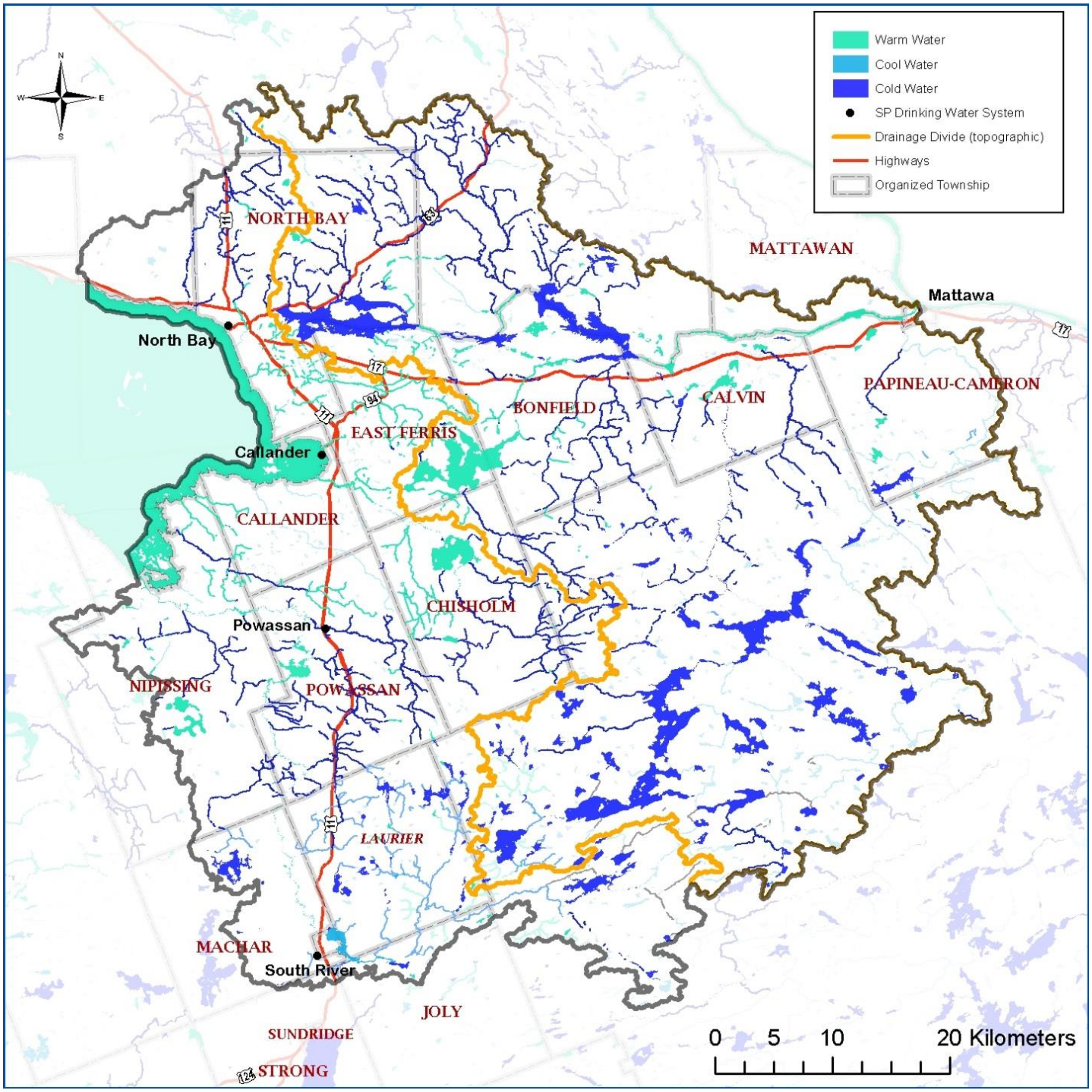
Figure 2-8 Non-Wooded Land Cover in the North Bay-Mattawa SP Area



Aquatic Habitats

Aquatic habitats are diverse, again due to the large unpopulated and undeveloped expanses of the SP Area, as well as the varied topography, shallow soils and impervious bedrock. Locations of warm water, cool (mixed) water and coldwater fisheries are indicated according to thermal aquatic regimes (Fig. 2-9). Cold water usually originates from groundwater discharge (baseflow) whereas warm water comes from overland flows. Therefore thermal regimes are important to understanding the movement of water through the system. Observing the distribution of coldwater and warm water fish species is a relatively simple way to identify thermal regimes; the information tends to be readily available as it is collected for other purposes. In the North Bay-Mattawa SP Area, cold water lake fisheries tend to be located in the upland areas and warm water fisheries in the lowlands.

Figure 2-9 Thermal Aquatic Regimes in the North Bay-Mattawa SP Area



Macroinvertebrate communities are valuable indicators of environmental conditions in aquatic habitats, typically found along shorelines, bottom substrates, and within the water column. Benthic monitoring was started in Chippewa Creek, an urban creek in North Bay, in 2009. Prior to that, sampling of benthic macroinvertebrates was occasionally conducted as part of broader water quality studies in the 1960s and 1970s in Trout, Wasi and Graham Lakes; in Four Mile, Chiswick, Chippewa, Sharpes, Blueseal, Cahill, and Landis Creeks; and in the Kaibuskong and North Rivers. Macroinvertebrate diversity and abundance were found to be low in Graham Lake, Wasi Lake, and Chiswick Creek, indicating eutrophic, oxygen-poor conditions. Macroinvertebrates were also sampled as part of the Wasi River Management Study conducted in 1984.

Aquatic habitats can be impacted by human activities such as urban-suburban development, road construction, agriculture, forestry, mining, and hydroelectric development. Changes such as shoreline alteration, water level fluctuation, siltation, flooding, and acidification exemplify how both water quality and quantity can be affected.

The Chippewa Creek monitoring program will attempt to compare conditions in undisturbed and disturbed sites, and may be expanded in the future beyond Chippewa Creek. Currently baseline conditions are still being established.

Species at Risk

The locations of species at risk are purposely not provided in this document or its associated maps due to the sensitivity of these species to disturbance and the risks for some species of illegal collection for the pet trade and direct persecution. Any direct linkages between source water protection features and species at risk occurrences should be handled in confidence by Ministry of Natural Resources staff with appropriate data sensitivity training. This information should be kept confidential with limited distribution.

Aquatic species are relevant to source protection planning for a number of reasons. Depending on water resources for part or all of their life cycles, these species are inherently tied to water quality and quantity issues. Their presence and abundance may serve as indicators of water quality. Considering the food web, other species depend on aquatic species for food. In this way, water quality and quantity conditions may indirectly impact these species with respect to food availability and contamination. The following information was compiled prior to 2007.

Designations

The Ministry of Natural Resources defines species at risk as “Any plant or animal threatened by, or vulnerable to extinction.” (MNR 2006d) As described below, designated species at risk are afforded protection under a variety of pieces of legislation, policies, and guidelines. They are also subject to stewardship initiatives and recovery efforts.

A species’ status may be assessed and designated[2] at both provincial and federal levels. “At risk” categories include Extirpated, Endangered, Threatened, and Special Concern. These categories build upon one another:

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[2] *Candidate species are evaluated by scientific committees of species experts. Provincially species are assessed by the Committee on the Status of Species at Risk in Ontario and designations are assigned by the Minister of Natural Resources and listed in the Species at Risk in Ontario List (MNR 2006e); Federally species are assessed and designated by the Committee on the Status of Endangered Wildlife*

- Extirpated species are those that no longer exist in the wild in Ontario or Canada but may still occur naturally somewhere else. In some cases, individuals of an extirpated species may be found in captivity (i.e. zoos). For some, it may be possible to reintroduce the species if the issues causing its extirpation have been mitigated. (COSEWIC 2006; MNR 2006e)
- Endangered species face an immediate threat of extirpation or extinction. In Ontario, endangered species are candidates for regulation and protection under the provincial *Endangered Species Act*[3]*.* Those which are listed in regulation under this Act are generally referred to as Endangered-regulated. (COSEWIC 2006; MNR 2006e)
- Threatened species face limiting factors to their continued existence in the wild. If limiting factors are not mitigated, these species may become endangered. (COSEWIC 2006; MNR 2006e)
- Species of Special Concern are at risk of becoming threatened or endangered generally due to inherent biological limitations, human activities and/or natural events. (COSEWIC 2006; MNR 2006e)

Other categories used include Extinct, Data Deficient and Not at Risk.

- Extinct species are no longer “at risk” of disappearing as they have already disappeared. They no longer exist at all, anywhere in the world. (COSEWIC 2006; MNR 2006e)

- Not at Risk species are those whose status has been evaluated by an assessment committee but determined to not be at risk at that point in time. (COSEWIC 2006; MNR 2006e)

- Data Deficient refers to those candidate species for which not enough information is available to assess their status. (COSEWIC 2006; MNR 2006e)

These status designations are very important as they provide legal or policy protection, or stewardship direction for species and their habitats.

Legislative Protection

As mentioned, at the provincial level, endangered species listed in regulation under the provincial Endangered Species Act (i.e. Endangered–regulated species) are provided province-wide protection for both the species and its habitat. The Planning Act provides protection for the habitat of Endangered (regulated and not-regulated) and Threatened species. The Fish and Wildlife Conservation Act provides some protection to those species at risk listed as “specially protected” under the Act. (MNR 2006e)

in Canada which maintains a list of designated species. (COSEWIC 2006) In response, the federal government may chose to assign status designations and list species under the Species at Risk Act. (Species at Risk Act, 2002)

[3] *It should be noted that the Endangered Species Act is currently undergoing a legislative review to strengthen provisions for species at risk, as mandated under Ontario's Biodiversity Strategy (MNR 2006b). The progress of this review should be monitored to ensure compliance with any new protection provisions and to accommodate any additional species at risk afforded legal protection provincially under a revised Endangered Species Act or new species at risk legislation. Following a period of public consulation, the proposed Endangered Species Act 2007 was introduced into the legislature on March 20, 2007 for consideration and has passed first reading. (MNR 2006d).*

At the federal level, Extirpated, Endangered and Threatened species are provided species, residence and habitat protection under the Species at Risk Act (Government of Canada 2006). In addition, many migratory birds are provided protection under the Migratory Birds Convention Act, while fish habitat protection is given through the Fisheries Act and associated regulations. (MNR 2006e)

Threats

Threats to aquatic and semi-aquatic species include:

- Shoreline development and alteration (loss of habitat);
- Water pollution (via rain, runoff, direct application, spills);
- Unnatural water level alteration (exposure/isolation, changes in flow patterns, erosion, flooding of nests);
- Drainage (exposure/isolation, loss of habitat, loss of prey habitat);
- Invasive species;
- Barriers (dams, roads);
- Disturbance (noise, water traffic);
- Over-harvesting;
- Climate change (causing water temperature changes, changes in aquatic vegetation communities).

Species at Risk in the North Bay-Mattawa SP Area

The SP Area has 14 provincially and/or federally designated species at risk (Table 2-6). As a result of their habitat and/or food sources, those directly influenced by water quality and/or quantity include Bald Eagle, Black Tern, Least Bittern, Peregrine Falcon, Aurora Trout, Lake

Table 2-6. Species at Risk within the North Bay-Mattawa SP Area

Taxon	Species Common Name	Scientific Name	Ontario Status	Federal Status
Birds	Bald Eagle (northern population – north of French and Mattawa Rivers)	Haliaeetus leucocephalus alascanus	SC	NAR
	Bald Eagle (southern population – south of French and Mattawa Rivers)	Haliaeetus leucocephalus alascanus	END-R	NAR
	Black Tern	Chlidonias niger	SC	NAR
	Least Bittern	Ixobrychus exilis	THR	THR
	Peregrine Falcon	Falco peregrinus anatum	THR	THR
	Red-shouldered Hawk	Buteo lineatus	SC	SC
Fish	Aurora Trout	Salvelinus fontinalis timagamiensis	END	END
	Lake Sturgeon (Great Lakes population)	Acipenser fulvescens	NAR	NAR
	Northern Brook Lamprey	Ichthyomyzon fossor	SC	SC
Reptiles	Blanding's Turtle	Emydoidea blandingii	THR	THR
	Eastern Hog-nosed Snake	Heterodon platirhinos	THR	THR
	Eastern Massasauga Rattlesnake	Sistrurus catenatus	THR	THR
	Eastern Milksnake	Lampropeltis triangulum triangulum	SC	SC

	Eastern Ribbon Snake	Thamnophis sauritus sauritus	SC	SC
	Wood Turtle	Clemmys insculpta	END	SC

(Sources: NHIC 2006; MNR 2006e; DFO 2006a; DFO 2006b; Totten Sims Hubicki 1997a citing NBMCA 1996; OPGI 2005)

Sturgeon, Northern Brook Lamprey, Blanding's Turtle, Eastern Hog-nosed Snake, Eastern Ribbon Snake and Wood Turtle (marked with an asterisk in the descriptions below). Other species at risk of interest noted in the area include Red-shouldered Hawk, Massasauga Rattlesnake, and Eastern Milksnake, however these species are not as closely tied to water resource issues as those mentioned previously

Other Rare Species

In addition, a number of rare, aquatic and semi-aquatic species are known to occur in this area. Of particular interest are the river- and pond-breeding dragonflies associated with the Mattawa River whose presence and abundance may serve as indicators of water quality. Rare plant species of interest include Algae-like Pondweed and Blunt-lobe Grapefern due to their association with water quality and quantity.

Habitats at Risk

A patch of the rare "Atlantic Coastal Plain Shallow Marsh Type" vegetation community occurs in the South River and Reserve–Beatty Creeks watersheds in the Township of Nipissing. This vegetation community is considered very rare provincially (S3) with few remaining hectares. Available information suggests it is imperiled globally (G2?). (NHIC 2006)

Invasive Species

There are over 160 non-native species occurring in the Great Lakes watershed of which many are considered "invasive". The spread of invasive species is monitored through a partnership program involving Ontario Federation of Anglers and Hunters and the Ministry of Natural Resources.

Typically non-native, invasive species have high reproductive rates, lack natural population checks such as predators and disease, and aggressively out-compete indigenous species for resources. Once introduced, invasive species spread quickly. Once established they are difficult to eradicate. (OFAH 2006)

Aquatic invasive species have been introduced to the Great Lakes system as a result of world-wide boat traffic, aquarium and water garden trades, and the aquaculture industry. Through recreational activities such as boating, angling, scuba diving, and flying (float planes), these species can be spread to inland lakes and rivers. Plants, fish, mussels, parasites, and other small organisms can be transported via boat hulls, boat trailers, float plane floats, scuba gear, bait buckets, ballast water, bilge water, and live wells. (OFAH 2006)

Invasive Species in the SP Area

Two invasive species in are found in the SP Area, namely Spiny Waterflea (*Bythotrephes longimanus*) and Purple Loosestrife (*Lythrum salicaria*). Purple loosestrife is a common and widespread invasive which has been in the area for over a century. The spiny waterflea was first discovered in Lake Nipissing in 1998 and occurs within Callander Bay.

Water Quality

Surface Water Quality and Monitoring

In Ontario, standards and guidelines have been established to protect water for designated uses such as drinking, recreation, agricultural irrigation, and the protection of aquatic life. The Ontario Drinking Water Quality Standards (ODWS; O.Reg 169/03) ensure that drinking water supplies pose a minimum risk to public health. The Provincial Water Quality Objectives (PWQO) are designed to protect all forms of aquatic life and to protect recreational water uses.

Water quality is currently monitored monthly from April through November at seven locations within the SP Area as part of the Provincial Water Quality Monitoring Network (PWQMN). http://www.ene.gov.on.ca/environment/en/resources/STD01_076358.html

Data has been collected provincially since 1974, but local participation has varied over the years depending on available funding and identified issues. An attempt was made in 2006 to establish locations for more consistent long term monitoring. Locations must be on flowing water and include rivers draining a variety of areas: unpopulated forested, urban, and agricultural. The PWQMN stations within the SP Area are listed in Table 2-7 below and shown on Figure 2.10.

Table 2-7. Provincial Water Quality Monitoring Network (PWQMN) Stations

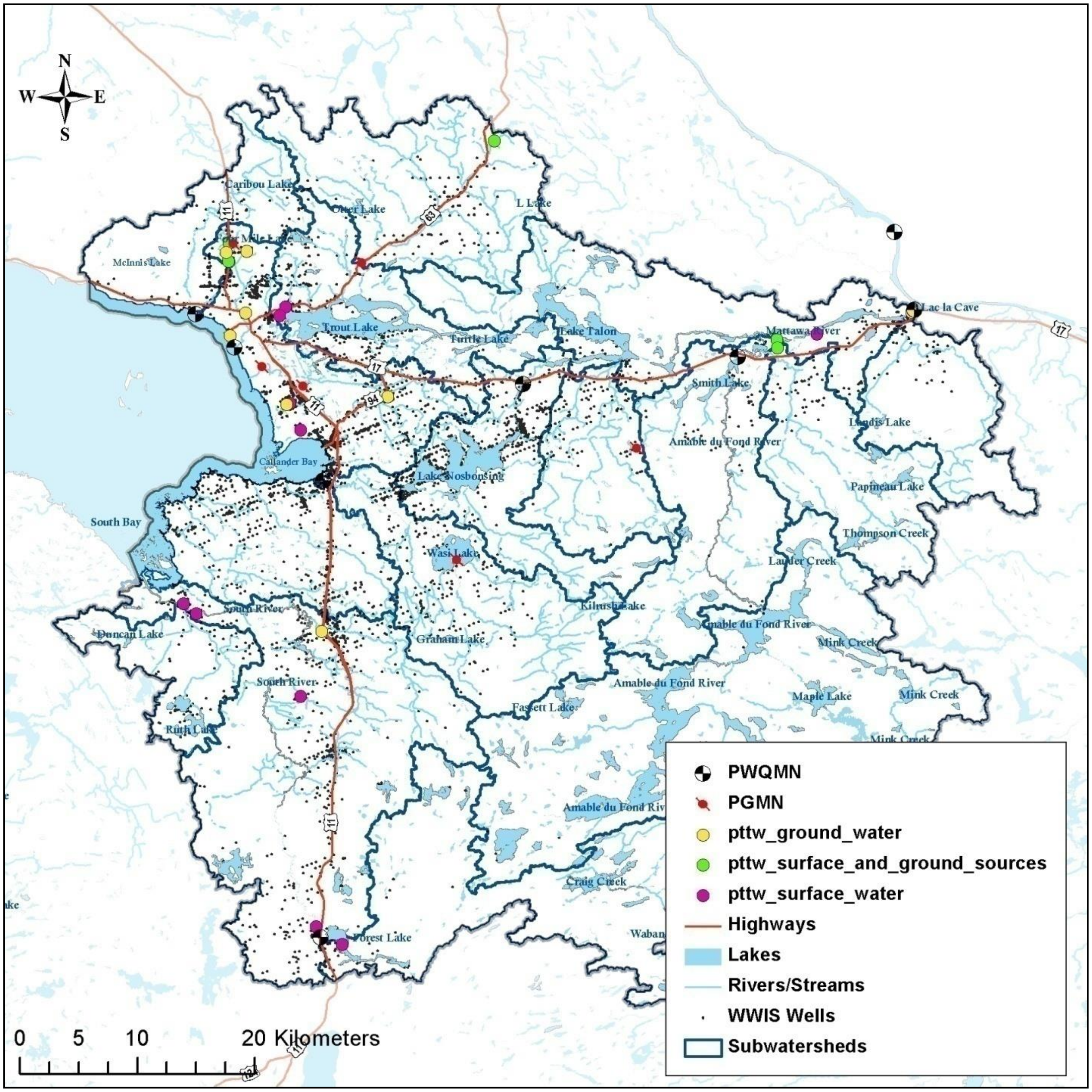
Station ID	Station Name	Location	Operational Status
3013301302	Duchesnay Creek	Main St W. (Hwy 17B), North Bay	1968-1994, 2007-present
3013301902	Chippewa Creek	Memorial Dr, Amelia Park, close to mouth into Lake Nipissing, North Bay	1968-1994, 2003-present
3013302302	South River	Hwy 11, downstream of Village of South River	1973-1991, 2007-present
3013303002	Wasi River	Lake Nosbonsing Rd, Hwy 654, upstream of falls near outlet to Callander Bay, S of Callander	1984-1994, 2003-present
18607002002	Mattawa River	Near Mattawa Island, Mattawa	1968-1994, 2007-present
18607006002	Kaibuskong River	Hwy 17 downstream of Lake Nosbonsing, N. of Bonfield	1972-1994, 2007-present
18607008002	Amable Du Fond River	Hwy 17, E. of Hwy 630, W of Mattawa	1972-1992, 2007-present

Data from the PWQMN stations are shown in Table 2-8. PWQMN water chemistry parameters determined by laboratory analysis include a wide range of parameters such as chloride, total phosphorus, nitrate, total suspended solids, zinc and many more. As well, physical parameters including temperature, pH, dissolved oxygen and conductivity are measured in the field. For the most part throughout the watershed, chemical parameters are consistently well below limits established by Provincial Water Quality Objectives (PWQO), the low levels reflecting the generally undeveloped conditions and relative lack of pollutant sources. Even Chippewa Creek, which drains some urbanized portions of the City of North Bay, meets the PWQO although chloride levels are sometimes much higher than in non-urbanized watersheds, most likely due to road salt application. Chippewa Creek also tends to exhibit the highest levels of total dissolved solids and nitrates. It has been noted that the Wasi River also displays seasonal spikes of nitrates in late August or early September (still well below PWQO limits), but the cause has not been investigated. There has been significant interest in phosphorus levels in some waterbodies for quite a few years so more information from other sampling is available in those cases.

Table 2-8. PWQMN Sample Results (2003-2009)

Parameter	Statistic	PWQMN Location and Site Number							Guidance or Benchmark
		Amable Du Fond River	Chippewa Creek	Duchesnay Creek	Kaibuskong River	Mattawa River	South River	Wasi River	
		18607008002	3013301902	3013301302	18607006002	18607002002	3013302302	3013303002	
Chloride (mg/L)	# Samples	23	44	23	23	23	23	42	250
	Minimum	0.5	21.1	1.9	3.8	2.3	1	2	
	Maximum	2.8	176	44.1	20.2	3.6	2.9	12.1	
	Median	1	90.75	12.2	4.7	3	1.6	4	
	Average	1.14	91.99	16.62	6.13	3.05	1.73	4.57	
Nitrate (mg/L)	# Samples	23	44	23	23	23	23	42	13
	Minimum	0.001	0.242	0.001	-0.001	-0.002	0.002	0.001	
	Maximum	0.087	0.812	0.228	0.076	0.122	0.101	0.188	
	Median	0.018	0.5235	0.05	0.006	0.042	0.028	0.039	
	Average	0.03	0.53	0.07	0.01	0.05	0.04	0.06	
Total Phosphorus (mg/L)	# Samples	23	43	23	23	23	23	42	0.03
	Minimum	0.002	0.008	0.003	0.003	0.002	0.003	0.015	
	Maximum	0.020	0.080	0.052	0.081	0.020	0.031	0.112	
	Median	0.010	0.019	0.023	0.018	0.012	0.010	0.041	
	Average	0.010	0.023	0.025	0.022	0.012	0.011	0.042	
Total Suspended Solids (mg/L)	# Samples	22	43	23	23	23	23	41	25
	Minimum	0.7	0.8	1.2	1.5	0.6	0.6	3	
	Maximum	3.6	337	15.6	6.3	4	5.8	25.2	
	Median	1.5	3.4	3.7	2.9	1.6	1.8	7.1	
	Average	1.71	15.94	4.95	3.19	1.70	1.97	8.08	
Zinc (mg/L)	# Samples	23	44	23	23	23	23	42	20
	Minimum	0.373	4.83	1.65	-0.0995	0.649	0.288	1.02	
	Maximum	3.56	186	11.7	3.53	3.02	3.81	5.16	
	Median	1.9	9.18	5.61	1.12	1.4	2.12	2.615	
	Average	1.86	13.41	5.81	1.26	1.51	2.21	2.85	

Figure 2-10. Water Quality Monitoring Station and PTTW Locations



Phosphorus is usually the limiting nutrient for algae growth in aquatic systems. It is a parameter of concern at two opposite extremes within the SP Area for the Callander and North Bay source waters. The Wasi River has consistently exhibited high levels of total phosphorus along with Wasi Lake and Callander Bay into which it drains. Eutrophication as evident in excessive growth of algae in the latter waterbodies has been an ongoing concern for many years. Callander Bay is the source for the municipal drinking water supply for Callander and has experienced blooms of toxic blue-green algae. Therefore, phosphorous sources contributing to the proliferation of those species of algae are currently the subject of a study due to be completed by November 2010. There is additional discussion included in the Callander Section of this report.

The other waterbody where phosphorus has been closely monitored is Trout Lake. Trout Lake is also the source for a municipal supply, namely the City of North Bay. However Trout Lake is a deep, cold, oligotrophic lake of very low nutrient status. Until recently, North Bay's water treatment system did not include filtration so was dependent upon very clear water largely devoid of algae or other particulates to ensure the effectiveness of disinfection. The City of North Bay has consistently supported the monitoring of phosphorus levels in Trout Lake on a weekly basis at eight sites since 1986. Over that period phosphorus levels have remained relatively consistent and do not display any obvious trends. Four Mile Bay is a long narrow and relatively shallow bay of Trout Lake, with a significant number of residences (some seasonal). Fed by Four Mile Creek, both the bay and the creek have been the subject of additional monitoring for signs of eutrophication and nutrient loading. Four Mile Creek is small and narrow, and exhibits substantial fluctuations in phosphorus concentrations but no discernable trends are evident. The last two years of data collection had extremely high rainfall, so any recent increases could be due to the unusual weather conditions.

High levels of zinc were noted in Four Mile Creek following an ONR train derailment in 1967 that resulted in substantial spillage of zinc and lead concentrates. Clean-up efforts were undertaken; however, 179 tons of lead concentrate and 630 tons of zinc concentrate were not recovered. Current data indicate that zinc concentrations are still elevated (average 22.7 µg/L between 2003 – 2005) and close to the PWQO limit of 25 µg/L. Increases in lead concentrations were not identified.

Assessments of the quality of surface water at municipal drinking water intakes are included in the relevant municipal Sections of this report.

Groundwater Quality and Monitoring

In 2003, six monitoring wells were installed in the North Bay-Mattawa region as part of the Ministry of the Environment Provincial Groundwater Monitoring Network (PGMN) program. As part of the PGMN, information on both groundwater levels and water quality is collected. Currently six stations are located in the SP Area (Table 2-9, Figure 2-10).

Table 2-9: Provincial Groundwater Monitoring Network (PGMN) Wells

GA #	Name	Location	Depth (m)	Static Water Level
272	Fabrene Inc.	Fabrene Inc.	24.7	5.50
274	Marshall Park	Marshall Avenue at Booth Rd	5.18	3.74
277	Trans Canada Pipeline	Hwy 11 N	10.8	7.74
390	Chisholm	Beach Rd, public beach	141	2.33
391	Bonfield	Grand Desert Rd and Boundary Rd	79.3	10.54
392	Feronia	Cemetery Rd and Hwy 63	91.9	10.07

A summary of key groundwater quality parameters, as taken for the PGMN program from 2003 to 2009, is available in Table 2-6. The information gathered through the PGMN helps to set baseline conditions, assess how groundwater is affected by land use and water use, help identify trends and emerging issues, and provide a basis for making resource management issues. Initial samples were taken in 2003 while a second and third set of samples were collected in 2007. Water quality samples have since been collected annually in four of the six wells (GA274, 277, 391 and 392).

Although the data is too sparse to conclude any definitive trends, a review of available information indicated that there are very few water quality issues. There are some parameters which were detected at elevated levels that are attributed to natural sources, such as iron, hardness and manganese. However all of these parameters are aesthetics related and easily treated to improve the aesthetic quality of the water. One health related naturally occurring parameter that was detected in two wells is sodium. Sodium is an important concern to people on sodium restricted diets.

Table 2-10. PGMN Sample Results (2003-2009)

Parameter	Statistic	PGMN Location and Well Number				
		Marshall Park	Trans Canada Pipeline	Chisholm	Bonfield	Feronia
		GA 274	GA 277	GA 390	GA 391	GA 392
Chloride (mg/L)	Minimum	5	7.7	10	0.5	9
	Maximum	45	14.6	46	1	29.5
Conductivity (uS/cm)	Minimum	867	73	-	144	237
	Maximum	878	98	348	155	501
DIC (mg/L)	Minimum	116	3	21	14.8	26
	Maximum	206	5.8	23.2	16.8	30
DOC (mg/L)	Minimum	15	0.7	0.8	0	0.6
	Maximum	20	1.15	4	0.6	1.2
Flouride (mg/L)	Minimum	0.1	0.01	0.95	0.11	0.67
	Maximum	0.2	0.027	1.7	0.15	1.11
Nitrate (mg/L)	Minimum	<0.005	1.05	<0.005	<0.005	<0.005
	Maximum	0.09	1.74	<0.005	0.2	3.98
Total Phosphorus (mg/L)	Minimum	0.16	0.02	<0.02	<0.02	<0.02
	Maximum	2.28	0.53	0.02	0.02	0.02
TDS (mg/L)	Minimum	570	28	128	94	144
	Maximum	828	64	226	144	326
Calcium (mg/L)	Minimum	123	2.8	19	17	39
	Maximum	173	6	23	150	72.6
Copper (mg/L)	Minimum	0.0004	0.0002	<0.001	<0.001	0.0002
	Maximum	0.004	0.002	0.002	0.003	0.003
Iron (mg/L)	Minimum	<0.05	0	<0.03	0.0006	0.008
	Maximum	28.9	<0.03	0.07	12	0.05
Magnesium (mg/L)	Minimum	25.2	0.64	4.5	5	3.65
	Maximum	43.2	1.05	6.1	38	8.8
Sodium (mg/L)	Minimum	37.7	7.8	31	2	9
	Maximum	72.6	9.86	44	56	13.1
Zinc (mg/L)	Minimum	0.0012	0.0003	<0.005	0.0005	0.0005

	Maximum	<0.01	<0.01	<0.01	<0.01	<0.01

Limitations:

Bedrock Geology

Overburden thickness and the contour of bedrock surface were interpreted using available Water Well Information System data. Well data was only available for the smaller, populated area within the Source Protection Area. Data gaps exist for areas north and south of the populated areas, preventing interpretation of overburden thickness and the contour of bedrock topography for these areas.

Surficial Geology

The Surficial Geology of Southern Ontario dataset does not provide mapping data for surficial geology of a small section in the south-western corner of SP Area. Therefore data from the Northern Ontario Engineering Geology Terrain Study (NOEGTS) was also used in order to provide seamless coverage of the SP Area.

Physiography

The Physiography of Southern Ontario only covers the southern section of the SP Area. Maps were developed by combining Northern Ontario Engineering Geology Terrain Study data (covers northern part of SP Area) and and Surficial Geology of Southern Ontario (covers southern part of SP Area).

Soils

There is a lack of complete and accurate mapping of soils for the SP Area. Best available soil information at this point is derived from underlying geology data. (Harry Cummings & Associates Inc 2001) Soils data for most of the SP Area is covered in the 1:50 000 scale soils data provided by the Ministry of Agriculture, Food and Rural Affairs so this dataset was used. No data is available for the Townships of Joly, Machar, Nipissing and Strong, and information is missing for part of Algonquin Park.

Species at Risk

The SP Area has not been extensively surveyed for occurrences of species at risk. The provincial Natural Heritage Information Centre, Ministry of Natural Resources, and Fisheries and Oceans Canada do not provide consistent data on species at risk in this area. Known occurrences appear to be associated with easily accessible study routes. Records may have resulted from other studies conducted in the area.

Water Quality

There are limitations in regards to assessing accurate trends relating to water quality in the SP area. Provincial programs such as the PWQMN and PGMN each involve the collection of surface water and groundwater samples, respectively, with the overall goal of water quality monitoring and assessment. Although these are useful tools, the amount of data currently on hand within the NBMCA SP Area is too sparse to determine dominant trends. Monitoring will continue towards an accurate statistical analysis of water quality parameters within the broader SP Area. A water quality analysis for the separate Municipalities in this report is further discussed in later sections.

2.2 Groundwater Vulnerability across the Source Protection Area

Determining groundwater vulnerability is a critical component towards the delineation of vulnerable areas in respect to groundwater. This includes Significant Groundwater Recharge Areas (SGRAs), Highly Vulnerable Aquifers (HVAs), and Wellhead Protection Areas (WHPAs). The Intrinsic Susceptibility Index (ISI) method was used for each groundwater vulnerable area in this assessment. Further refinement of individual WHPAs in relation to vulnerability are discussed in each municipal subsection, while SGRAs and HVAs are further discussed below.

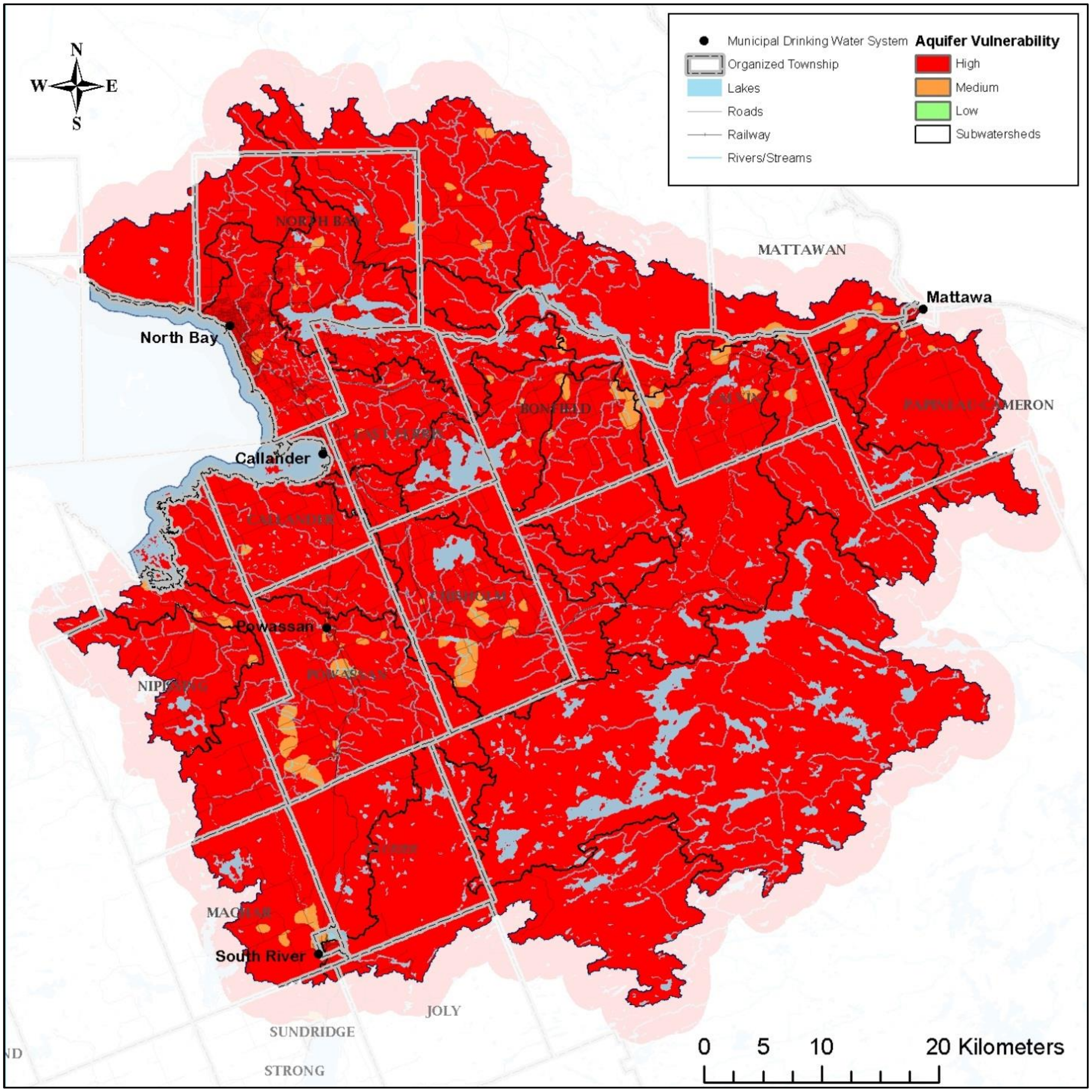
The nature of surficial deposits largely determines the susceptibility (mapped as Intrinsic Susceptibility Index - ISI) of the underlying aquifers to water-borne contaminants. Overburden soil layers are classified based on how readily each transmits water, and the thickness of each is considered. The estimated protective value of each layer is then added to calculate the total susceptibility at any point.

Most of the SP Area is shown as having high susceptibility. Data for this assessment comes from various sources; water well records being perhaps the most highly relied upon because of their detail and availability. Water well records provide a description of each soil type encountered and its depth during the drilling of a well. However, it should be recognized that in unpopulated areas, there are few well records and little data regarding the nature of the soils at depth. Therefore, the uniformly high susceptibility indicated in the southeast portion of the SP Area, mostly in the sparsely populated Algonquin Highlands, would probably be more variable if there were data available at a finer scale.

This mapping was originally prepared for the NBMCA Groundwater Study (Waterloo Hydrogeologic, 2006) and subsequently refined in some locations with the acquisition of additional data during the municipal groundwater studies for Mattawa, Powassan and Trout Creek; additional information is available in the 2006 Waterloo Hydrogeologic report.

SGRAs and HVAs were delineated using the mapped intrinsic susceptibility (Figure 2-11), as well as through further criteria discussed below.

Figure 2-11. Intrinsic Groundwater Vulnerability in the North Bay-Mattawa SP Area



2.2.1 Significant Groundwater Recharge Areas (SGRAs)

Significant Groundwater Recharge Areas (SGRAs) are a type of vulnerable area identified in the Technical Rules (MOE, 2009b) that will be protected under the *Clean Water Act (2006)*. Recharge areas are land areas where water seeps into an aquifer from rain and melting snow, supplying water to underlying aquifers. Recharge rates have previously been quantified through the North Bay–Mattawa Source Protection Area Conceptual Water Budget (Gartner Lee 2008a), and were further utilized for the delineation of SGRAs.

The identification of the SGRAs for any given watershed is considered a two step process. The first step is to delineate those areas that provide the most volume over the smallest area of recharge to the watershed. The second step is to consider which of these areas are hydrologically connected to a source of drinking water, both surface water and groundwater sources.

Significant Groundwater Recharge Areas were identified in accordance with Technical Rules 44 (1), 45 and 46 as follows:

> *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;*
>
> *45. Despite rule 44, an area shall not be delineated as a significant groundwater recharge area unless the area has a hydrological connection to a surface water body or aquifer that is a source of drinking water for a drinking water system.*
>
> *46. The areas described in rule 44 shall be delineated using the models developed for the purposes of Part III of these rules and with consideration of the topography, surficial geology, and how land cover affects groundwater and surface water.*

The Technical Rules (MOE, 2009b) require the identification of Significant Groundwater Recharge Areas (SGRAs) as a specific type of vulnerable area that will be protected under the *Clean Water Act (*2006). The role of SGRAs is to support the protection of drinking water across the broader landscape. SGRAs delineated using the water budget tools are further scored as areas of high, moderate or low groundwater vulnerability based on their mapped intrinsic susceptibility (see Figure 2-11).

Under Rule 46, the consideration of topography, surficial geology and land cover was considered in the Intrinsic Susceptibility Index (ISI) mapping shown in Figure 2-11 and furthermore in the SGRA delineation. Greater discussion on these factors is available in the Watershed Characterization section of this report.

Before determining SGRAs, the process requires calculating the rate of recharge within the area. Groundwater recharge is defined as the supply of water which infiltrates to the water table, supplied by either rainfall or snowmelt. The Conceptual Water Budget determined the rate of recharge within the SP area to be 208 mm/year. Greater detail on the calculations summarized below is available in Section 2.2.

With an annual recharge rate of 208mm/yr, and under Rule 44(1), SGRAs require delineating the area which annually recharges water to the underlying aquifer at a rate that is greater than a factor of 1.15 (or 115%) of the annual recharge rate. Within the North Bay-Mattawa SP Area, SGRAs are delineated as the areas with an annual recharge rate of 239.2 mm/yr or greater (208 mm/yr*1.15).

Under Rule 45, SGRAs only includes areas which are hydrologically connected to a surface water body or aquifer that is a source of drinking water for a drinking water system. Hydrological connectivity was determined by using two overlays overtop of the 1.15 times recharge area layer. For determination of groundwater connectivity, the Water Well Information

System layer was overlaid. If a recharge aquifer had one or more wells connected to it, it was determined that there is groundwater connectivity. For determination of surface water connectivity, the MPAC land-use layer was examined. If the source water was classified as a Lake or River, these parcels were determined to have surface water connectivity to the recharge area.

According to Rule 44 (1) and 45, Figure 2-12a illustrates the SGRAs for the SP Area, while Figure 2-12b shows SGRAs with the corresponding vulnerability scores (larger versions of these figures are provided in Appendix A). SGRAs can be given a vulnerability score of 6, 4, or 2, where the groundwater vulnerability is high, medium, or low, respectively.

Areas where significant, moderate or low drinking water threats can exist, within the umbrella of SGRAs, are summarized in Table 2-11, and further supported by the SGRA map.

The table headings within Table 2-12 (CSGRAHVA6M and CSGRAHVA6L) represent the MOE Provincial Tables of Circumstances which apply to SGRAs. These provincial tables outline the specific circumstances related to potential chemical threats. Note that pathogen threats cannot exist for an SGRA, and areas with a vulnerability score of 4 or 2 cannot contain even a low threat. The actual provincial tables can be found at http://www.ene.gov.on.ca/environment/en/legislation/clean_water_act/STDPROD_081301.html

The table headings in Table 2-12 are acronyms for the list of circumstances which constitute as potential threats. The corresponding tables relating to SGRAs represent:

- C **C**hemical Threats in a
- D DNAPL Threat in a
- SGRA **S**ignificant **G**roundwater **R**echarge **A**rea or
- HVA **H**ighly **V**ulnerable **A**quifer with a vulnerability score of
- 6 **six**, categorized as a
- M or L **M**oderate or **L**ow threat

Because of the maximum vulnerability score of 6 applied to SGRAs, there are no significant threats associated with these areas.

Table 2-11. Areas within SGRAs where Activities Are or Would be Significant, Moderate and Low Drinking Water Threats

Threat Type	Vulnerable Area	Vulnerability Score	Threat Level Possible		
			Significant	Moderate	Low
Chemical	SGRA	6	NA	✓	✓

Table 2-12. Summary of Tables of Circumstances Related to SGRAs

Vulnerability Score	Significant	Moderate	Low
6	NA	CSGRAHVA6M	CSGRAHVA6L

		DWHVASGRA6M	DWHVASGRA6L

In accordance with the Technical Rules a water quality issue in the SGRA may be identified if the presence of a parameter listed in the Ontario Drinking Water Quality Standards is shown to deteriorate the quality of the water as a source of drinking water, or there is a trend towards deterioration of the quality of the water as a source of drinking water. Groundwater quality data in the area is limited to the data collected as part of the Provincial Groundwater Monitoring Network, as discussed in Section 2.1. There are a total of 2 Provincial Groundwater Monitoring wells located in the SGRA. A review of the water quality data from these wells indicate that there are no known issues associated with these areas. Note that this conclusion has been based on a limited amount of data. Additional data would be required to confirm that there are no issues in these areas.

Figure 2-12a. Significant Groundwater Recharge Areas (SGRAs)

Note: larger 11" x 17" version is available in Appendix A.

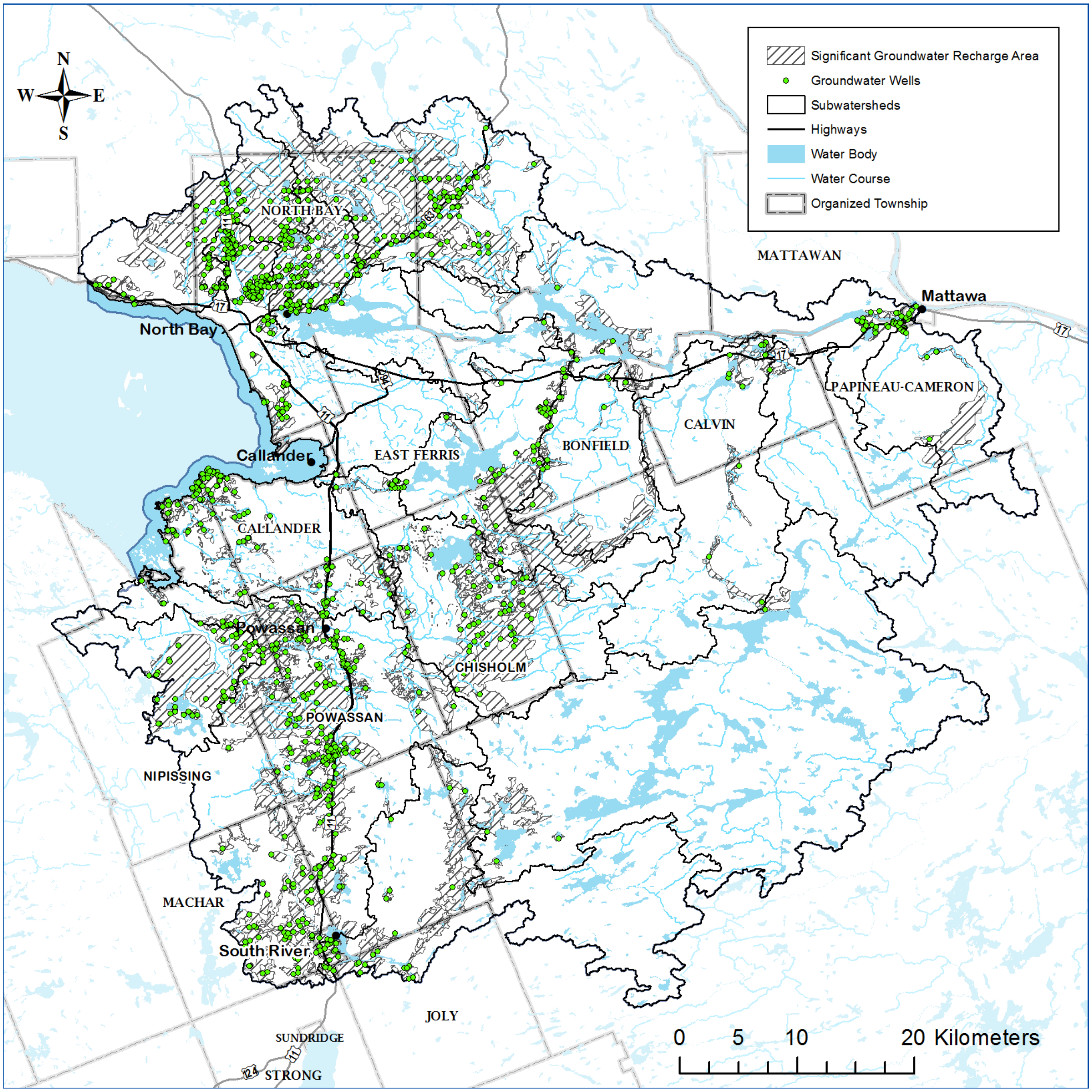
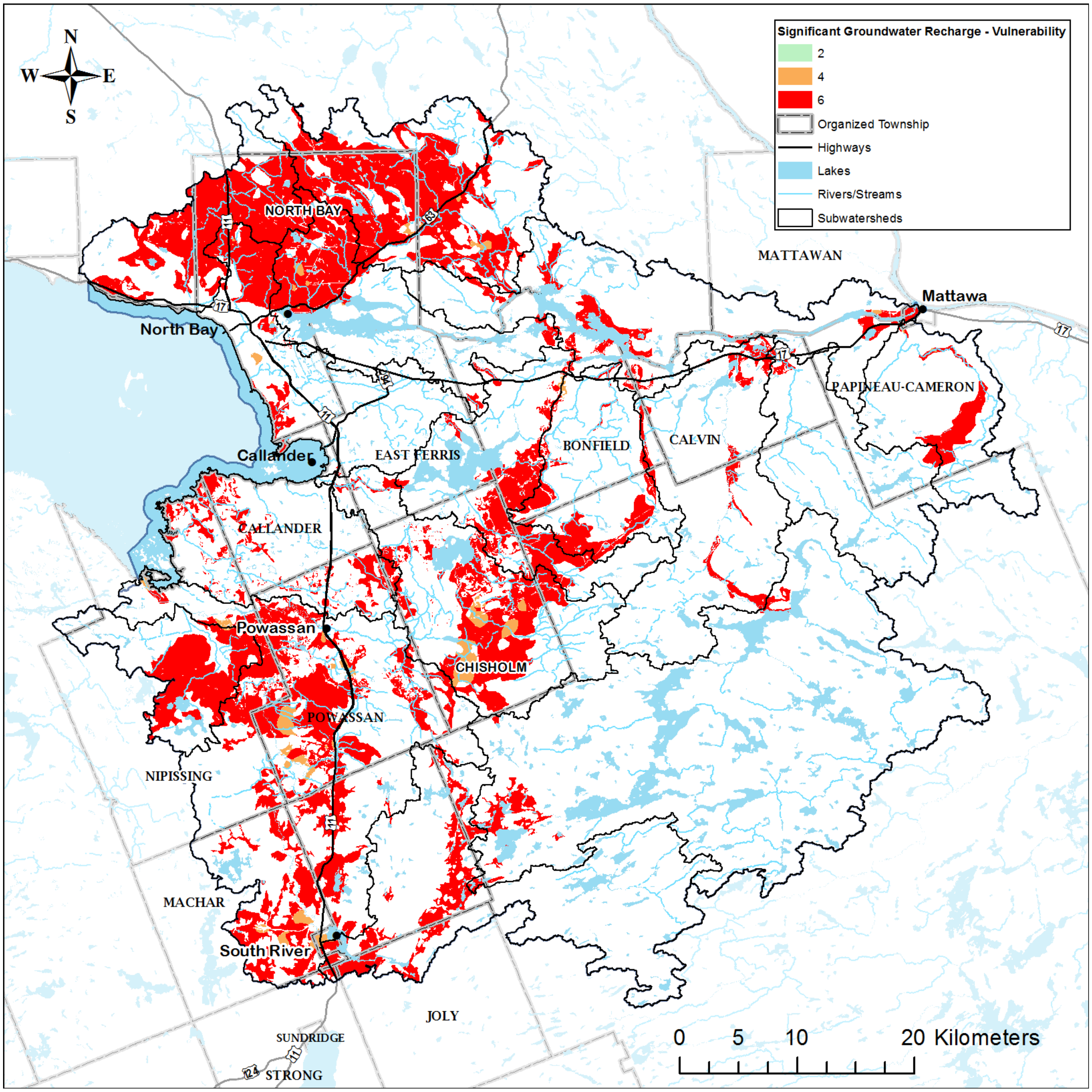

N
W
E
S
Significant Groundwater Recharge Area
Groundwater Wells
Subwatersheds
Highways
Water Body
Water Course
Organized Township
NORTH BAY
MATTAWAN
Mattawa
North Bay
PAPINEAU-CAMERON
CALVIN
BONFIELD
EAST FERRIS
Callander
CALLANDER
Powassan
CHISHOLM
POWASSAN
NIPISSING
MACHAR
South River
JOLY
SUNDRIDGE
STRONG
0 5 10 20 Kilometers

Figure 2-12b. Vulnerability Scoring within Significant Groundwater Recharge Areas (SGRAs) Note: larger 11" x 17" version is available in Appendix A.



2.2.2 Highly Vulnerable Aquifers (HVAs)

A highly vulnerable aquifer (HVA) is defined as the subsurface beneath areas of high groundwater vulnerability (Technical Rule 43). The type and thickness of the overlying substrate can determine the vulnerability of the aquifer to contamination from surface activities, and as such is used as the basis for determining HVAs.

The intrinsic susceptibility index (ISI) method was used to assess groundwater vulnerability in the SP Area, which categorizes aquifers into areas of high, medium or low vulnerability (Rule

38). Areas with high vulnerability are automatically given a vulnerability score of 6 within HVAs. HVAs in the North Bay-Mattawa SP Area are shown in Figure 2-13 (larger version of this figure is provided in Appendix A. Note that for the Trout Creek areaHVAs were mapped based on the vulnerability for the shallow aquifer. Areas where significant, moderate or low drinking water threats can exist, within the umbrella of HVAs, are summarized in Table 2-13, and further supported by the HVA map.

The table headings within Table 2-14 (CSGRAHVA6M and CSGRAHVA6L) represent the MOE Provincial Tables of Circumstances which apply to HVAs. These provincial tables outline the specific circumstances related to potential chemical threats (note that pathogen threats cannot exist for an HVA). The actual provincial tables can be found at http://www.ene.gov.on.ca/environment/en/legislation/clean_water_act/STDPROD_081301.html

The table headings in Table 2-14 are acronyms for the list of circumstances which constitute as potential threats. The corresponding tables relating to HVAs represent:

- C **C**hemical Threats in a
- D DNAPL Threat in a
- SGRA **S**ignificant **G**roundwater **R**echarge **A**rea or
- HVA **H**ighly **V**ulnerable **A**quifer with a vulnerability score of
- 6 **six**, categorized as a
- M or L **M**oderate or **L**ow threat

Because of the vulnerability score of six applied to HVAs, there are no significant threats associated with them.

Table 2-13. Areas within HVAs where Activities Are or Would be Significant, Moderate and Low Drinking Water Threats

Threat Type	Vulnerable Area	Vulnerability Score	Threat Level Possible		
			Significant	Moderate	Low
Chemical	HVA	6		✓	✓

Table 2-14. Summary of Tables of Circumstances Related to HVAs

Vulnerability Score	Significant	Moderate	Low
6	NA	CSGRAHVA6M DWHVASGRA6M	CSGRAHVA6L DWHVASGRA6L

In accordance with the Technical Rules a water quality issue in the HVA may be identified if the presence of a parameter listed in the Ontario Drinking Water Quality Standards is shown to deteriorate the quality of water as a source of drinking water, or there is a trend towards deterioration of the quality of the water as a source of drinking water. Groundwater quality data in the area is limited to the data collected as part of the Provincial Groundwater Monitoring Network, as discussed in Section 2.1. A review of this information indicates that there are no known issues associated with these areas. Note that this conclusion has been based on a limited amount of data. Additional data would be required to confirm that there are no issues in these areas.

2.2.3 Limitations

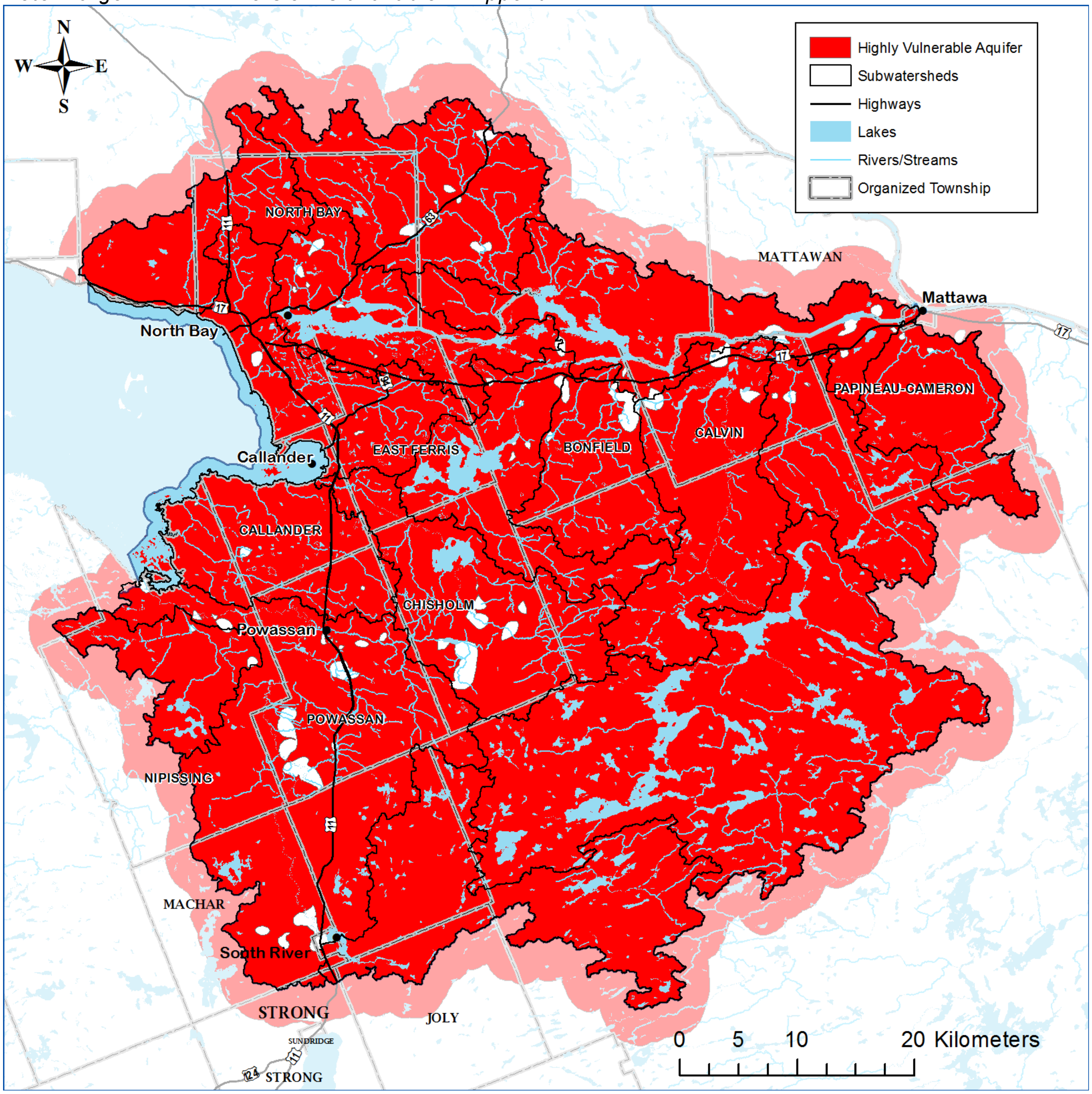
The lack of Water Well Information System data in some areas presents a data gap in significant hydrologic features related to groundwater discharge and recharge. It should be recognized that in unpopulated areas, there are few well records and little data regarding the nature of the soils at depth. Therefore, the uniformly high susceptibility indicated in the southeast portion of the SP Area, mostly in the sparsely populated Algonquin Highlands, would probably be more variable if there were data available at a finer scale.

2.2.4 Uncertainty

The process towards delineating SGRAs and HVAs was completed following standardized guidance from the Province. However, the lack of Water Well Information System data in certain areas of the region results in shortcomings related to knowledge of soil depth/type and the corresponding susceptibility to recharge, discharge or contamination. As such, both SGRAs and HVAs are considered to have a high uncertainty in much of the area.

Figure 2-13. Highly Vulnerable Aquifers (HVAs)

Note: larger 11" x 17" version is available in Appendix A.



2.3 Impervious Surfaces

Impervious surfaces are included in drinking water source protection because of concerns regarding road salt application. Both sodium and chloride, the component ions of road salt have potential impacts to water quality. In the North Bay-Mattawa SP Area, only roads were considered. Data at the resolution necessary to identify parking lots was not available.
The area was divided into 1 km grids centered on the SP Area according to the provincial standard, and each square was assessed as to percentage of impervious surfaces (roadways) in four categories:

- Less than 1%
- Between 1% and 8%
- Between 8% and 80%
- Equal to or greater than 80%

Roadways were identified using the Ontario Road Network feature class from Land Information Ontario, last updated in 2009. Estimates of paved widths varied as follows:

- 8.5 m for most streets and roadways
- 12 m for Highway 11 and Highway 17
- 15 m for major urban streets and boulevards
- 18.5 m for sections of Algonquin Blvd. In North Bay

The resulting coverage of impervious surfaces was then compared to vulnerable areas to determine where the application of road salt would be either a significant moderate or low threat. Areas where the threat was less than low were not mapped. Table 2-15 summarizes the relationship between impervious surface coverage, vulnerability and resulting threat level.

Table 2-15. Impervious Surfaces Threat Status within Vulnerable Areas

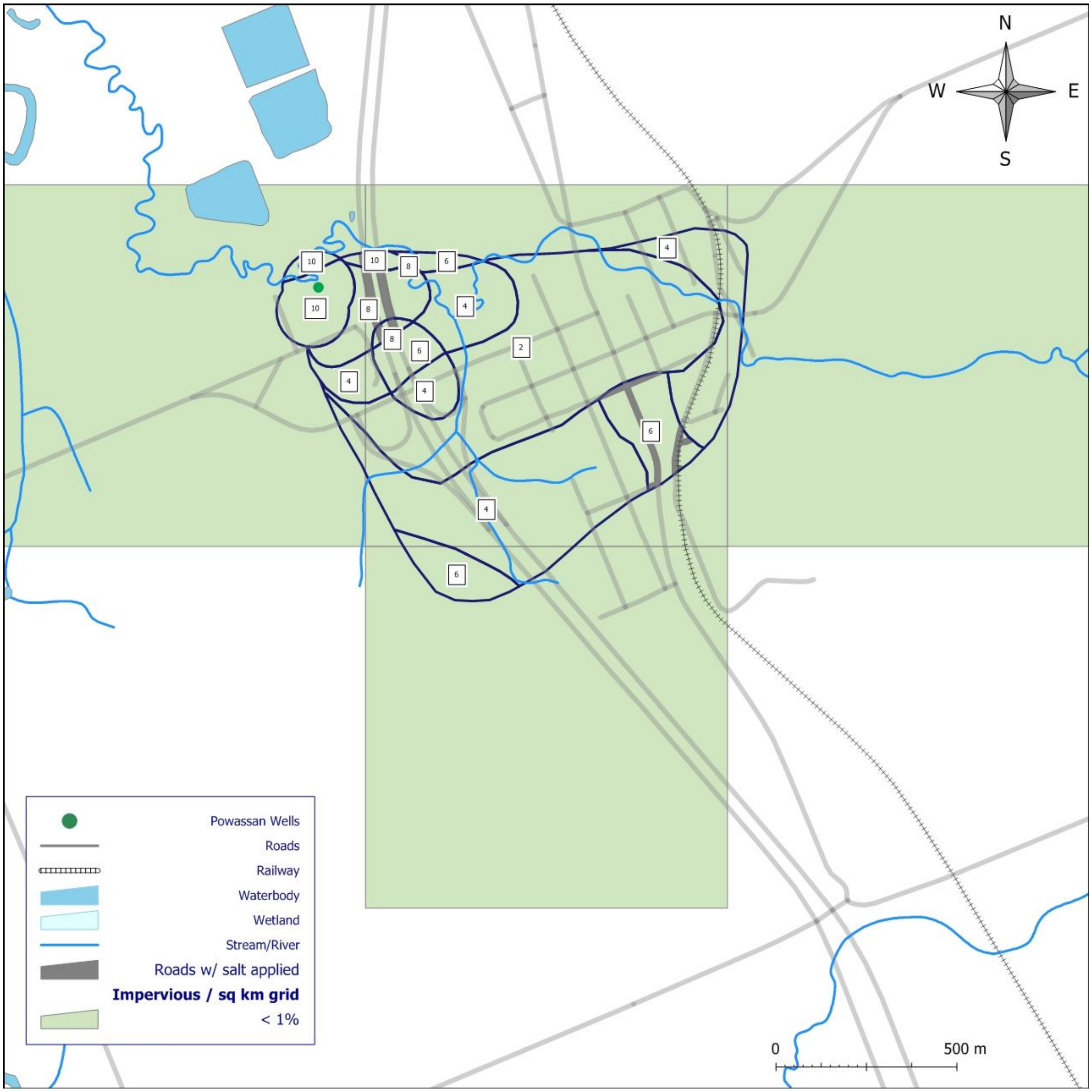
Impervious Surface Circumstance (Ref #)	Vulnerable Area	Vulnerability Score and Threat Status		
		Significant	Moderate	Low
Less than 1% Presence of Chloride (88) or Sodium (89) in GW or SW	IPZs		9 - 10	6 - 8.1
	WHPAs			8 - 10
	HVA			
	SGRA			
Between 1% and 8% Presence of Chloride (90) or Sodium (91) in GW or SW	IPZs		8 - 10	5.4 - 7.2
	WHPAs		10	6 - 8
	HVA			6
	SGRA			6
Between 8% and 80% Presence of Chloride (92) or Sodium (93) in GW or SW	IPZs	10	8 - 9	4.9 - 7.2
	WHPAs		8 - 10	6
	HVA			6
	SGRA			6
Greater than 80% Presence of Chloride (94) or Sodium (95) in GW or SW	IPZs	9 - 10	7 - 8.1	4.5 - 6.4
	WHPAs	10	8	6
	HVA			6
	SGRA			6

Potential drinking water threats pertaining to the application of road salt have also been considered throughout the individual threats assessments for each municipal drinking water source (Sections 4 to 9). Through these threats assessments, any potential significant drinking water threat within certain vulnerable areas must be addressed in the forthcoming Source Protection Plan phase. More details are in the subsequent municipal sections.

2.3.1 Municipality of Powassan

Figure 2-14 shows Powassan's total impervious surfaces area map. Very small areas of the Powassan WHPA score high enough to consider impervious surfaces, including a section of Highway 11 and a portion of Main Street. All areas considered have a total impervious surfaces area of <1% . As a result, there are no existing significant threats relating to impervious surfaces for the Municipality of Powassan.

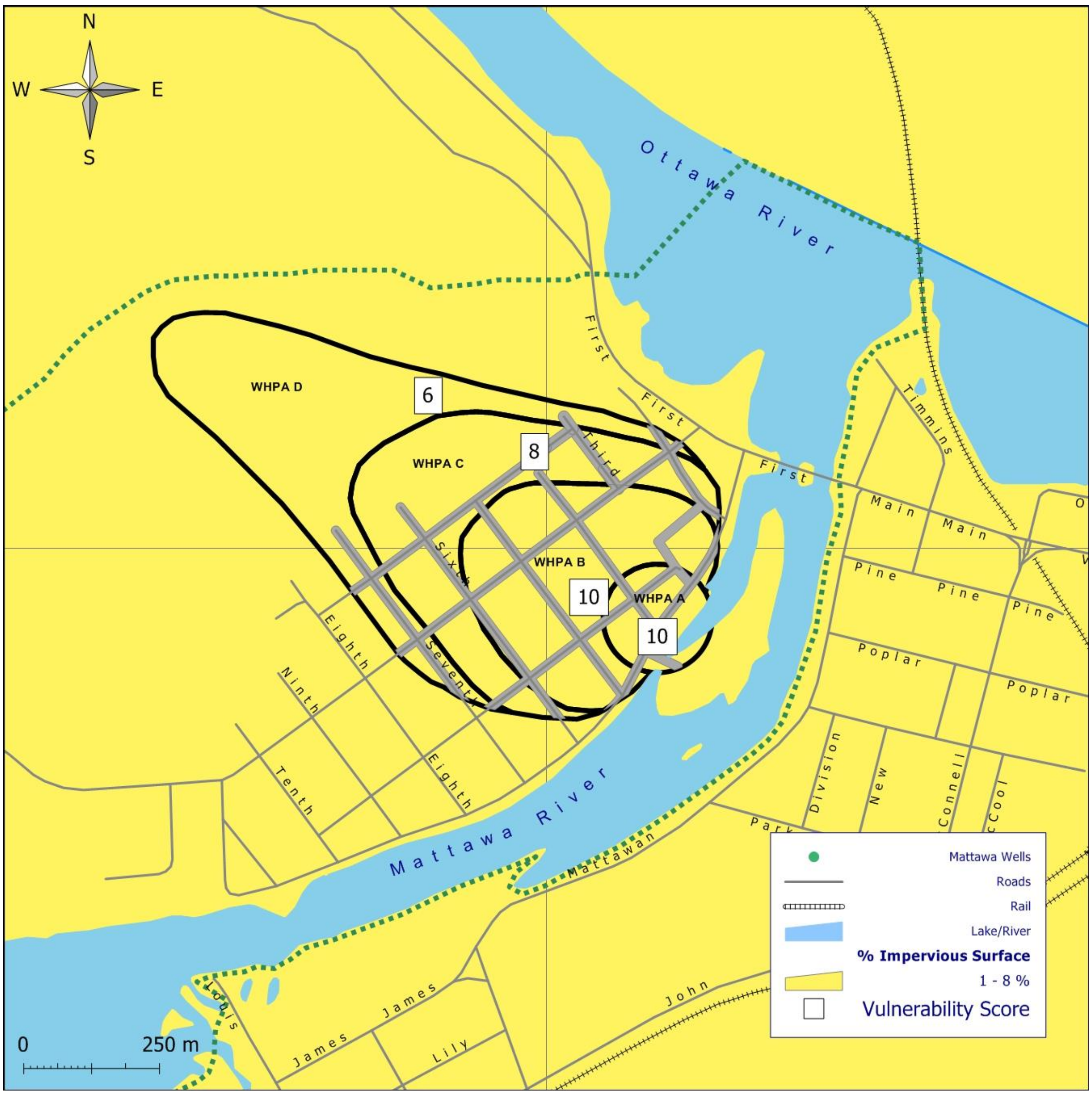
Figure 2-14. Impervious Surfaces in the Powassan Wellhead Protection Area


N
W
E
S
10
10
8
6
4
10
8
4
8
6
2
4
4
6
4
6
Powassan Wells
Roads
Railway
Waterbody
Wetland
Stream/River
Roads w/ salt applied
Impervious / sq km grid
< 1%
0
500 m

2.3.2 Town of Mattawa

Figure 2-15 shows Mattawa's total impervious surfaces area map. The intrinsic susceptibility for Mattawa is classed as high for the entire area. This means impervious surfaces were considered for all WHPAs in Mattawa. The Mattawa WHPA is largely residential homes/properties, with small streets characterizing the general area. Most of the residential streets lie in the WHPA A and B, and the rest of the WHPA is undeveloped and unpopulated forested areas. The total impervious surfaces area in Mattawa is between 1-8%. As a result, there are no existing significant threats associated with impervious surfaces for the Town of Mattawa.

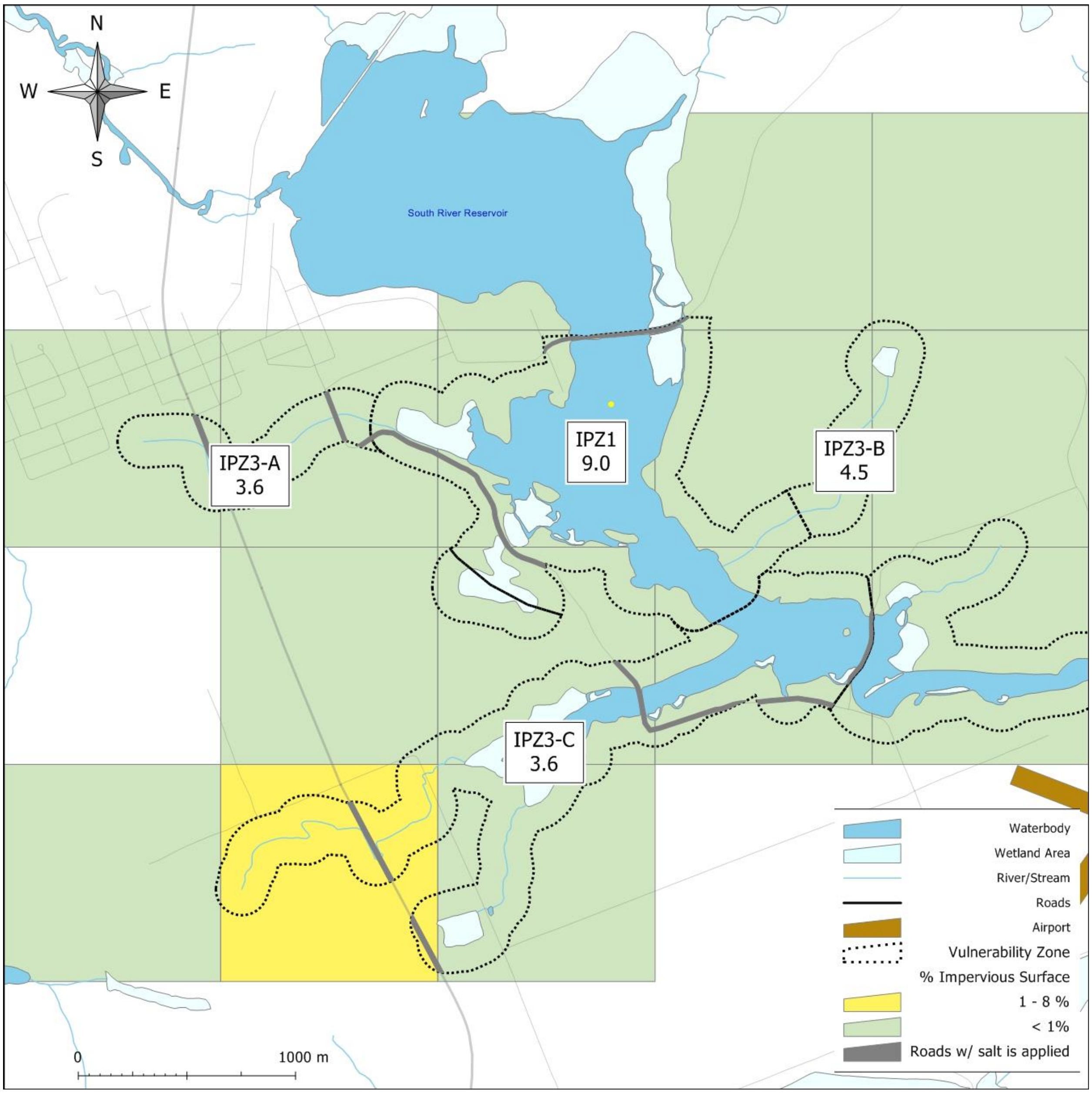
Figure 2-15. Impervious Surfaces in the Mattawa Wellhead Protection Area



2.3.3 Village of South River

Figure 2-16 shows South River's s total impervious surfaces area map. In South River, the IPZ-1 and areas of IPZ-3 have a high enough vulnerability score to be evaluated for impervious surfaces. Most of these vulnerable areas have a total impervious surfaces area of <1%, while one square kilometre grid area is ranked as 1-8%. Based on these circumstances, there are no existing significant threats associated with impervious surfaces for the Village of South River.

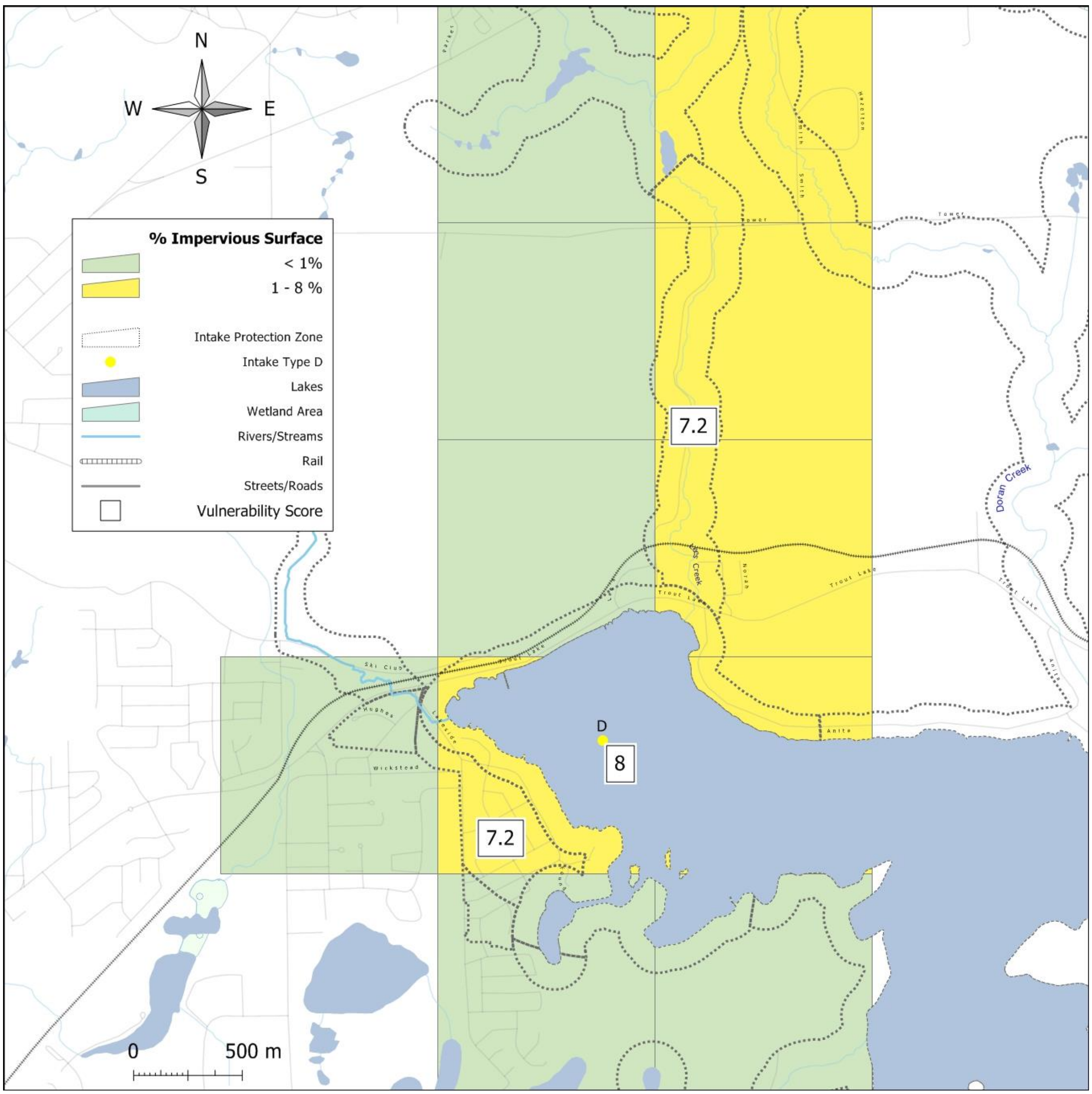
Figure 2-16. Impervious Surfaces in the South River Intake Protection Zone



2.3.4 City of North Bay

Figure 2-17 shows North Bay's total impervious surfaces area map. For the City of North Bay, of the 11 square kilometre grid zones where the vulnerability score is high enough to be evaluated for impervious surfaces, roughly 6 square kilometres have <1% impervious surfaces because of a lack of paved roads over large portions of these areas. The other five square kilometres were ranked with a total impervious surfaces area of 1-8% where salt is applied. These areas include the Lee's Road corridor to Tower Drive, and the residential area west of Delaney Bay. Based on these circumstances, there are no existing significant threats associated with impervious surfaces for the City of North Bay.

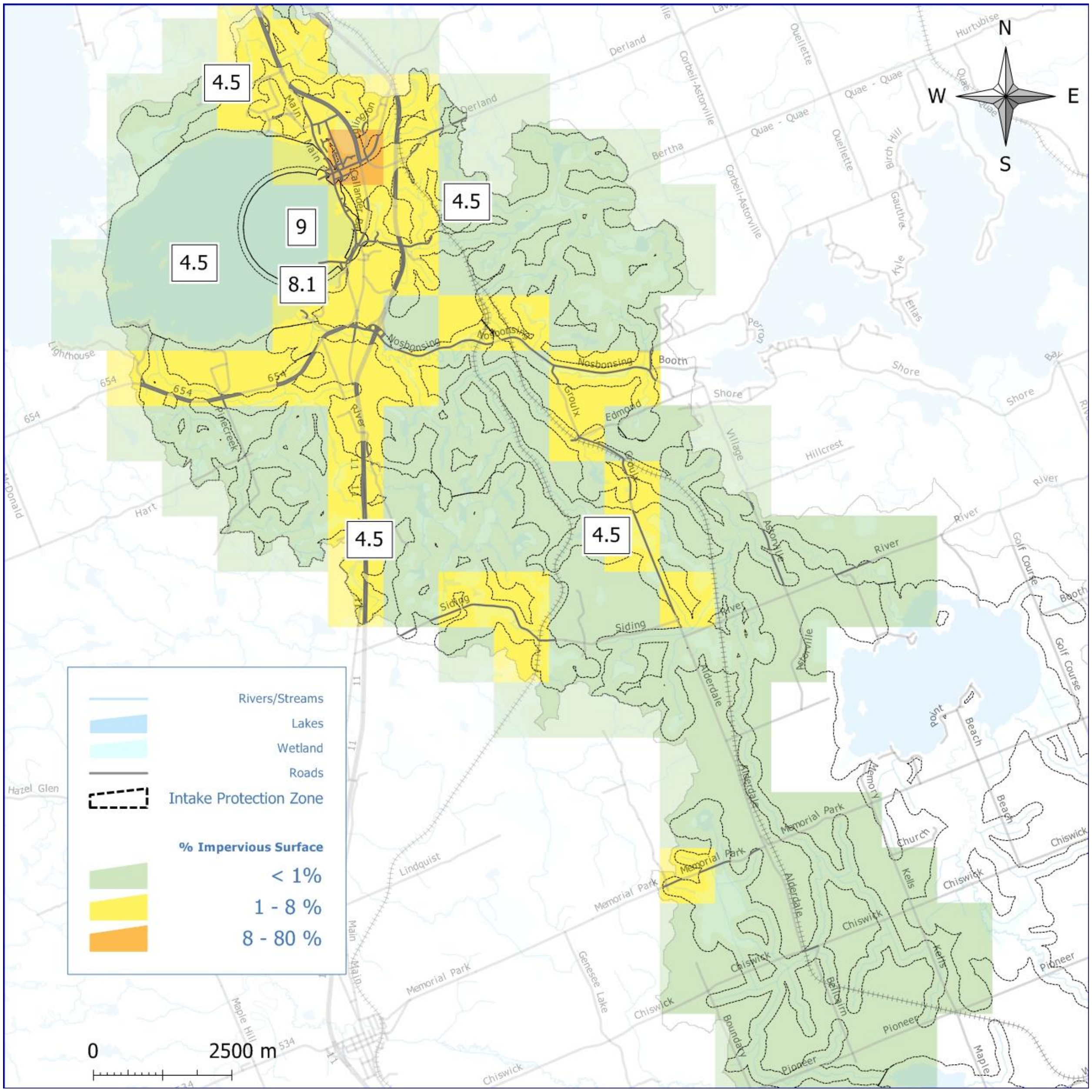
Figure 2-17. Impervious Surfaces in the North Bay Intake Protection Zone



2.3.5 Municipality of Callander

Figure 2-18 shows Callander's total impervious surfaces area map. The IPZ-1 and IPZ-2 of the Callander Bay intake covers much of Callander's urban developed areas, while the IPZ-3 has a vulnerability score high enough to evaluate impervious surface in the rural areas of Chisholm. 14 square kilometre grid areas of this region were ranked as having <1% total impervious surfaces per square km area, while 37 grid areas have a total impervious surfaces area of 1-8%. There is one grid area inside Callanders' IPZ 1 and 2, in downtown Callander, where the total Impervious surfaces area is 8-80% of the total area; however, the vulnerability score in this area is not high enough to consider this grid as containing a significant threat to drinking water. Based on these circumstances, there are no existing significant threats associated with impervious surfaces for the Municipality of Callander.

Figure 2-18. Impervious Surfaces in the Callander Intake Protection Zone

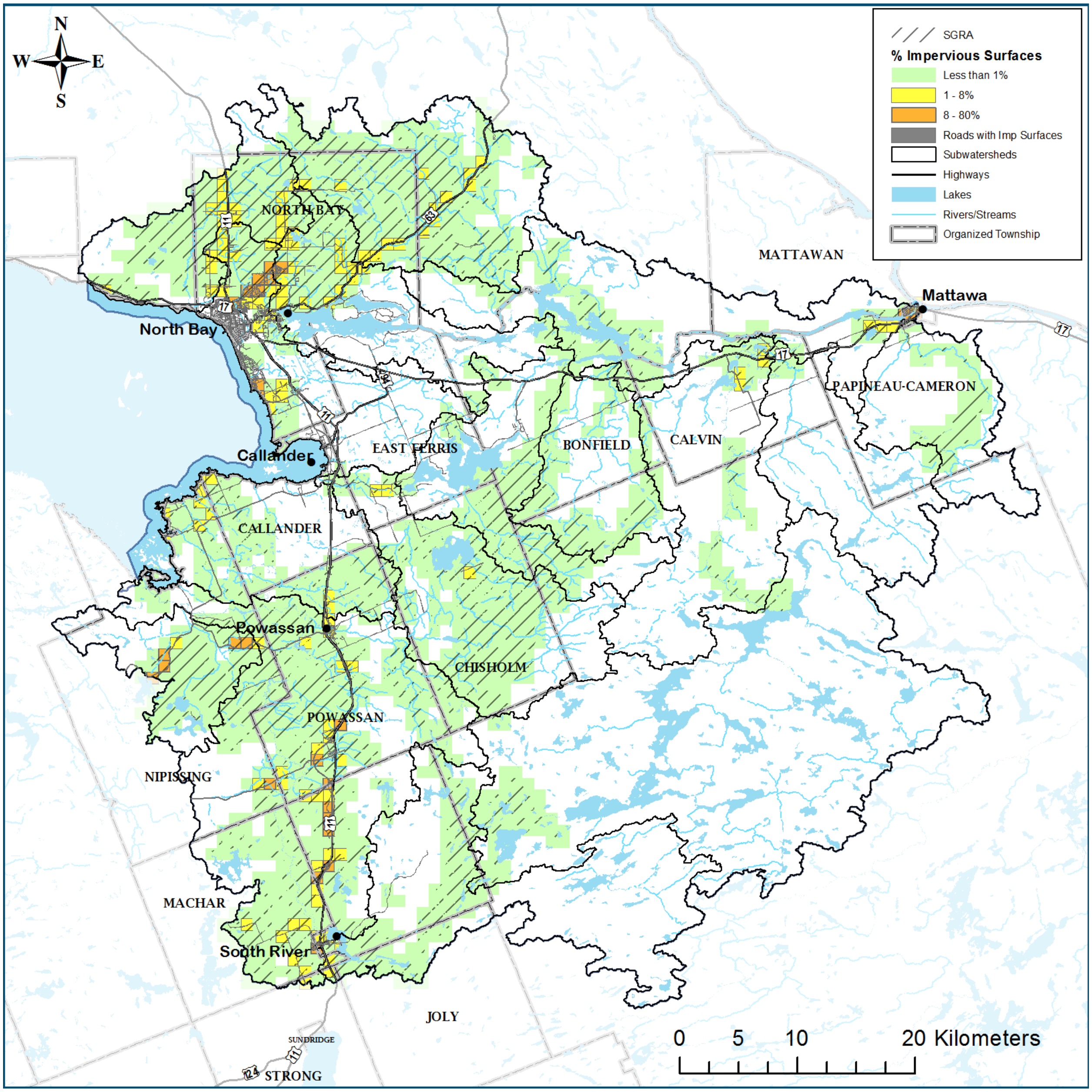


2.3.6 Significant Groundwater Recharge Areas (SGRA)

Figure 2-21 shows the impervious surfaces for SGRAs in the area. Due to the relatively undeveloped nature of the SP Area, the majority of the region is classified as having either no impervious surfaces or <1%. Much of the 1-8% impervious surfaces occurs along city roads and connecting highways. The City of North Bay holds 8-80% impervious surfaces within much of the urban areas of the City. There are also many pockets of 8-80% impervious surfaces in developed areas of Callander, Powassan, Mattawa, and South River.

Because of the low vulnerability score, there are no significant threats associated with impervious surfaces for SGRAs.

Figure 2-19. Impervious Surfaces in Significant Groundwater Recharge Areas



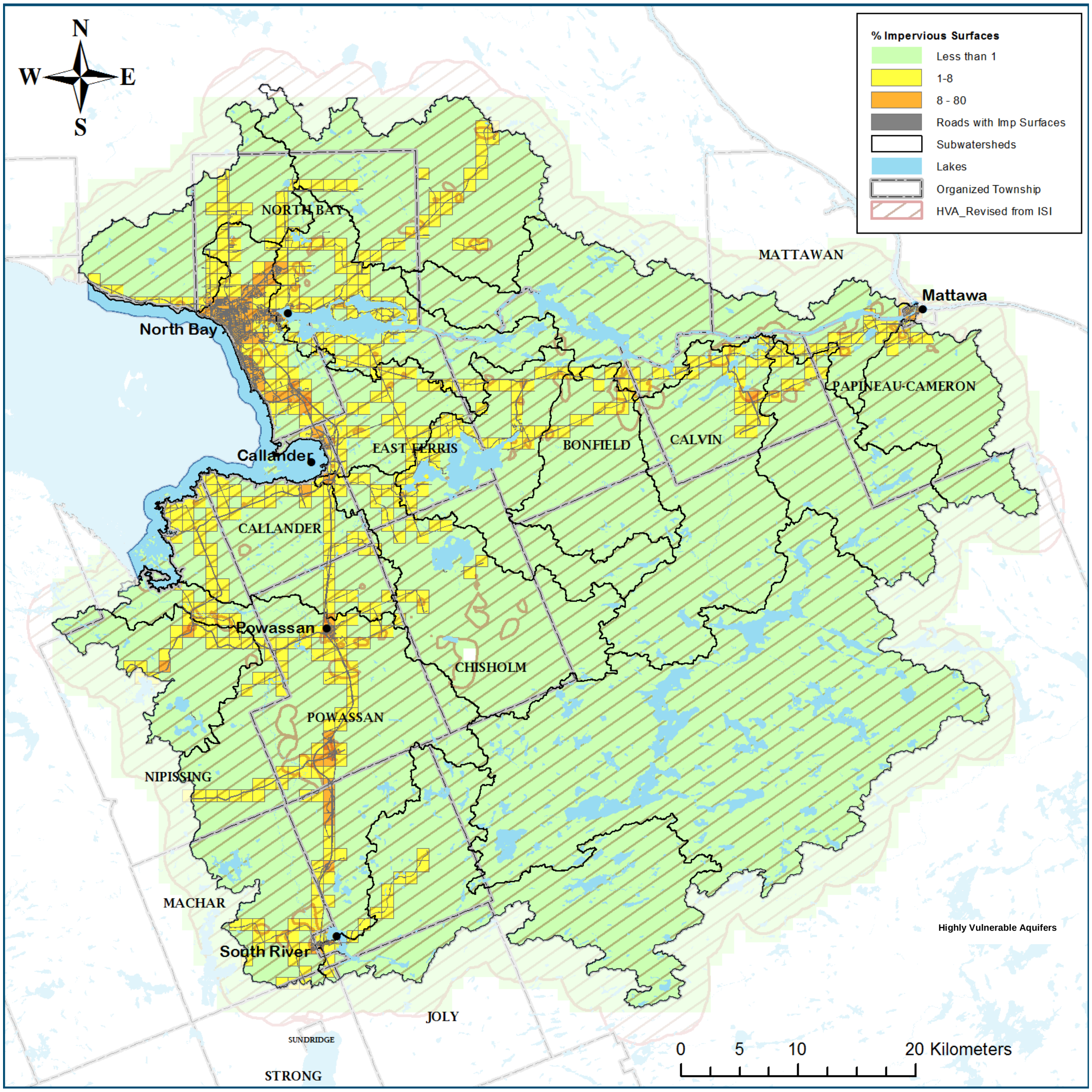
N
W
E
S
SGRA
% Impervious Surfaces
Less than 1%
1 - 8%
8 - 80%
Roads with Imp Surfaces
Subwatersheds
Highways
Lakes
Rivers/Streams
Organized Township
NORTH BAY
North Bay
MATTAWAN
Mattawa
PAPINEAU-CAMERON
EAST FERRIS
BONFIELD
CALVIN
Callander
CALLANDER
Powassan
CHISHOLM
POWASSAN
NIPISSING
MACHAR
South River
JOLY
SUNDRIDGE
STRONG
0 5 10 20 Kilometers

2.3.7 Highly Vulnerable Aquifers (HVA)

Similar to SGRAs, most of the HVA is generally undeveloped and with low populations outside of urban areas. As such, road salt application is generally low, as either <1% or no impervious surfaces. The highest percentages of vulnerable areas with impervious surfaces are in the urban and smaller urban centres. HVAs in Powassan, Mattawa and the City of North Bay are considered to have areas of 8 - 80% Impervious Surfaces. Callander has a small amount of Highly Vulnerable Aquifers in the District boundary, and South River is characterized as having between 1 and 8% impervious surfaces.

Because of the low vulnerability score, there are no significant threats associated with impervious surfaces for HVAs.

Figure 2-20. Impervious Surfaces in Highly Vulnerable Aquifers



2.3.8 Limitations

Private and public parking lots could not be considered in the impervious surfaces area calculation. This data was not available for the SP Area, the time to create this would be more than manageable for current staff. Since these areas are likely to have road salts applied, particularly during the winter months, impervious surfaces should be reassessed once the information becomes available.

2.4 Managed Lands and Livestock Density

Managed Lands

Managed land is land to which nutrients (fertilizer) may be applied. Managed lands can be broken into two subsets: agricultural managed land such as cropland, fallow, and improved pasture, and non-agricultural managed land such as golf courses, sports fields, lawns and other grassed areas. Data from MPAC (Municipal Property Assessment Corporation) was used for this analysis.

The Assessment Report process includes identifying areas involved in the potential application of agricultural source material, non-agricultural source material and commercial fertilizers within each vulnerable area. These areas are expressed as a percentage of the total vulnerable area being evaluated. More details pertaining to the individual vulnerable areas discussed below are available in the various corresponding sections of this report.

The percentage of managed land area within a vulnerable area or subset of the vulnerable area was calculated as the sum of agricultural managed land and non-agricultural managed land, divided by the total land area within the vulnerable area (or subset of the area) multiplied by 100.

Thresholds for threat levels for managed lands are as follows:

- Low - areas less than 40% managed lands have a low potential for nutrient application to be causing contamination
- Moderate - areas with between 40% and 80% managed lands have a moderate - potential for nutrient application to be causing contamination
- High - areas with managed lands greater than 80% have a high potential for nutrient application to be causing contamination

Livestock Density

Livestock density is used as a surrogate measure of the potential for generating, storing, and applying agricultural source material as a source of nutrients within a defined area. Livestock density is estimated by comparing nutrient units (NU) to the total area of agricultural managed lands. Livestock density is expressed as nutrient units/acre (NU/Acre).

NUs are expressed as either the number of animals housed or pastured at one time on a farm unit, or where no animals are housed the weight or volume of manure/other biosolids used annually on a Farm Unit. The number of animals was obtained for the most part by using MPAC data. In some cases, landowners were contacted within vulnerable areas to verify the data. Once the type of livestock operation is known, the next step was to estimate the area of the livestock building. The square footage of each identified livestock building was estimated using GIS applications.

Once the livestock type and the barn dimensions were known, the number of NUs on a farm unit were determine using the conversion factors shown in Table 2-16 below. For the use of land as a livestock outdoor confinement area (OCA) or a farm-animal yard within the vulnerable areas, NUs were also calculated for animal species that have the potential to dwell in an outdoor confinement area at the farm level. The nutrients generated at an annual rate were determined by the number of NU for the farm divided by the size of the livestock OCA or a farm-animal yard, in square feet.

Table 2-16. NU Conversion Factors based on barn size for different MPAC farm classifications.

MPAC Classification	Sq.ft./NU	Sq.m./NU
Dairy	120	11
Swine	70	7
Beef	100	9
Chickens	267	25
Turkeys	260	24
Horse	275	26
Goat	200	19
Sheep	150	14
Fur	2,400	223
Mixed	140	13

Livestock density in an area, expressed in terms of nutrient units/acre (NU/Acre), was determined by dividing the NUs generated in each vulnerable area by the number of acres of agricultural managed land in that area where agricultural source material is applied. More details pertaining to the individual vulnerable areas discussed below are available in the various corresponding sections of this report.

The thresholds for evaluating the risk of nutrient application of ASM within vulnerable areas are:

- Low - less than 0.5 NU/acre is considered a low potential for exceeding crop requirements
- Moderate - over 0.5 and less than 1.0 NU/acre has a moderate potential for exceeding crop requirements
- High - greater than 1.0 NU/acre is considered a high potential for exceeding crop requirements

Determining Drinking Water Threats: Hazard Scores and Vulnerable Areas

The percentage of managed land and the livestock density of an area are then combined to represent the quantity of nutrients present as a result of nutrient generation, storage, and land application within a vulnerable area. In turn, an assessment on managed lands and livestock density is one method towards determining the potential impacts on water quality, particularly in regards to chemical threats posed by nitrogen and phosphorus.

The Tables of Drinking Water Threats requires consideration of the maps for both percentage of managed lands and livestock density when evaluating the circumstances and the thresholds for the land application of nutrients. The combination of percent of managed land and NU/Acre gives a hazard rating for the land application of nutrients, which is then coupled with the vulnerability scores of an area to determine the overall threat status of that activity. A high hazard rating, coupled with a vulnerability score of 9 or 10, may result in a significant chemical threat to surface water or groundwater.

Managed lands and livestock density are only evaluated in vulnerable areas where the vulnerability score is high enough for activities to be considered a significant, moderate or low drinking water threat. This would be a WHPA with a vulnerability score of 6 or higher, or an IPZ with a vulnerability score of 4.4 or higher. Significant Groundwater Recharge Areas (SGRAs) as well as Highly Vulnerable Aquifers (HVAs) are also considered for managed lands and livestock density.

Each of the vulnerable areas were mapped for managed lands and livestock density, and are further discussed below to determine whether a significant drinking water threat exists as a result of agricultural or non-agricultural activities. A summary of the possible threat levels involving the combination of managed lands and livestock density, coupled with specific vulnerability scores, is shown in Table 2-17.

Table 2-17. Managed Lands and Livestock Density

Managed Lands Classification	Livestock Density Classification	Chemical of Concern	Vulnerable Area	Vulnerability Score and Threat Status		
				Significant	Moderate	Low
Low (<40%)	Low (<0.5 NU/acre)	Nitrogen	IPZs		9 - 10	6 - 8.1
			WHPAs		10	8
			HVA			
			SGRA			
		Phosphorus (total)	IPZs		9 - 10	6 - 8.1
Low (<40%)	Medium (0.5-1 NU/acre)	Nitrogen	IPZs		8 - 10	5.4 - 7.2
			WHPAs		10	6 - 8
			HVA			6
			SGRA			6
		Phosphorus (total)	IPZs		8 - 10	5.4 - 7.2
Low (<40%)	High (>1 NU/acre)	Nitrogen	IPZs	10	7 -9	4.8 - 6.4
			WHPAs	10	8	6
			HVA			6
			SGRA			6
		Phosphorus (total)	IPZs	10	7 -9	4.8 - 6.4
Medium (40-80%)	Low (<0.5 NU/acre)	Nitrogen	IPZs		8 - 10	5.4 - 7.2
			WHPAs		10	6 - 8
			HVA			6
			SGRA			6
		Phosphorus (total)	IPZs		8 - 10	5.4 - 7.2
Medium (40-80%)	Medium (0.5-1 NU/acre)	Nitrogen	IPZs	10	7.2 - 9	4.8 - 7
			WHPAs		8 - 10	6
			HVA			6
			SGRA			6
		Phoshorus (total)	IPZs	10	8 - 9	4.9 - 7.2
Medium (40-80%)	High (>1 NU/acre)	Nitrogen	IPZs	9 - 10	7 - 8.1	4.5 - 6.4
			WHPAs	10	8	6
			HVA			6
			SGRA			6
		Phosphorus (total)	IPZs	9 - 10	7 - 8.1	4.5 - 6.4
High (>80%)	Low (<0.5 NU/acre)	Nitrogen	IPZs	10	7 - 9	4.8 - 6.4
			WHPAs	10	8	6
			HVA			6

Managed Lands Classification	Livestock Density Classification	Chemical of Concern	Vulnerable Area	Vulnerability Score and Threat Status		
				Significant	Moderate	Low
			SGRA			6
		Phosphorus (total)	IPZs	10	7 - 9	4.8 - 6.4
High (>80%)	Medium (0.5-1 NU/acre)	Nitrogen	IPZs	9 - 10	7 - 8.1	4.5 - 6.4
			WHPAs	10	8	6
			HVA			6
			SGRA			6
		Phosphorus (total)	IPZs	9 - 10	7 - 8.1	4.5 - 6.4
High (>80%)	High (>1 NU/acre)	Nitrogen	IPZs	9 - 10	7 - 8.1	4.5 - 6.4
			WHPAs	10	8	6
			HVA			6
			SGRA			6
		Phosphorus (total)	IPZs	9 - 10	7 - 8.1	4.5 - 6.4

Through this assessment, and further discussed below, there were no significant drinking water threats relating to managed lands and livestock density in any of the vulnerable areas.

It is worth noting that potential drinking water threats pertaining to the application of agricultural source material (ASM), commercial fertilizer or non-agricultural source material (NASM) have also been considered throughout the individual threats assessments for each municipal drinking water source (Sections 4 to 9). Through these threats assessments, any potential significant drinking water threat within certain vulnerable areas must be addressed in the forthcoming Source Protection Plan phase, as a means to protecting municipal drinking water. More details are available in the subsequent municipal sections.

2.4.1 Municipality of Powassan

Managed Lands

Powassan's managed lands are shown in Figure 2-21. Powassan's WHPAs include rural pasture land as well as the built-up town area, and so includes both agriculture and non-agricultural managed lands. Agricultural managed lands are present in WHPA-B and C (where vulnerability score is 6 or greater); these managed lands are represented by a single dairy farm operation spanning the area of these WHPAs. Several non-agricultural managed lands exist in each of the WHPAs, including yards or unused fields and the Powassan Fairgrounds.

The areas of each managed land parcel within individual WHPAs were combined and analyzed as an overall percentage of managed lands per each respective WHPA. The result is a managed lands percentage for each WHPA in the Powassan vulnerable area, which were classified as high, moderate or low, depending on the criteria mentioned at the beginning of this section. Since the percentage of managed lands within each separate vulnerable area was less than 40% of that vulnerable area, the managed lands classification is low within all of Powassan's vulnerable areas.

Livestock Density

Powassan's livestock density map is available in Figure 2-22. The dairy operation included in the managed lands analysis is the only property determined to have a livestock density score applicable in the Powassan vulnerable area.

The square footage of agricultural managed land was estimated using the GIS area measurement tool, and the NU's within each WHPA were then added up. Then, the NUs were divided by the area of agricultural managed farm land. Since this operation was determined to produce greater than 1.0 NU/acre of agricultural managed land, the livestock density was ranked as high within WHPA-B and C.

Drinking Water Threats

The managed lands and livestock density hazard scores assigned by MOE guidance were coupled with the vulnerability scores within the vulnerable areas to determine significant, moderate or low drinking water threats in relation to the land application of ASM, NASM and commercial fertilizers.

Based on the criteria shown in Table 2-17, there are no significant threats related to managed lands/livestock density in the Municipality of Powassan.

Figure 2-21. Managed Lands in the Powassan Wellhead Protection Area

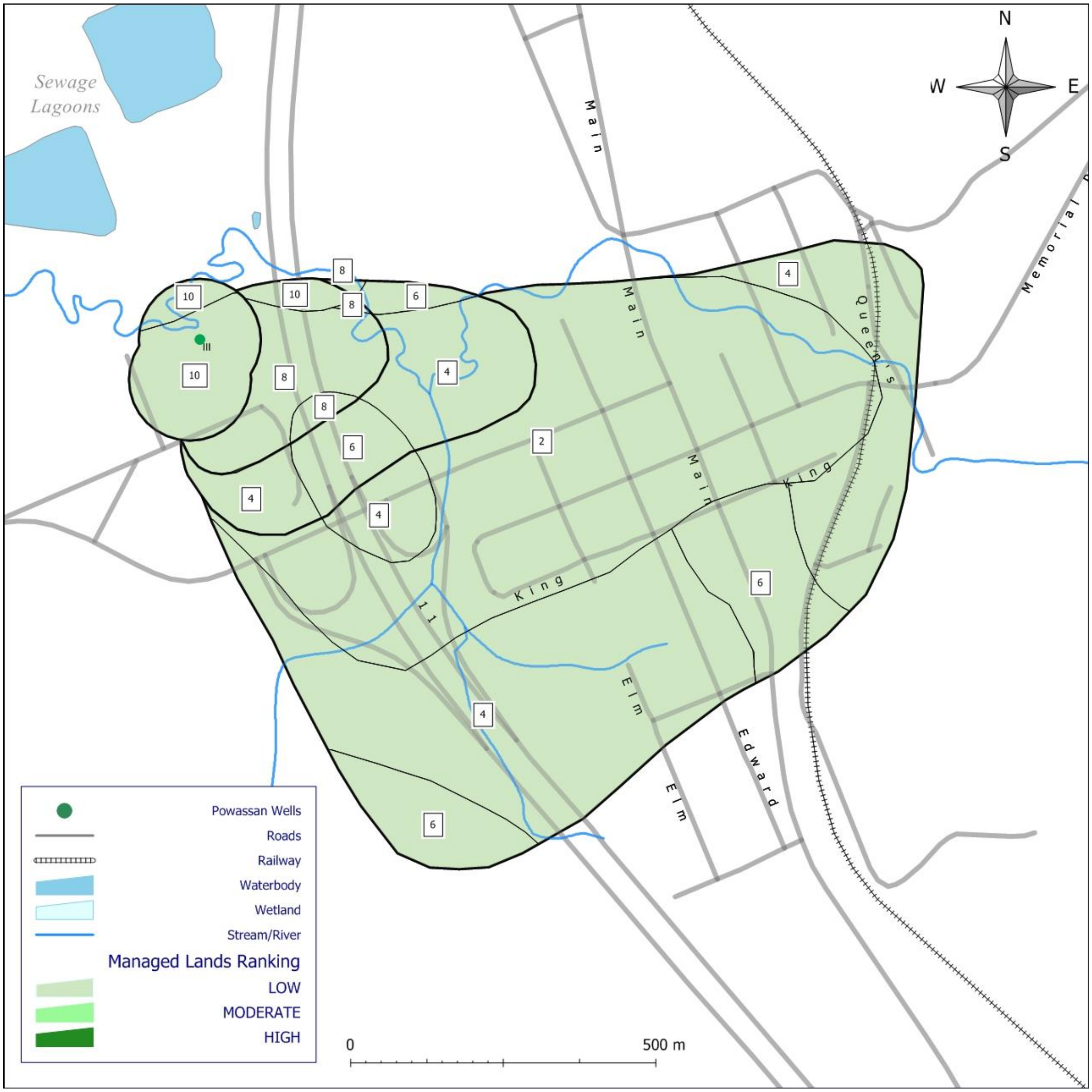
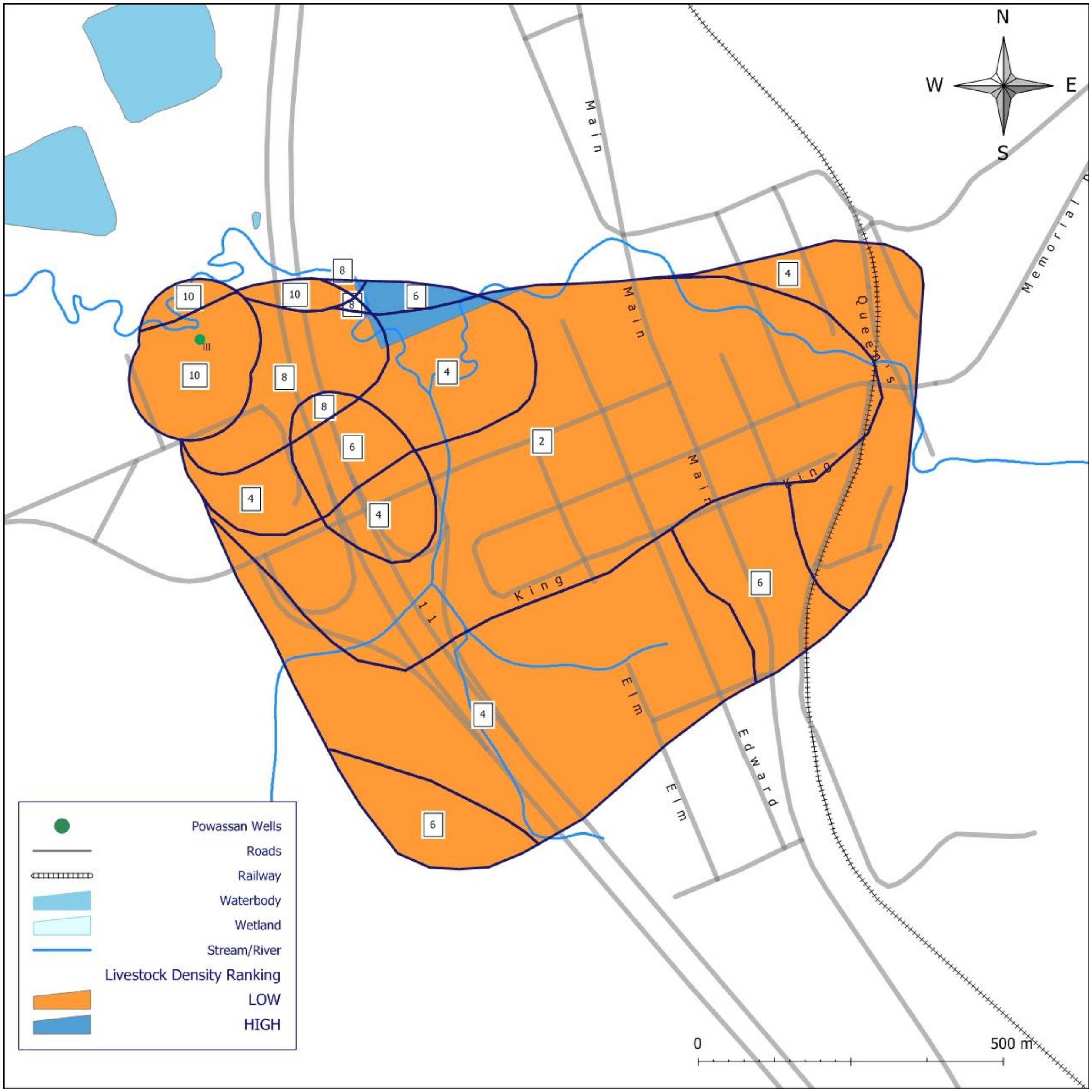


Figure 2-22. Livestock Density in the Powassan Wellhead Protection Area



2.4.2 Town of Mattawa

Managed Lands

Mattawa's managed lands are shown in Figure 2-23 below. There were no agricultural managed lands identified in any of the Mattawa WHPAs. Non-agricultural managed lands mainly relate to residential lawns, with a few commercial lawns.

The areas of each managed land parcel within individual WHPAs were combined and analyzed as an overall percentage of managed lands per each respective WHPA. The result is a managed lands percentage for each WHPA in the Mattawa vulnerable area, which were classified as high, moderate or low, depending on the criteria mentioned at the beginning of this section. Since the percentage of managed lands within each separate vulnerable area was less than 40% of each vulnerable area, the managed lands classification is low within all of Mattawa's vulnerable areas.

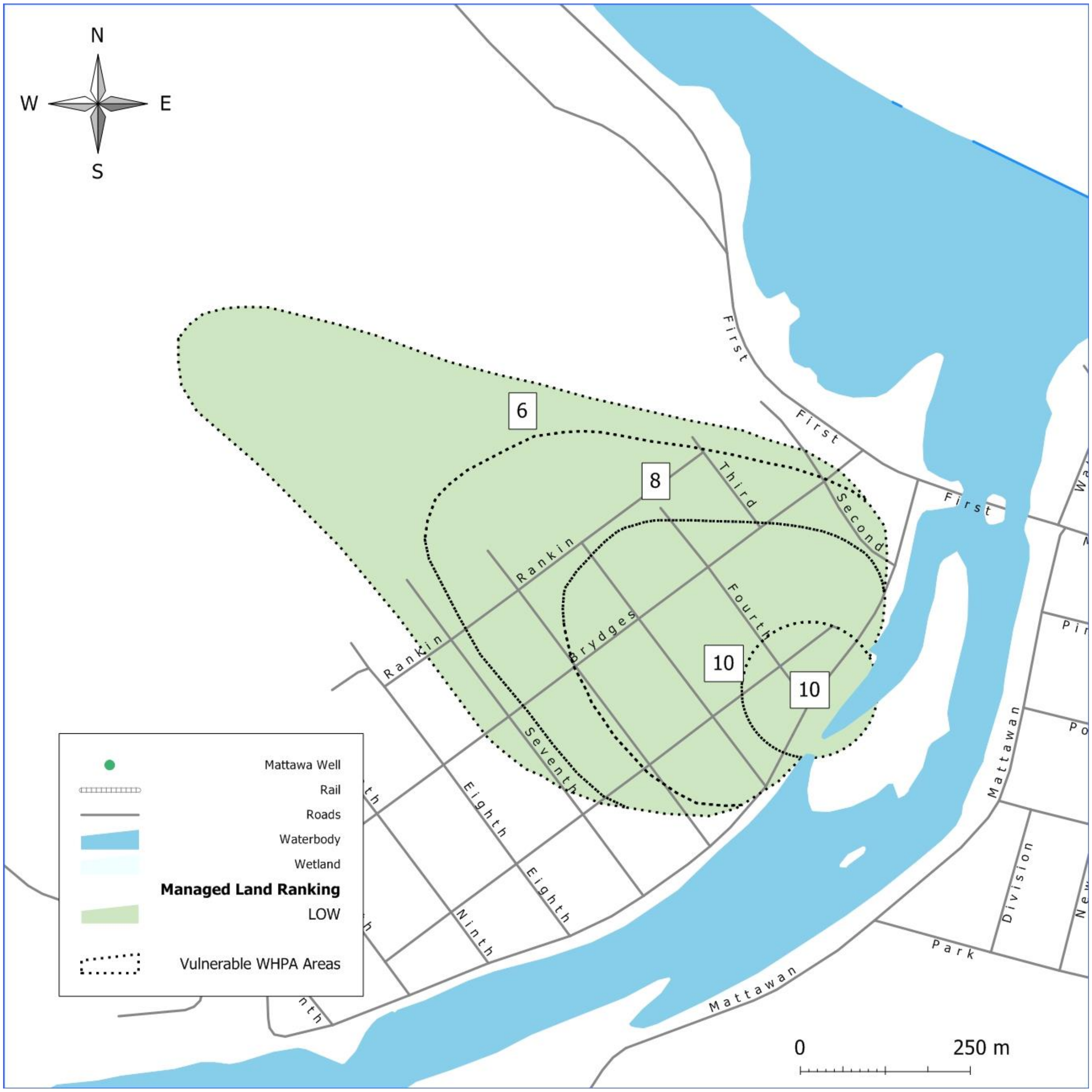
Livestock Density

Since there were no agricultural managed lands identified in the Mattawa vulnerable areas, a livestock density map was not included. Regardless, livestock density was considered low within all WHPAs.

Drinking Water Threats

Since entire WHPA scored low for managed land and for livestock density, and based on the criteria shown in Table 2-17, there are no significant threats related to managed lands/livestock density in the Town of Mattawa.

Figure 2-23. Managed Lands in the Mattawa Wellhead Protection Area



2.4.3 Village of South River

Managed Lands

South River's' managed lands are depicted below in Figure 2-24. Agricultural managed lands include a poultry operation and a beef operation, each within the IPZ-3A for South River. Non-agricultural managed lands include residential lawns, a few commercial lawns, and sports fields.

The areas of each managed land parcel within individual IPZs were combined and analyzed as an overall percentage of managed lands per each respective IPZ. The result is a managed lands percentage for each IPZ in the South River vulnerable area, which were classified as high, moderate or low, depending on the criteria mentioned at the beginning of this section. Since the percentage of managed lands within each separate vulnerable area was less than 40% of each vulnerable area, the managed lands classification is low within South River's IPZ-1 and 3A.

Livestock Density

South River's Livestock Density mapping is shown on Figure 2-25. According to MPAC data there are two agricultural managed lands parcels, each in the IPZ-3A; these include a poultry operation and a beef operation. Based on the NUs generated and the total number of acres of agricultural managed land, the livestock density was considered high since greater than 1.0 NU/acre is considered to be applied.

Drinking Water Threats

The managed lands and livestock density hazard scores assigned by MOE guidance were coupled with the vulnerability scores within the vulnerable areas to determine significant, moderate or low drinking water threats in relation to the land application of ASM, NASM and commercial fertilizers.

Based on the criteria shown in Table 2-17, there are no significant threats related to managed lands/livestock density in the Village of South River.

Figure 2-24. Managed Lands in the South River Intake Protection Zone

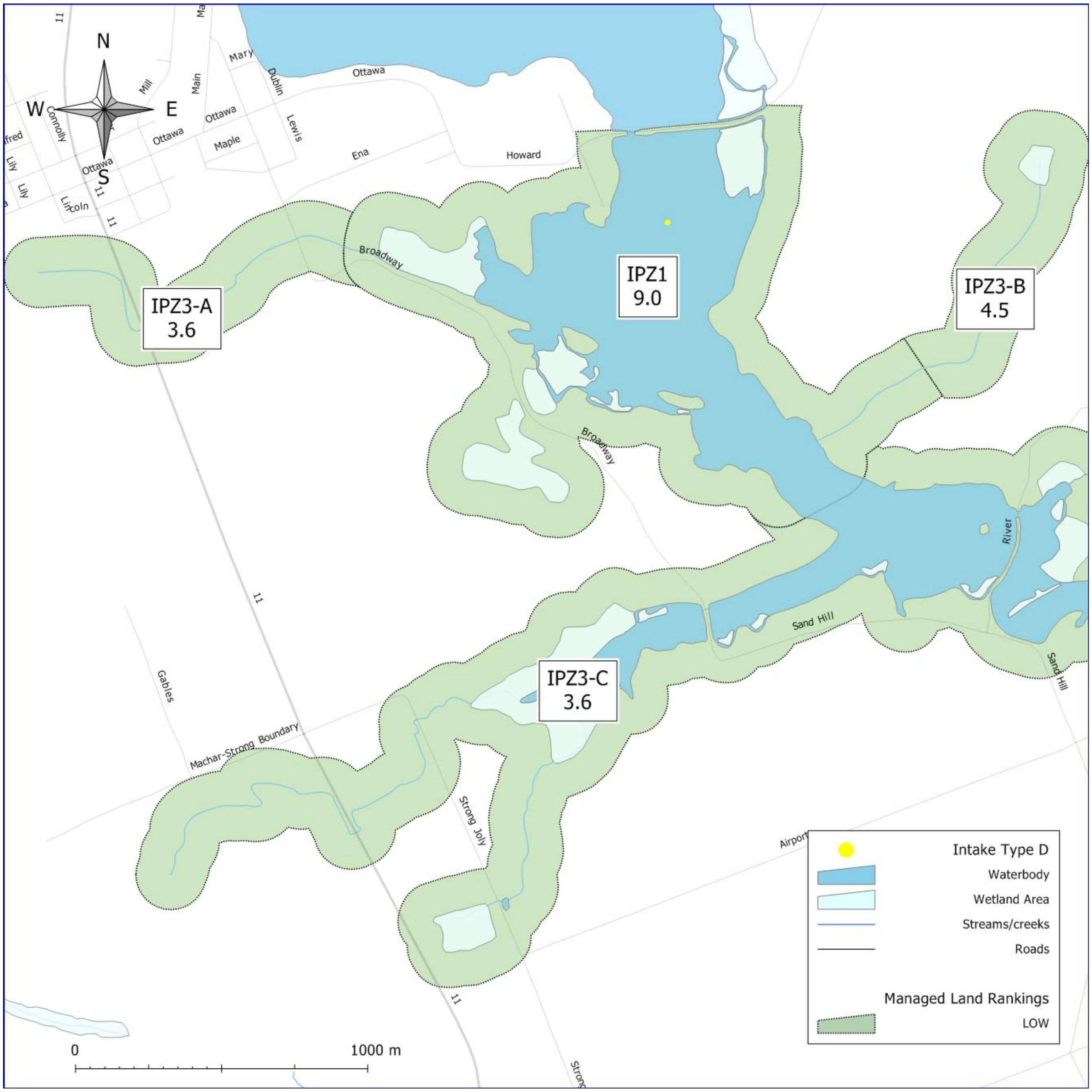
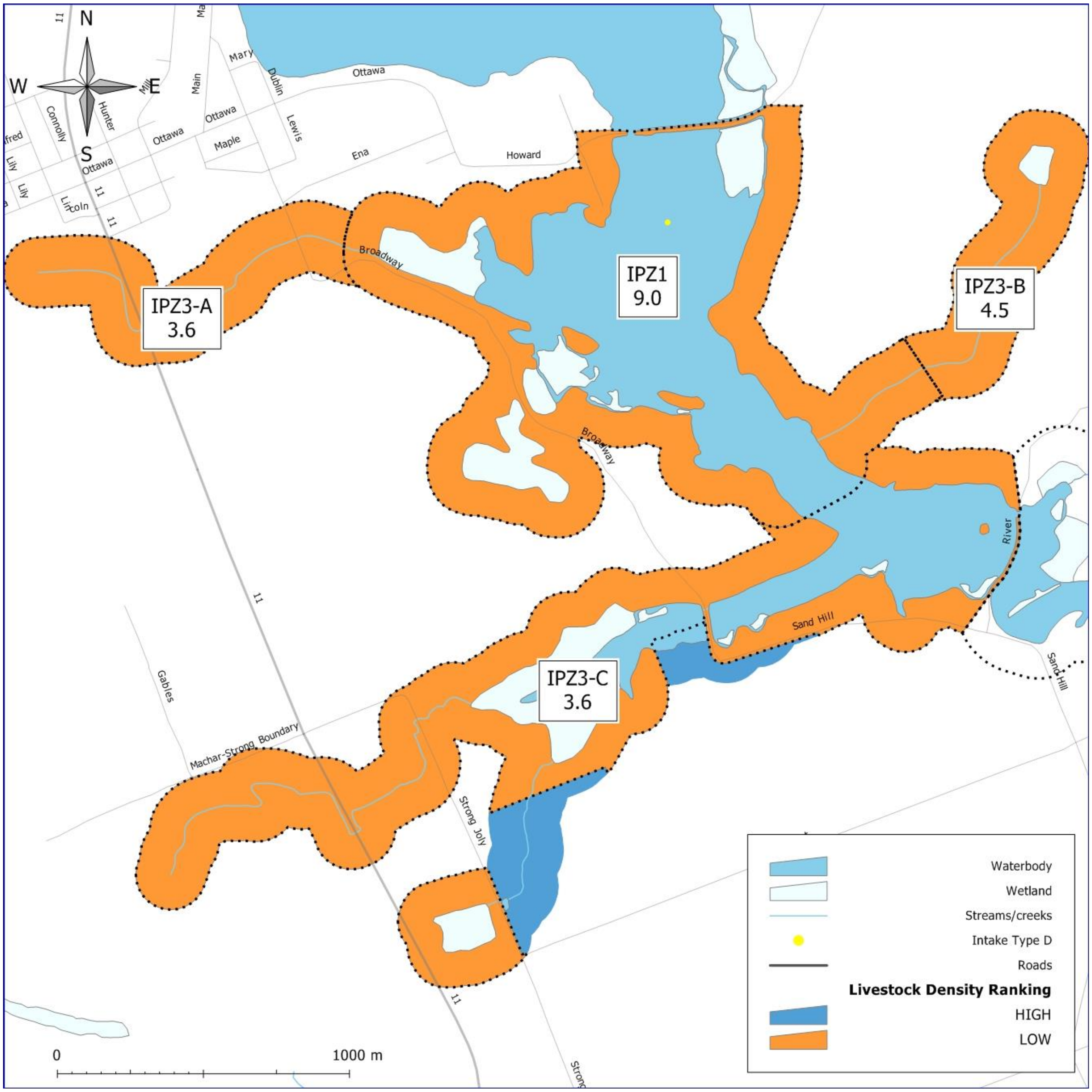


Figure 2-25. Livestock Density in the South River Intake Protection Zone



2.4.4 City of North Bay

Managed Lands
Managed lands within the vulnerable area for the City of North Bay intake are shown in Figure 2-26. Both agricultural and non-agricultural managed lands have been identified. Agricultural managed lands include one mixed farming parcel considered within the IPZ-2. Non-agricultural managed lands mainly relate to residential lawns, with a few commercial lawns.

The areas of each managed land parcel within individual IPZs were combined and analyzed as an overall percentage of managed lands per each respective IPZ. A managed lands percentage for each IPZ in the North Bay vulnerable area was calculated and classified as high, moderate or low, depending on the criteria mentioned at the beginning of this section. Since the percentage of managed lands within each separate vulnerable area was less than 40% of each vulnerable area, the managed lands classification is low within all of North Bay's IPZs.

Livestock Density
North Bay's Livestock density is shown in Figure 2-27. It was determined that one active agricultural property practices 'mixed' farming activities. Based on the NUs generated and the total number of acres of agricultural managed land in the North Bay IPZ-2, less than 0.5 NU/acre is considered to be applied, resulting in a low livestock density.

Drinking Water Threats
The managed lands and livestock density hazard scores assigned by MOE guidance were coupled with the vulnerability scores within the vulnerable areas to determine significant, moderate or low drinking water threats in relation to the land application of ASM, NASM and commercial fertilizers.

Based on the criteria shown in Table 2-17, there are no significant threats related to managed lands/livestock density in the City of North Bay.

Figure 2-26. Managed Lands in the North Bay Intake Protection Zone

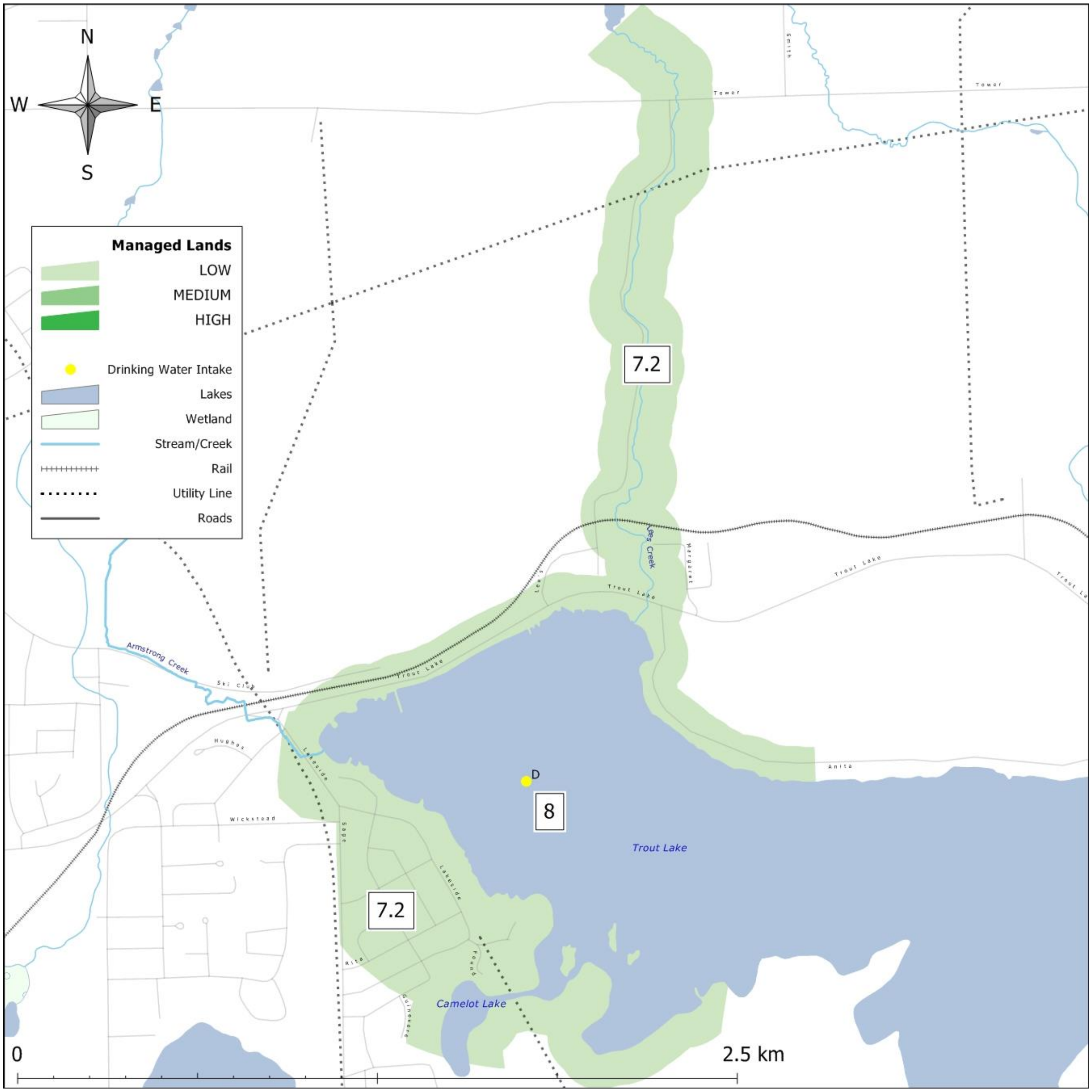
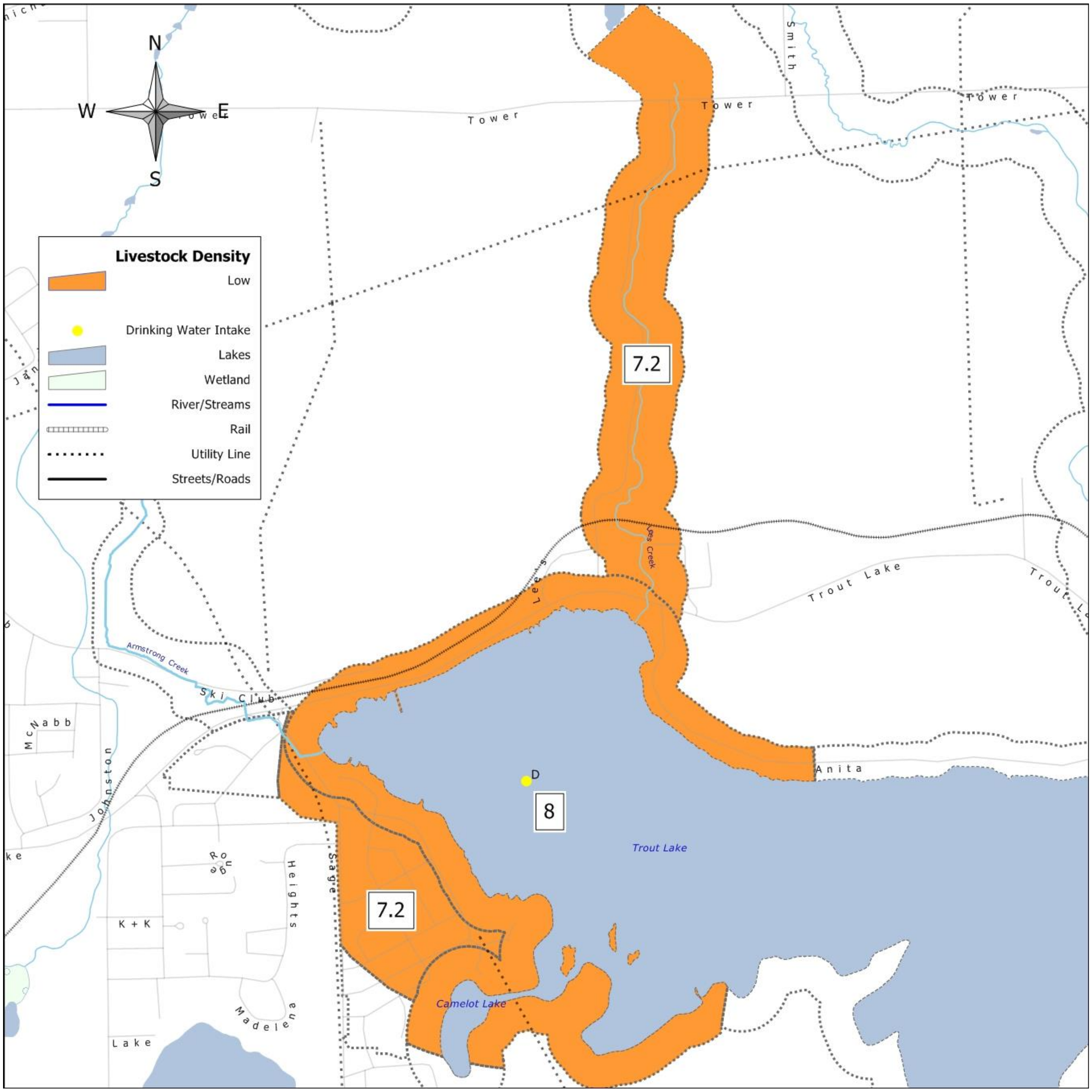


Figure 2-27. Livestock Density in the North Bay Intake Protection Zone



2.4.5 Municipality of Callander

Managed Lands

Managed lands for the contributing area to the Callander intake are mapped in Figure 2-28. Both agricultural and non-agriculturally managed lands are present in the vulnerable areas. A number of farms were identified as agricultural managed lands in the Callander vulnerable areas. Non-agricultural managed lands were also identified, and include a variety of residential lawns, commercial lawns, sports fields/parks and golf courses. Each of these parcels are located in various sections of the IPZ-3; respective parcel areas within each vulnerable area were added up to calculate the percentage of managed lands within each vulnerable area.

Managed lands within each of Callander's vulnerable areas were classified as high, moderate or low, depending on the criteria mentioned at the beginning of this section. Since the percentage of managed lands within each separate vulnerable area was less than 40% of the corresponding vulnerable area, the managed lands classification is low within Callander's IPZ-1, 2, 3A and 3B.

Note that large sections of the Callander vulnerable areas have historically been active agricultural areas, and this was reflected in the MPAC layer used for analysis. However, there are questions as to the validity of the land-uses recorded in the MPAC layer by many local residences. Also, the MPAC database did not give sufficient information for a number of properties; if farm type was "not identified" or if there was no cropland, an analysis was not included.

Livestock Density

Callander's livestock density is shown in Figure 2-29. According to MPAC data there are various agricultural managed lands parcels in the IPZ-3. Based on the NUs generated and the total number of acres of agricultural managed land in the subzones of IPZ-3, the livestock density was considered low, moderate and high within various areas.

Drinking Water Threats

The managed lands and livestock density hazard scores assigned by MOE guidance were coupled with the vulnerability scores within the vulnerable areas to determine significant, moderate or low drinking water threats in relation to the land application of ASM, NASM and commercial fertilizers.

Based on the criteria shown in Table 2-17, there are no significant threats related to managed lands/livestock density in the Municipality of Callander.

Although this protocol would determine that there are no significant threats related to managed lands/livestock density, the drinking water issue of microcystin further explores the concept of nutrient loading contributing to drinking water threats; this is more specifically addressed in the Callander section of this report and readers are encouraged to consult that section as well.

Figure 2-28. Managed Lands in the Callander Intake Protection Zone

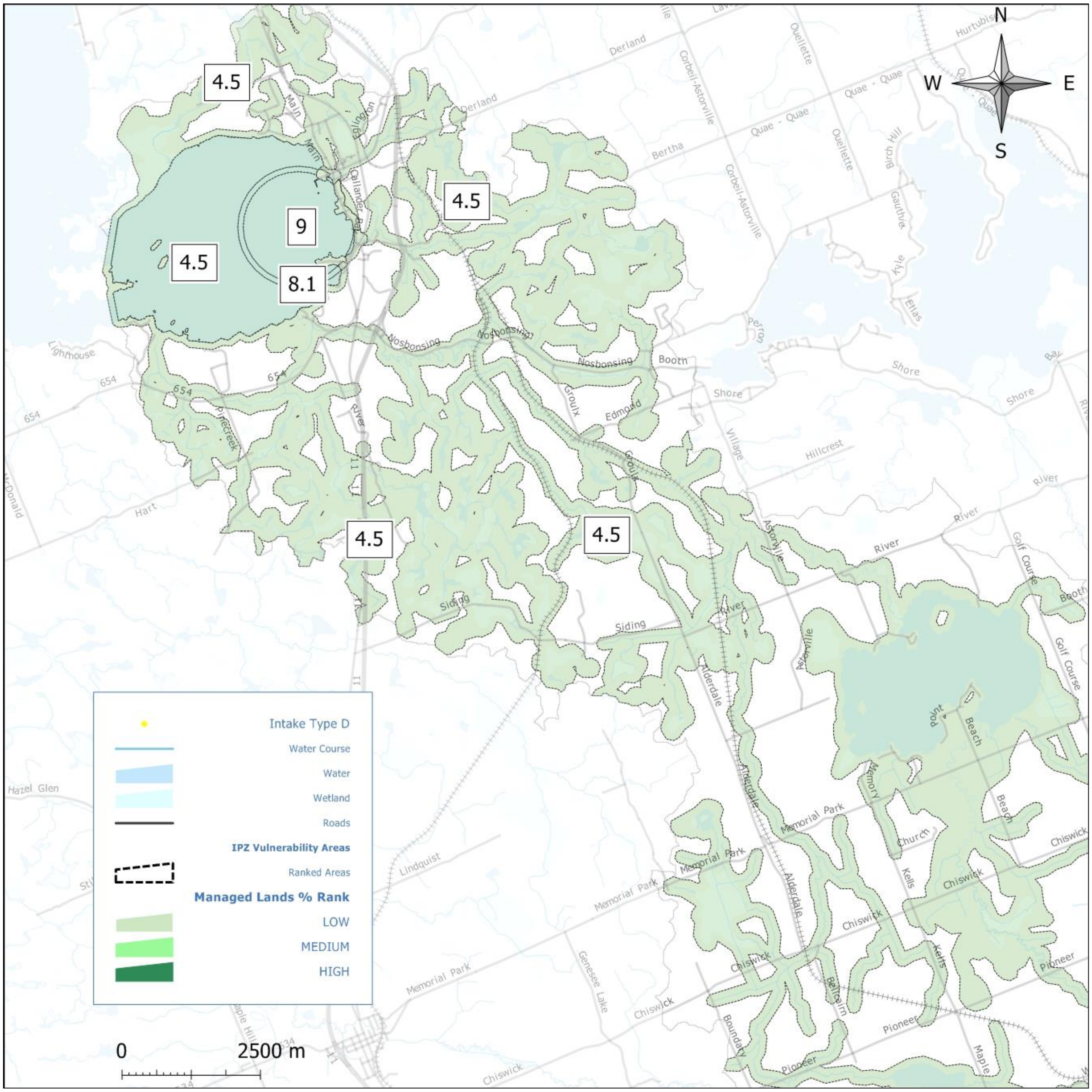
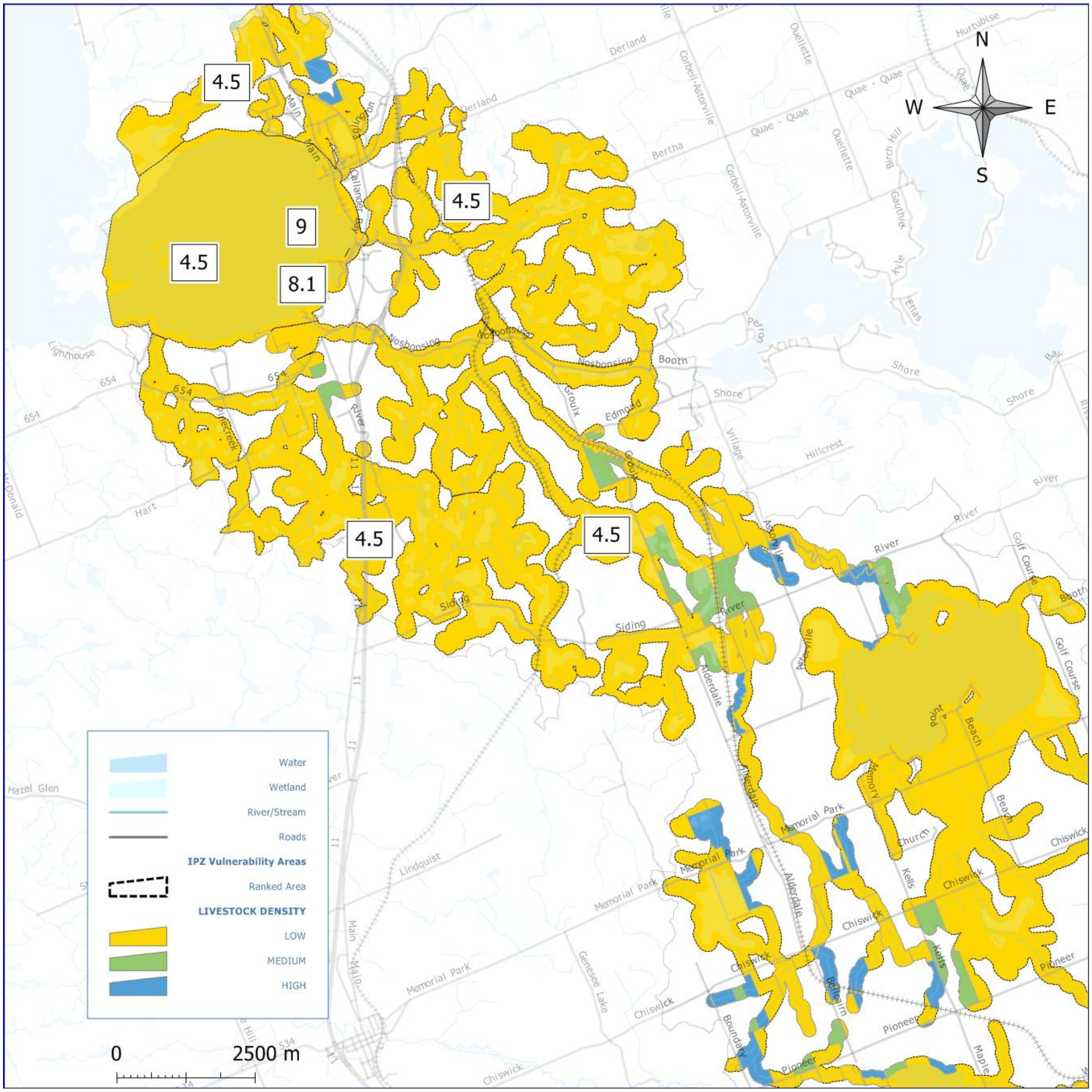


Figure 2-29. Livestock Density in the Callander Intake Protection Zone



2.4.6 Significant Groundwater Recharge Areas (SGRAs) and Highly Vulnerable Aquifers (HVAs)

Managed Lands

Figures 2-30 and 2-31 show managed lands and livestock density for SGRAs, while Figures 2-32 and 2-33 show managed lands and livestock density for HVAs, respectively. Managed lands and livestock density are quite similar for both SGRAs and HVAs, and as such are each discussed below.

A number of farms were identified as agricultural managed lands in both the SGRAs and HVAs. Non-agricultural managed lands were also identified, and include a variety of residential lawns, commercial lawns, sports fields/parks and golf courses. The areas of each managed land parcels within the separate SGRA and HVA zones were combined and analyzed as an overall percentage of managed lands per each respective vulnerable area. A managed lands percentage was calculated and classified as high, moderate or low, depending on the criteria mentioned at the beginning of this section. Since the percentage of managed lands within each separate vulnerable area was less than 40% of the corresponding vulnerable area, the managed lands classification is low within all the SGRAs as well as HVAs.

Livestock Density

Various examples of agricultural managed lands exist in both the SGRAs and HVAs. Similarly, nutrient units and livestock density calculations were the same in many of the areas of the SGRAs and HVAs, while the extent of livestock density is greater within the HVAs. The majority of moderate or high managed lands and livestock density areas occur within or surrounding the Township of Chisholm and the Municipality of Powassan, with various other pockets throughout the SP Area. Again, HVAs include a greater portion of livestock density since HVAs cover a larger area than the delineated SGRAs.

Drinking Water Threats

The managed lands and livestock density hazard scores assigned by MOE guidance were coupled with the vulnerability scores within the vulnerable areas to determine significant, moderate or low drinking water threats in relation to the land application of ASM, NASM and commercial fertilizers.

SGRAs and HVAs are each only capable of having a maximum vulnerability score of 6. Therefore, based on the criteria shown in Table 2-17, there are no significant threats related to managed lands/livestock density within SGRAs or HVAs.

Figure 2-30. Managed Lands in Significant Groundwater Recharge Areas (SGRAs)

Figure 2-31. Livestock Density in Significant Groundwater Recharge Areas (SGRAs)

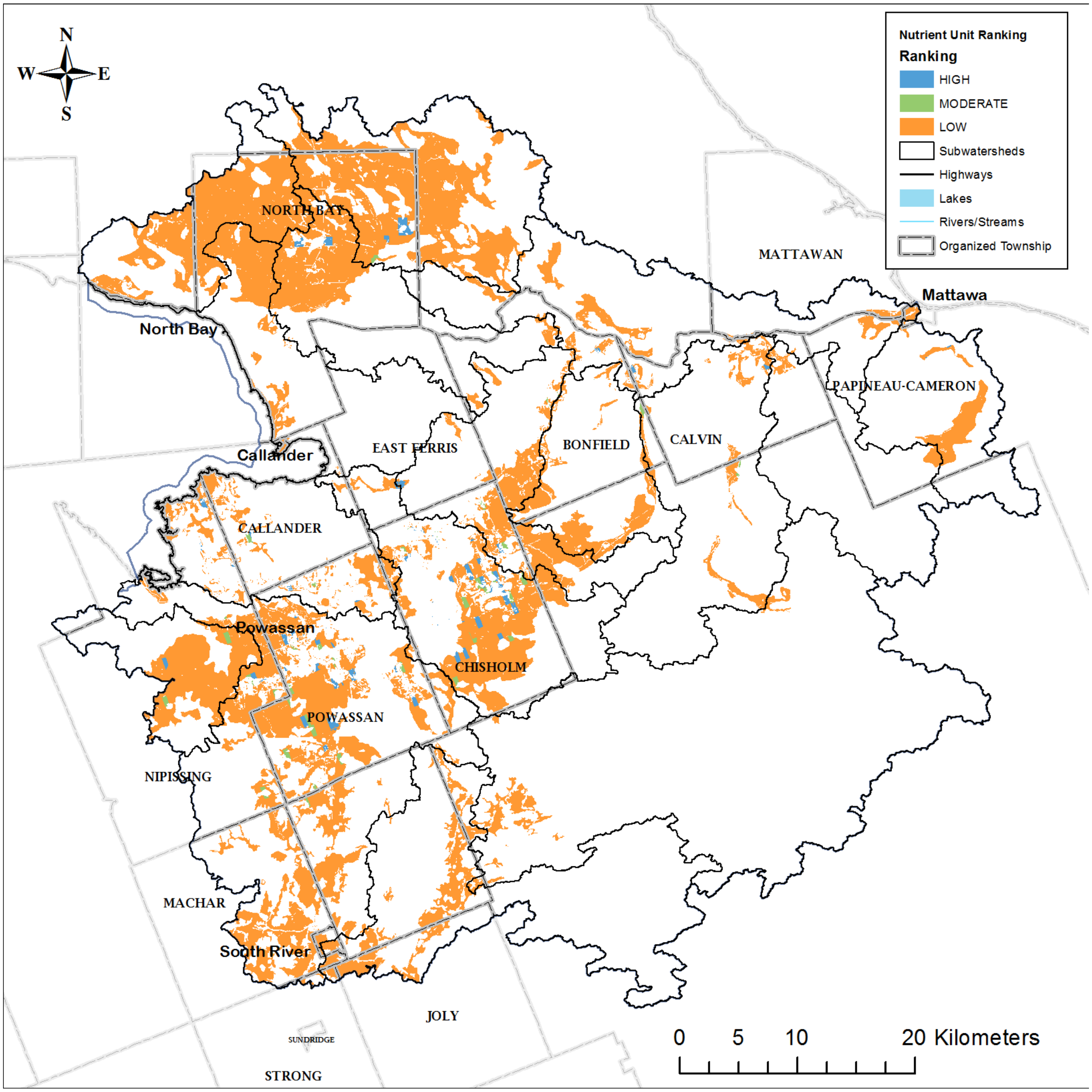
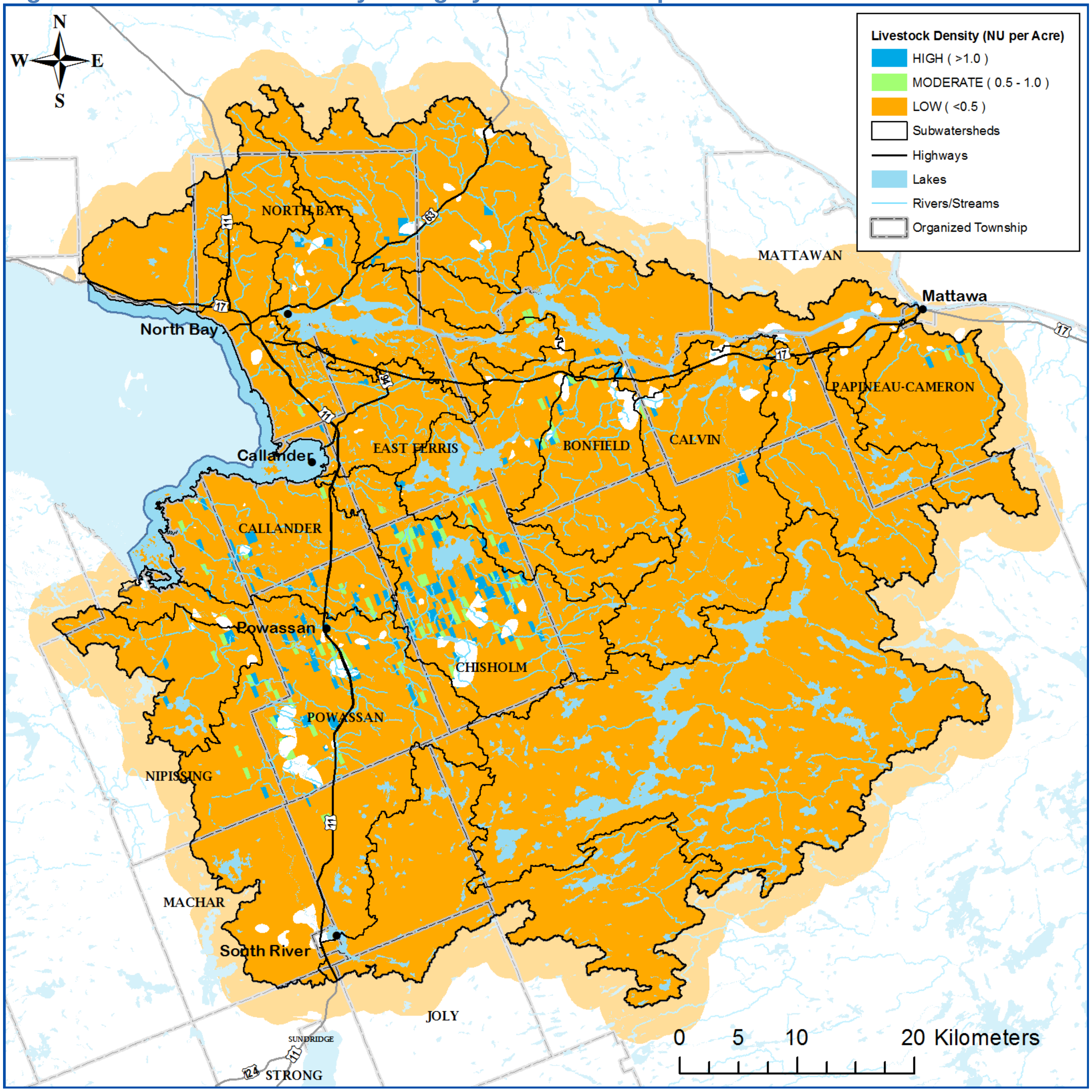


Figure 2-32. Managed Lands in Highly Vulnerable Aquifers

Figure 2-33. Livestock Density in Highly Vulnerable Aquifers



Data Gaps/Limitations

MPAC data was primarily used towards the identification and delineation of managed lands and livestock density parcels in the SP Area. It should be noted that the MPAC data on hand is considered somewhat dated and may not reflect the current conditions of the landscape; this constitutes as a data gap within the assessment.

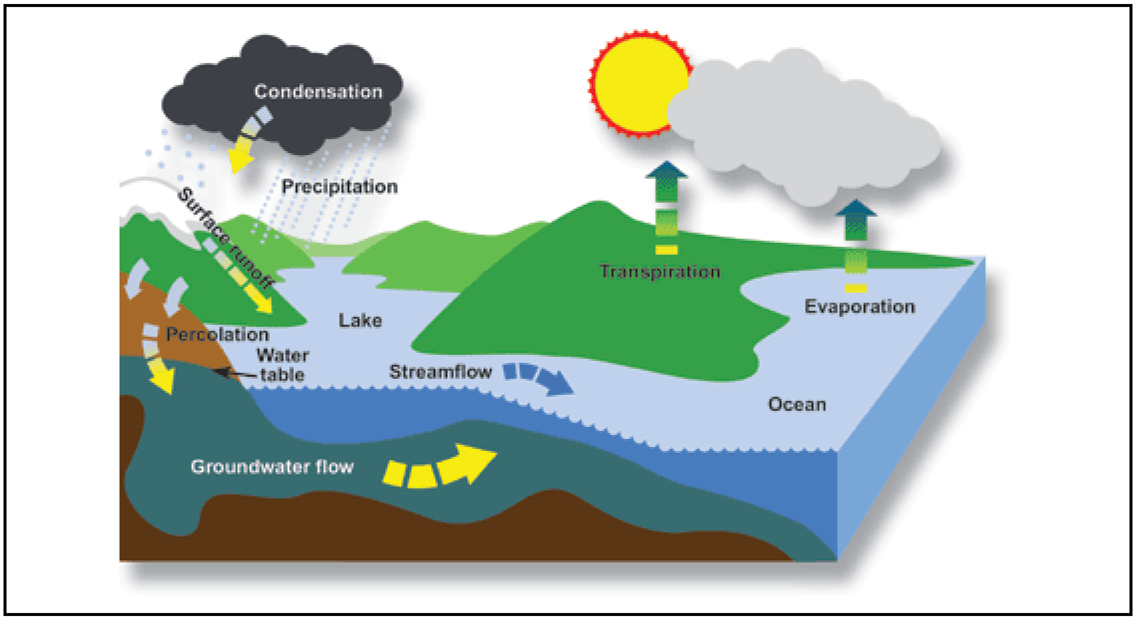
Work is currently being conducted towards attaining accurate land use data for the Callander subwatershed, specifically within the scope of a separate Callander Bay Subwatershed Phosphorus Budget project. Attaining this land use data will also refine the significant threats related to the drinking water issue of microcystin-LR (chemical produced by blue-green algae blooms), which is discussed in greater detail within Section 4.0.

2.5 Conceptual Water Budget

The conceptual water budget provides an overview of how the groundwater and surface water interact and move through the watershed. The need for, and level of, water budget assessment through numeric modelling can then be determined.

The water budget sets out to answer four questions:
1. Where is the water found?
2. How does the water move?
3. What and where are the stresses?
4. What are the trends for water availability?

Figure 2-34. Hydrologic Cycle in a Watershed



Source: Environment Canada,2004c.

Principles and Components

Water vapour accumulates in the atmosphere by evaporation from open water and land surfaces and transpiration from plants. When it condenses, it falls to the land surface as precipitation (P, comprised of rain and snow). Part of this is returned to the atmosphere by evaporation and plant uptake (ET, that is, evapotranspiration). Part of the remaining precipitation soaks into the ground and recharges (R) the groundwater table. The rest runs off (RO) and is stored on the surface (e.g., lakes, ponds and marshes). From there it is evaporated back to the atmosphere to complete the cycle. The hydrologic cycle is illustrated in Figure 2-40 and explained in further detail below.[4] .

4. The detailed water balance components are described mathematically at the beginning of Section 5.1.3 of the Conceptual Water Budget, Gartner Lee, 2007.

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 movement of the precipitation amounts once upon the ground surface.

This water (as rain or snowmelt) can follow three pathways. In liquid form water either runs off across the ground surface directly to a surface watercourse, or infiltrates into the ground to recharge groundwater storage, or goes back to the atmosphere by evaporation or through plant transpiration. The latter two are generally combined under the term evapotranspiration.

Water entering the ground is termed infiltration. The portion of the infiltration that reaches the water table is termed recharge, the difference being lost to plant uptake (transpiration) from the rooting zone. The amount of water that actually infiltrates the ground surface is controlled by the rate of precipitation (rainfall or snowmelt), soil type (i.e., clay, silt, sand or gravel), presence and depth to bedrock, ground surface conditions (e.g., topographic slope, seasonally frozen or desiccated soils) and vegetative cover (e.g., urban, agricultural or forested). In some areas (e.g., hummocky ground), the surface topography has created large depressions, which creates ponding 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. Flow of groundwater is governed by the porosity and permeability of the soil or rock, the driving head, and the geometry of the pathways.

Runoff water 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 may return to the atmosphere by evaporation, it may infiltrate into the ground, or it may spill into downstream channels. The travel time of flow in these stream channels is governed by the length, slope, roughness and cross-*Sectio*nal shape of these channels. If the flow is high and fast enough, water may overtop the channel banks, flooding the adjacent land area, resulting in further evaporation or recharge.

Evapotranspiration is a function of multiple factors including temperature, wind, humidity and solar radiation. Potential evapotranspiration (PET) is the amount of water that could be evaporated and transpired if there were an infinite amount of water available in the soil. PET can be calculated indirectly, from other climatic factors, but 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 delivered to the atmosphere by evaporation and transpiration under field conditions. AET is either equal to or less than PET. In wet months, when precipitation exceeds PET, AET is equal to PET. In dry months, when PET exceeds precipitation, AET is equal to precipitation plus the absolute value of the change in soil moisture storage (in these cases AET < PET). At the regional scale, a Water Budget provides a conceptual understanding of how groundwater and surface water interact and move through the watershed.

The following equation describes the relationship between the components. The left side of the equation accounts for all the inputs and the right side accounts for losses from the system. The difference between inputs and losses is accounted for by the change in storage **ΔS.**

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

Where:
- **P** = Precipitation
- Sw_{in} = Surface water inflow into the system from outside
- Gw_{in} = Groundwater inflow into the system from outside
- $ANTH_{in}$ = Anthropogenic or human inputs
- **ET** = Evapotranspiration losses
- Sw_{out} = Surface water outflow from the system
- Gw_{out} = Groundwater outflow from the system
- $ANTH_{out}$ = Anthropogenic or human removals
- ΔS = Change in storage (both surface and groundwater)

Surface water inflow into the system (**Sw_{in}**) is equal to zero because the analysis is for the entire watershed. Groundwater inflow into the system **(Gw_{in})** was assumed to be zero largely because of the limited overburden (soils) along the watershed boundary and the relatively impervious shallow bedrock. No anthropogenic inputs were identified. Equation (1) applies to the entire watershed.

An important objective of the exercise is to identify how much surplus exists which may be available for additional consumptive uses, or as a safety margin should there be changes in climate. Internal to the watershed the precipitation follows a more intricate pathway. The evapotranspiration is derived from surface water and groundwater. The groundwater recharge is only a portion of the actual infiltration, some of it being lost to transpiration. Evaporation comes from open waterways, canopy interception and temporary puddle storage. Streamflow is made up of both runoff and groundwater discharge (called baseflow). The water balance can be simplified, on a local scale and ignoring any change in storage, as:

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

Where:
- **P** = Precipitation
- **AET** = Actual Evapotranspiration
- **S** = Surplus

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

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

Therefore Equation (2) can be restated as:

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

For the preliminary estimation of the water balance components (i.e., actual evapotranspiration, surface runoff and recharge for equation (4) above), the climactic data are used. Environment Canada has generated climate normals for the period (1971-2000) for all stations used.

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 the creek following three main paths: by directly falling on the creek surface, by running over the land surface to the streams/water bodies (surface runoff) or by infiltrating into the ground and reappearing as groundwater discharge (springs or seeps) along the stream course.

It is important to note that not all of the precipitation that falls on the watershed makes its way to the surface water and groundwater system. A portion of the precipitation that falls returns to the atmosphere by evaporation from open water surfaces (including sublimation in the winter from the snow covered surfaces), or is used by plants through transpiration. A portion of the water infiltrates into the ground and may leave the watershed by discharge to an adjacent watershed.

The path water follows in a watershed will determine to a great extent how the watershed responds to precipitation. The local climate, physiography (surficial geology, topography and land use) are dominant factors that influence how water is delivered to the streams and rivers that form a watershed. In the SP Area, consumptive activities (e.g., drinking water, irrigation, etc.) are locally dominant, but minor in comparison to the overall availability of water. Streamflow is the response to how water is delivered to the streams and creeks forming the drainage network of a watershed. Each of these factors must be considered when describing the water balance within a watershed.

To develop a conceptual water budget the following elements were considered using available data (some of which is discussed below, while other portions are covered in Section 2.1):

- Climate
- Land Cover
- Geology/Physiography
- Groundwater
- Surface Water (including reservoirs and major discharges) and
- Water Use.

Summary of Conceptual Water Budget Findings

The Mattawa and South Rivers are the two major watersheds comprising the North Bay-Mattawa Source Protection Area (North Bay-Mattawa SP Area). North Bay is the major urban centre with a population of about 56,000. At the eastern end of the region where the Mattawa River flows into the Ottawa River is the Town of Mattawa (population ~2,300). Powassan, Callander, and the Village of South River are all small communities lying along the north-south Highway 11 corridor and together host about 7,400 people.

The area considered within the North Bay-Mattawa SP Area is estimated to be 3,963 km^2, with 2,295 km^2 (58%) draining to the Mattawa River, and 930 km^2 (23%) draining to South River. The remaining smaller watersheds comprise 738 km^2 (19%). These watersheds, along with the South River, drain to Lake Nipissing. Only the Mattawa River and its contributing watersheds drain to the Ottawa River.

A portion of Lake Nipissing is included within the North Bay-Mattawa SP Area. As per Technical Rule 4, where the source is a Great Lake or other very large water body (ie. Lake Nipissing), a water budget assessment is not required. Therefore it is not mentioned in the Conceptual Water Budget.

These watersheds are characterized largely by shallow soils over bedrock particularly in the southern and eastern parts of the region. The overburden is mostly sand and gravel, which readily accepts infiltration of precipitation. The underlying Precambrian bedrock is comparatively impermeable and locally deflects groundwater flow laterally to the streams, wetlands and lakes. South of North Bay, there is an area of deeper soils lying in a geologic basin where the bedrock is lower due to prehistoric faulting. These deeper soils host the most extensive agricultural area in the SP Area and have many private wells. The thickest overburden has been reported on the north and south side of Mattawa River in Olrig Township and Boyd Township, respectively. In Mattawa and Powassan, there are limited sand and gravel aquifers that supply water to these villages.

In the north end of the SP Area, the City of North Bay obtains all of its drinking water from Trout Lake. This is important because treated wastewater is discharged to Lake Nipissing, effectively transferring water from one watershed to another (i.e., inter-basin transfer). Mattawa and Powassan obtain their drinking water from two municipal groundwater wells at each location. The well configuration consists of one active well and one standby well in each town.

The water balance was calculated based on historical data from 13 meteorological stations within the vicinity of the SP Area. The analysis considered water surplus, soils, topography and vegetation. The results were verified against the average annual streamflow of four gauging stations within the SP Area from 1971 to 2000, when the meteorological records were most coincident with existing streamflow records. Measured meteorological data and related calculations (i.e., actual evapotranspiration) were interpolated for the SP Area from values measured (or calculated) at the 13 meteorological stations. Individual monthly and annual interpolations were made using ordinary Kriging techniques.

The interpolated average annual precipitation for the study area during this period was 972 mm/yr. The interpolated actual evapotranspiration was estimated to be 535 mm/yr, leaving a surplus of 437 mm/yr. This surplus is available for runoff and groundwater recharge. The average recharge for the area was 208 mm/yr and average runoff was 229 mm/yr. Since the recharge ultimately reaches the watercourses in this shallow flow system, it generates baseflow. The combination of runoff and baseflow compares well with measured streamflow at selected subwatersheds over the 30 years of record, with a difference of just 11%. This is considered to be in very close agreement, given the variability of the supporting information, and provides some independent assurance of the final conclusions.

When considering water volumes for the entire SP Area, annual consumptive surface and groundwater takings equal 33.6 and 1.5 million cubic metres, respectively, for a total of 35.1 million cubic metres per year. This represents approximately 2% of the available annual surplus, which is about 1,732 million cubic metres. Therefore, there appears to be ample drinking water supplies within the SP Area, and on a basin-wide basis there is no apparent water quantity issue.

Watershed Overview

For management purposes, the SP Area is divided into quaternary watersheds of appropriate size. The natural independent watersheds are far more variable in size, and for developing an understanding of the movement of water through a system at the conceptual level, it is the independent watersheds that were considered.

The six independent watersheds in the North Bay-Mattawa SP Area (Table 2-18 and Figure 2-35) include:

1. Mattawa River watershed – the largest watershed within the jurisdiction of North Bay–Mattawa SP Area. It is composed of eight subwatersheds including Mattawa River, North River, Kaibuskong River, Sharpes Creek, Amable du Fond River, Pautois Creek, Boom Creek and Upper South-Upper Amable du Fond Rivers.
2. Duchesnay River watershed.
3. LaVase River watershed
4. Wistiwasing River watershed (referred to locally as the Wasi River).
5. Bear-Boileau Creeks watershed.
6. South River watershed, including Reserve-Beatty and Wolf Creeks.

The last five watersheds discharge flow westward into Lake Nipissing separately. Therefore, they were considered as five independent watersheds for the purpose of hydrologic analysis.

Table 2-18. Independent Watersheds with Corresponding Drainage Areas

Independent Watershed	Drainage Area (km^2)
Mattawa River Watershed	2,295
South River Watershed	930
Wistiwasing River Watershed	234
LaVase River Watershed	182
Bear-Boileau Creeks Watershed	178
Duchesnay River Watershed	144
Total	**3,963 km^2**

Two major river systems are the Mattawa and the South River. The South River has several dams and generating stations along it. Their profiles are depicted on Figure 2-36 and Figure 2-37, and their locations are shown in Figure 2-41. The control structures on the Mattawa River include Turtle Lake, Talon Lake and Hurdman Dams. The Trout Lake control structure is a spill dam located at the outlet of Turtle Lake, at the border of Bonfield and Phelps Townships. The primary purpose of the dam is to control the water level of Trout Lake for recreational and navigational purposes, at an elevation of 202.2 mASL.

Talon Lake Dam is located at the outlet of Talon Lake, directly downstream of Boivin Lake on the border of Olrig and Calvin Townships. The water level upstream of the dam is maintained at 193.8 mASL. Hurdman Dam is a spill dam with the capacity to generate hydroelectric power. This dam is located 3.2 km upstream of the Town of Mattawa and backs water up for approximately 6 km, forming the narrow water body known as Plain Lake.

The South River also holds multiple control structures, including Craig, Sausage and Smyth Lake Dams as well as the Nipissing, Elliot Chute and Bingham Chute Generating Stations (GS). The Craig Lake control dam is located approximately 36 km east of the Village of South River, and maintains the upstream water elevation of the headwater lake of South River at 386 mASL. The South River Dam is located at the outlet of the South River Reservoir, adjacent to the Village of South River, and maintains a water level elevation of 354 mASL.

The Truisler Chute GS is located approximately 15 km downstream of the South River Reservoir. Downstream of this dam are the Geisler Chute GS and Corkery Falls GS, followed by the Elliot Chute GS (264 mASL) and Bingham Chute GS (263 mASL). The Sausage and Smyth Lake Dams are approximately 5.6 and 9.5 km east of the Village of Trout Creek, respectively. The most downstream control structure on South River is the Nipissing GS, located 3 km east of the Village of Nipissing, with an upstream water elevation of 239 mASL.

There are also three water control structures in the Amable Du Fond River basin. Recreation spill dams are located on Moore Lake in Champlain Provincial Park, at the outlet of Lake Kioshkokwi in Kiosk and on Club Lake in Algonquin Park.

The following table (Table 2-19) summarizes the water levels along the Mattawa and South River systems.

Table 2-19 Water Levels of the Major River Systems

Name of River	**Lake/Dam**	Water Level
Mattawa River	Trout Lake	202
	Turtle Lake	202
	Whitethroat Lake	199
	Bigfish Lake	198
	Tilliard Lake	197
	Talon Lake	194
	Pimisi Bay	178
	Bouillon Lake	163
	Mattawa River	161
	Chant Plain Lake at Hurdman Dam	159
	Boom Lake	154
	Ottawa River	152

Name of River	Lake/Dam	Water Level (mASL)
South River	Craig Lake	386
	Twenty Seven Lake	367
	South River	354
	Forest Lake	353
	South River Reservoir	351
	Elliott Chute	264
	South River	263
	Bingham Chute	252
	South River	245
	South River	244
	Nipissing GS	239
	Outlet – Lake Nipissing	197

Figure 2-35. Independent Watersheds Considered in the Conceptual Water Budget

Figure 2-36. Water Level Profile for the Mattawa River System

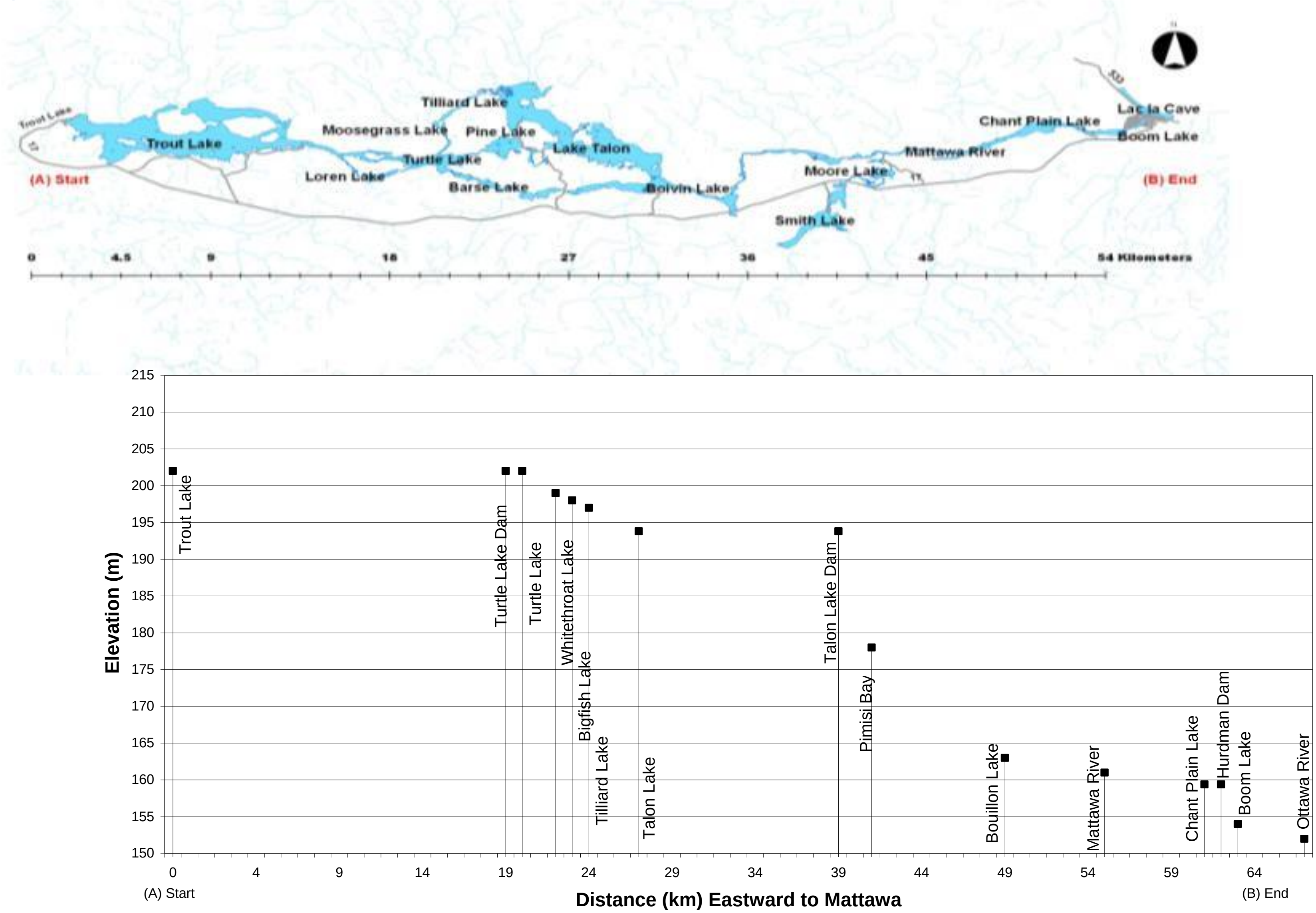
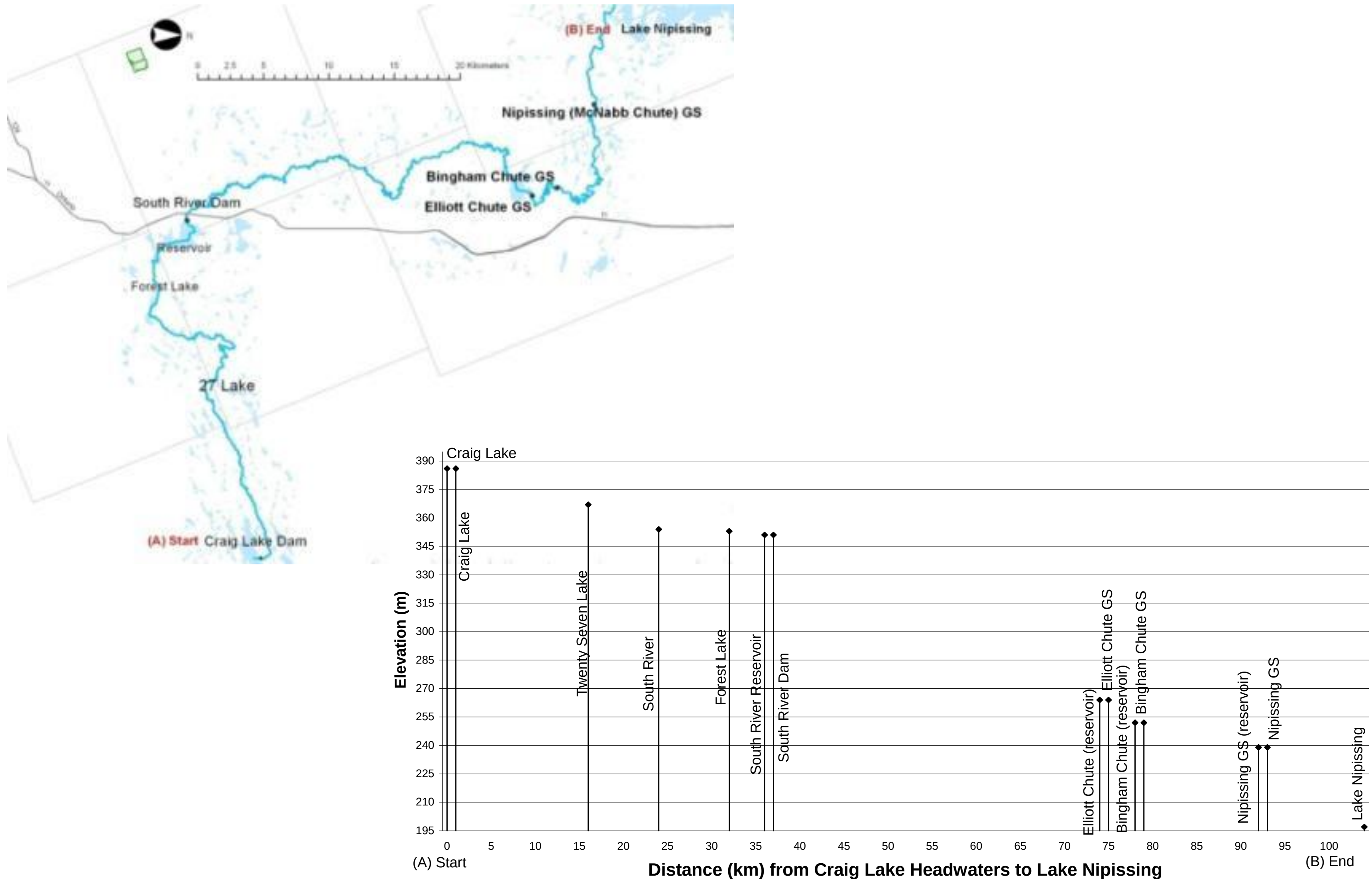


Figure 2-37. Water Level Profile for South River System



Climate Data

The first step was to prepare a water budget for existing conditions from the meteorological data at each meteorological station. The average annual precipitation for the period 1971 to 2000 was selected, as it could be directly compared to the available period of streamflow record.

Using the method of Thornthwaite and Mather (1957) the actual evapotranspiration (AET) was calculated for each station. This method uses precipitation, temperature, site latitude, surficial geology and vegetation cover to calculate the AET. The water surplus was determined by subtracting this from the average annual precipitation.

Soil moisture storage, which is defined as the amount of water that is stored in the soil within the plant's root zone and used to buffer evapotranspirative losses, was assumed to be 100 mm based on the generally sandy soil type.

The results of this analysis are presented in Table 2-20.

Table 2-20. Summary of Water Balance for Selected Meteorological Stations (1971-2000)

	Meteorological Station	Precipitation (mm/yr)	AET (mm/yr)	Water Surplus (mm/yr)
Stations North of the Study Area	Belleterre (QUE)	996	513	483
	Remigny (QUE)	916	507	409
	Sudbury A (ON)	899	507	392
	Earlton A (ON)	785	482	303
Stations Directly in the Study Area	North Bay Airport	1008	534	474
	Powassan (ON)	936	539	397
Stations Inland of the East of the Study Area	Combermere (ON)	869	511	358
	Madawaska (ON)	843	512	331
	Chalk River (ON)	860	542	318
Stations South of the Study Area	Dwight (ON)	1183	526	657
	Dunchurch (ON)	1114	523	591
	Muskoka A (ON)	1099	533	566
	Minden (ON)	1045	533	512

Surplus, Runoff and Recharge

Water surplus was determined throughout the area using a GIS analysis. Precipitation was extrapolated to the entire SP Area, as was evapotranspiration. GIS analysis was then performed to subtract the actual evapotranspiration from the precipitation to generate water surplus.

The next step in determining recharge is to partition the surplus between runoff and recharge, using the following methodology. The partitioning of the water surplus between runoff and recharge depends on four main factors: 1) topography; 2) soil texture, 3) cover type, and 4) available water.

The MOEE method relies on calculating "Infiltration Factors" composed of the first three factors that are applied to the fourth factor, average annual water surplus. These factors are tabulated in the MOEE manual (Table 2) on pages 4-62, and are reproduced here as Table 2.21 for the reader's convenience.

The MOEE method is based on the principle that water will recharge more easily through:

- sands compared to clays;
- on flat slopes compared to steep slopes; and
- through vegetated soils compared to areas that do not intercept runoff.

Runoff is greater on slopes than on flat ground. Topographic factors were calculated based on actual slopes derived from the digital elevation model using a grid-based GIS method. Application of the generalized Infiltration Factors recommended by MOE, was refined by developing a relationship between Infiltration Factor and degrees of slope.

For the categories where slope ranges were given, the appropriate slope (in degrees) was calculated for the mid-point of the range. The resulting relationship is shown in Figure 2-44.

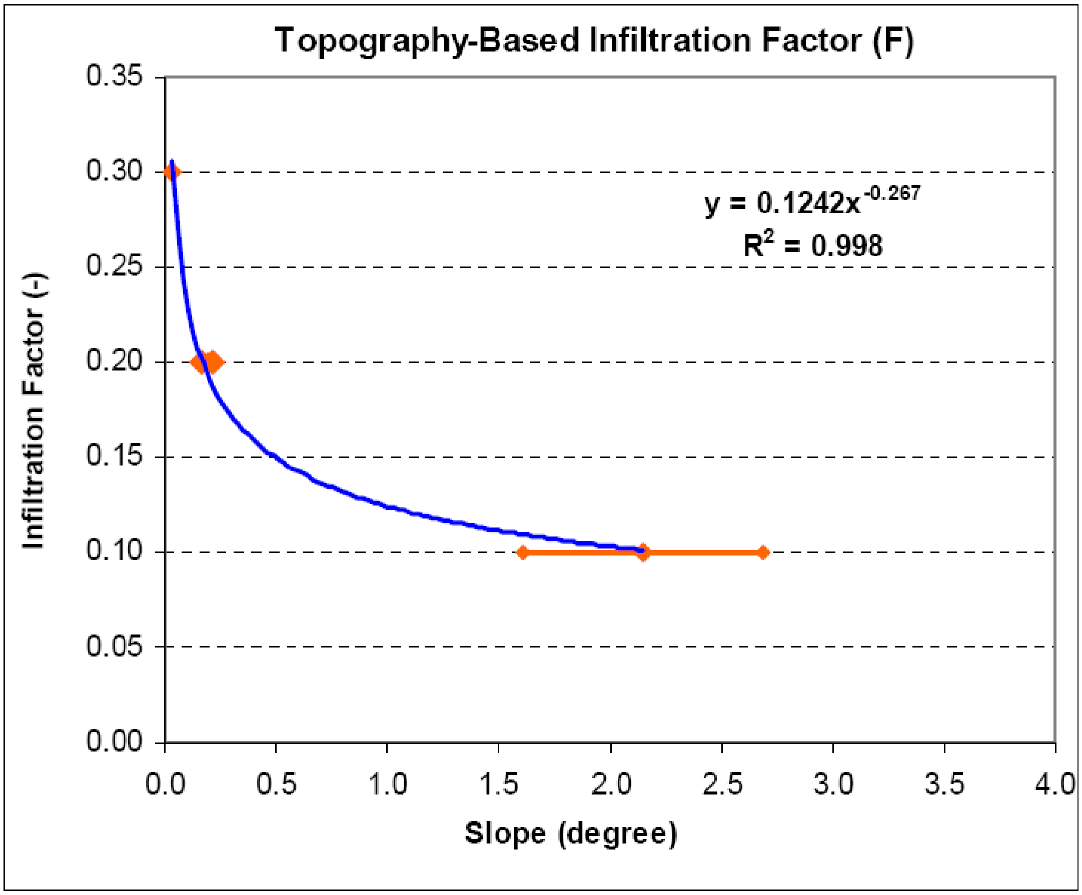
The table of example infiltration factors (Table 2-21) provides an indication of the effects of topography, soil and land cover on runoff. Woodlands provide twice the infiltration of agricultural crops.

Table 2-21. Infiltration Factors Used for Estimating Runoff and Recharge

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

Reproduced from MOEE (1995), Technical Guidelines for the Preparation of Hydrogeological Studies for Land Development Application

Figure 2-38. Relationship between Infiltration Factor (F) and Slope



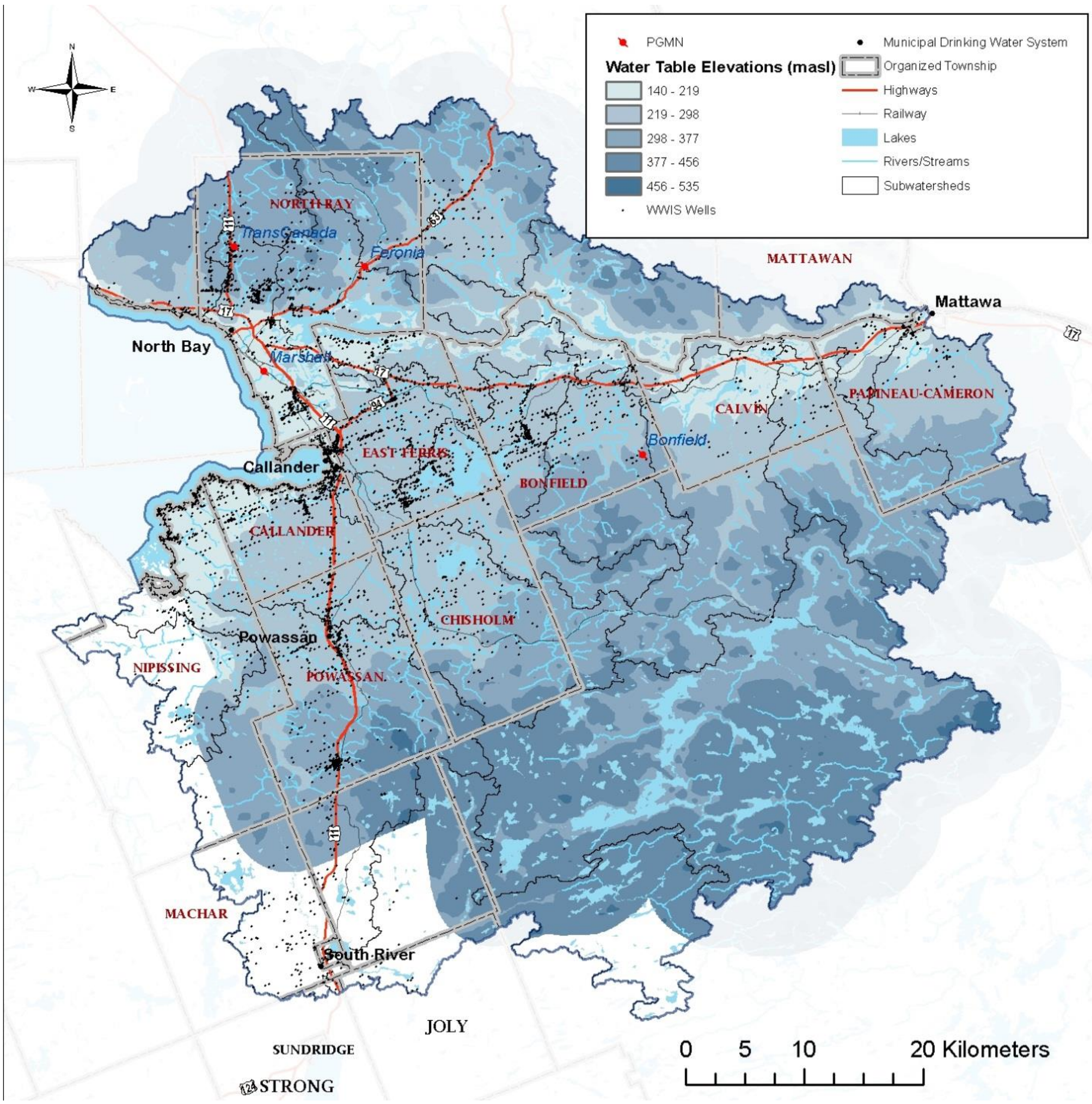
Baseflow Separation

As the watershed region is composed of numerous rivers, lakes and wetlands, and is mostly of silt, sand and gravel soils, there is a significant interaction between surface 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 runoff and 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 (say in less than 24 hours) is referred to as 'subsurface flow' and sometimes as 'interflow', and is usually considered as part of the 'storm flow'. In agricultural watersheds that are drained by subsurface tiles, the flow in the tiles (hence, 'tile flow') is considered part of the 'rapid subsurface flow' (or the 'slow' storm flow). Water that infiltrates deeper into the ground, and returns to the stream much later would be considered as the 'baseflow'.

Therefore, baseflow comprises the accumulated subsurface or groundwater discharge to the watercourses. These are important for the natural function of the ecosystem, providing clean water and sustaining streamflow and wetlands in dry periods. In particular, it supplies the cold water that provides thermal buffering in headwater streams and sustains fish habitat. Figure 2-8 in Section 2.1 Watershed Characteristics categorizes the temperature regimes of various streams and water bodies as indicated by the species of fish. The accumulation of baseflow throughout the watershed sustains the river system and lakes. From a source water protection aspect, this is an important component of Trout Lake, which is the main source of water for North Bay. The escarpment highlands are an important landscape feature contributing baseflow to Trout Lake.

The water table for the SP Area is presented in Figure 2-45. Water level elevations range from 404 m in the north and south, to 120 m near Lake Nipissing, and the Mattawa and Ottawa Rivers. Lateral groundwater movement will also occur in the shallow bedrock where fractures exist. Groundwater recharge can be defined as the supplementation of the groundwater by the infiltration of rainfall and snowmelt, which is not returned to the atmosphere by evapotranspiration. This provides the driving force that causes groundwater to flow, and ultimately discharge as baseflow to wetlands, watercourses and lakes.

Figure 2-39. Water Table in North Bay-Mattawa SP Area



Water Use

Water use in the SP Area is typically focused around developed areas and is used for municipal drinking water, irrigation, industry, and recreation. This water comes from both ground and surface water sources. Water use greater than 50,000 litres per day falls under the Permit to Take Water Process. Tables 2-22 and 2-23 summarize the surface water takings (values are maximum allowed by each permit) and groundwater allotted takings according to the Permit to Take Water database.

A rural population of approximately 19,173 lives in the study area, and most use water from private groundwater wells for domestic supply. Rural groundwater use has therefore been estimated to be approximately 2.34 Mm^3/yr. This is based on an assumed consumption of 335 L/person/day.

An overview of agricultural water use is provided in Table 2-24. The Permit to Take Water database indicates that there are no groundwater permits for agricultural use and that all agricultural water use is satisfied through surface water takings.

Table 2-22. Maximum Permitted Surface Water Takings According to PTTW Database (2006)

Permit No	Easting	Northing	Water Use	Source (River, Lake, Creek)	Takings * (Mm^3/yr)
03-P-5011	615190	5105850	Agriculture (Field and Pasture Crops)	South River	1.43
03-P-5018	664730	5129230	Campgrounds	Long Lake	0.03
74-P-5011	653900	5125200	Other – Industrial	Pimisi Lake	0.05
8315-6ADM8M	640600	5146150	Aquaculture	Balsam Creek	1.47
81-P-5226	624100	5098800	Agriculture (Field and Pasture Crops)	Unnamed Creek	0.01
89-P-5762	639900	5117300	Other – Commercial	Unnamed Creek	0.02
94-P-5025	626450	5118750	Municipal	Callander Bay	1.10
90-P-5838	622300	5131250	Municipal	Trout Lake	29.02
94-P-5011	622800	5131750	Other – Institutional	Trout Lake	0.08
98-P-5023	668099	5129680	Manufacturing	Mattawa River	0.36
99-P-5010	627650	5077650	Municipal	Forest Lake	0.61
00-P-5052	629536	5133188	Field and Pasture Crops	Four mile Creek	0.02
0251-6ADRGZ	623200	5123800	Golf Course Irrigation	LaVase River	0.12
01-P-5006	673388	5131071	Power Production	Mattawa River	*293.28*
92-P-5988	Not Available	Not Available	Agriculture (Field and Pasture Crops)	Boulder Creek	0.80
00-P-5002	625244	5075778	Golf Course Irrigation	Irrigation Ponds	0.35
01-P-5008	624718	5121441	Golf Course Irrigation	Irrigation Ponds	0.40
Total					**329.15**
Non-consumptive (Power Generation)					***293.28***
Consumptive (Municipal, Irrigation, Other-Industrial, Campgrounds etc.)					**35.86**
Municipal					**30.73**
Irrigation					**4.60**
Other-Industrial, Campgrounds etc)					**0.53**

Table 2-23. Maximum Permitted Groundwater Takings According to PTTW Database (2006)

Permit No	Easting	Northing	Source Name	Water Use	Takings (Mm^3/yr)
02-P-5059	676210	5131526	Well # 1 (Mattawa)	Municipal	1.67
02-P-5059	676210	5131526	Well # 2 (Mattawa)	Municipal	0.72
04-P-5008	619528	5136736	Leachate Collection System & Pump Station	Groundwater-Remediation	0.44
92-P-5975	617750	5136650	Well Other	Industrial	0.03
04-P-5027	Not available	Not Available	Well #1	Campgrounds	0.03
04-P-5027	622900	5123700	Well #2	Campgrounds	0.001
82-P-5292	625900	5104350	Well #1 (Powassan)	Municipal	0.48
82-P-5292	625900	5104350	Well #2 (Powassan)	Municipal	0.48
93-P-5026	618300	5100550	Springs #1	Bottled Water	0.05
93-P-5026	618300	5100550	Springs #2	Bottled Water	0.07
93-P-5026	618300	5100550	Springs #3	Bottled Water	0.09
00-P-5002	625244	5075778	Dug Well	Golf Course Irrigation	0.04
02-P-5002	631550	5124340	Well #1	Other-Institutional	0.03
02-P-5002	631550	5124340	Well #2	Other-Institutional	0.02
02-P-5002	631550	5124340	Well #3	Other-Institutional	0.01
02-P-5002	631550	5124340	Well #4	Other-Institutional	0.02
03-P-5018	664750	5128520	Well #1	Campgrounds	0.03
				Total	**4.20**
				Municipal	**3.35**
				Irrigation	**0.04**
				Other-Industrial, Campgrounds etc.	**0.81**

Table 2-24. Agricultural Water Use (m^3/yr) (2006)

Quaternary Watershed	No. of Farms	Livestock	Field	Vegetable	Specialty	Total
North River (2JE-09)	0	0	0	0	0	0
Duchesnay Creek (2DD-19)	0	0	0	0	0	0
LaVase River (2DD-20)	13	3,497	13	4,501	4,209	12,220
Mattawa River (2JE-02)	18	4,612	32	2,000	1,866	8,511
Bear-Boileau Creeks (2DD-21)	13	5,580	27	197	1,996	7,799
Reserve-Beatty Creeks (2DD-25)	10	2,597	13	174	4,491	7,275
South River (2DD-23)	59	26,261	116	633	4,986	31,995
Wistiwasing River (2DD-22)	36	11,301	86	1,113	1,002	13,500
Upper Amable Upper South Rivers (2JE-04)	0	81	1	0	0	82
Amable du Fond River (2JE-03)	19	4,612	34	18	0	4,663
Pautois Creek (2JE-05)	7	1,591	11	7	0	1,609
Sharpes Creek (2JE-06)	11	2,975	28	0	0	3,003
Kaibuskong River and Depot Creek (2JE-07)	19	5,255	40	1,556	1,449	8,300
Boom Creek (2JE-17)	0	0	0	0	0	0
Total	**205**	**68,362**	**401**	**10,199**	**19,998**	**98,957**

The volume of consumptive surface and groundwater demand within the watershed is summarized in Table 2-25 below. Consumptive water use is water that is taken from a groundwater aquifer or surface water body and is not returned to the same aquifer or surface water body in a reasonable time frame. Consumptive surface water takings total about 33.6 Mm^3/yr, which is only about 10.2% of the amounts allotted in the PTTW database. Similarly, the consumptive groundwater takings from the watershed is approximately 1.49 Mm^3/yr, which is 35.5% of the amounts allotted in the PTTW database.

Table 2-25. Consumptive Surface and Groundwater Use/Demand in the SP Area According to the PTTW Database (2006)

Water Use		Water Takings (Mm^3/yr)	Consumptive Factor	Consumptive Use
Surface Water				
Total Surface Water Takings according to PTTW		329.15		
Permitted Takings: Power Generation		293.28	0.0	0.0
Permitted Takings: Other- Industrial		0.53	0.25	0.13
Permitted Takings: Municipal Water Supply	*Trout Lake*	29.02	[1]1.0	29.02
	Callander Bay	1.10	0.2	0.22
	South River Reservoir	0.61	0.2	0.12
Permitted Takings: Agriculture (Irrigation)		4.60	0.9	4.14
Total Consumptive Surface Water Use/Demand				**33.63**
Groundwater				
Total Groundwater Takings according to PTTW		4.20		
Permitted Takings: Other- Industrial		0.81	0.25	0.20
Permitted Takings: Municipal Water Supply		3.35[2]	0.20	0.67
Permitted Takings: Agriculture (Irrigation)		0.04	0.90	0.04
Water Takings: Private wells		2.34	0.25	0.58
Total Consumptive Groundwater Use/Demand				**1.49**

SP Area Water Budget Calculations

Precipitation

It was noted that climate normals data for thirteen stations within and surrounding the SP Area were available for the period 1971 to 2000 (see Table 2-20). The mean annual precipitation for each of these thirteen stations was computed for that time period to agree with the time frame for streamflow records available in the SP Area.

The point observations of mean annual precipitation for the thirteen climatic stations were entered into the GIS database and mean annual precipitation was interpolated over the entire study area with ordinary Kriging. Table 2-27 below presents annual average precipitation estimated by this method for the different watersheds (above specific stream gauges) in the SP Area. Among the 13 selected meteorological stations, precipitation ranges from 785 mm/yr to 1,182 mm/yr with an arithmetic average annual precipitation of 965.6 mm/yr and an area weighted interpolated annual average for the entire study area is 972 mm/yr.

Evapotranspiration

Actual evapotranspiration (AET) losses were 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), which are adjusted to yield AET by considering soil moisture storage. Based on the application of this method, AET estimated for the thirteen stations ranges from 481 mm to 542 mm with an arithmetic average of 520.2 mm annually. An areally-weighted mean annual AET total of 535 mm is derived and used in Table 2-28.

Streamflow

In the North Bay-Mattawa SP Area, there are records from eleven streamflow gauges/hydrometric stations among which four stations have periods of record that match closely with the climatic stations. Complete flow records are available at these gauges for the period mentioned in Table 2-26 . The annual flow volumes (expressed as depth) for the four stations are provided in Table 2-27.

The mean, maximum and minimum stream flows in this exercise for the entire watershed were calculated on a pro rata basis. For example, the flow rate of each individual subwatershed was divided by the corresponding subwatershed area, averaging it out and finally multiplying it with the total area of the watershed.

Table 2-26. Summary of Continuous Streamflow Gauge Stations within Study Area

Station Name	Station ID	Drainage Area (km^2) [1]	Latitude	Longitude	Period of Records	Number of Years	Max Annual Flow Rate (m^3/S)	Mean Annual Flow Rate (m^3/S)	Min Annual Flow Rate (m^3/S)
Duchesnay River Near North Bay	02DD008	90.4	46°19'53"N	79°30'20"W	(1956-1982)	26	2.32	1.65	0.93
Chippewa Creek at North Bay	**02DD014**	37.3 (32.4)	46°18'42"N	79°26'54"W	(1974-2003)	29	**0.821**	**0.62**	**0.444**
LaVase **River Near North Bay**	**02DD013**	70.4 (69.2)	46°15'48"N	79°23'42"W	(1974-2003)	29	**1.33**	**0.93**	**0.559**
South River Near Nipissing	02DD005	787	46°05'49"N	79°28'45"W	(1937-1984)	47	17.9	11.8	6.36
South River Near Powassan	**02DD001**	761 (783)	46°5'40"N	79°23'45"W	(1914-1936)	22	**23.2**	**12**	**6.57**
South River Above Truisler Chute	02DD002	420	45°57'48"N	79°24'21"W	(1919-1952)	33	13.3	6.7	3.33
South River at South River Prov-Terr-State	**02DD009**	316 (326.3)	45°50'54"N	79°22'46"W	(1956-1991)	35	**7.33**	**5.34**	**2.93**
Kaibuskong River At Bonfield	02JE008	174	46°14'5"N	79°09'0"W	1915	1	ND	ND	ND
Mattawa River Near Rutherglen	02JE014	2040	46°18'7"N	78°52'51"W	(1962-1971)	9	35.2	25.6	14.4
Amable Du Fond River at Samual Du Champlain Provin	**02JE019**	1130 (1140)	46°18'0"N	78°52'45"W	(1972-1995)	23	**22.6**	**16.1**	**9.05**
Mattawa River Below Bouillon Lake	**02JE020**	909 (951.5)	46°17'56"N	78°54'26"W	(1971-1998)	27	**20.6**	**15.4**	**9.31**

Note: 1. Drainage areas are from Hydat database. Drainage areas in parentheses were calculated using Archydro. ND: No data. Streamflow gauge stations marked with a shaded area were used for water budget analyses as they closely match with climatic stations data (see also discussion in Section 5.2.3).

Summary of the SP Area Water Budget

Table 2-27 provides a summary of the water budget for the four watersheds with gauges and includes the surficial area (in square kilometres) draining past each gauge. The selection of these watersheds was based on the consistent period of records (1971-2000) between streamflow and climatic data.

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Table 2-27. Summary of Water Budget on Subwatershed Basis

Catchment Name (Gauge #)	Area (km^2)	Average Annual Precip. (mm)	Average Annual Actual ET (mm	Surplus (mm)	Runoff (mm)	Recharge (mm)	Streamflow (mm)	Baseflow (mm)**
Chippewa Creek (02DD014)	32.4	1005	533	472	193	279	621	256
LaVase **River (02DD013)**	69.2	967	536	431	265	166	438	127
Amable Du Fond River (02JE019)	1140	961	535	426	235	191	439	215
Mattawa River Below Bouillon Lake (02JE020)	951.5	966	535	431	225	206	500	227

*Note: **Baseflow was calculated using an automated baseflow separation program described by Arnold and Allen, 1994*

Examination of Table 2-27 yields some interesting observations. The surplus value (comprised of runoff and recharge) theoretically should match the Streamflow value (correspondingly comprised of storm runoff and baseflow). There is excellent agreement for LaVase and Amable Du Fond watersheds at their respective gauges. The Mattawa River is out by only 14%, which is near the accuracy of streamflow measurement. Only Chippewa Creek was significantly different (by 31%), which may have more to do with the urbanized character of this smaller watershed. An urbanized watershed will have less transpiration, shorter water retention times and thus less evaporation. This means that there is a greater surplus, which generally ends up as runoff. Hence the measured Streamflow value is greater than the theoretical surplus.

Table 2-28 below provides a summary of the integrated water budget for the entire SP Area. The description column of the table provides some insight as to assumptions and limitations of the analysis. To simplify the interpretations of Table 2-28, the following narrative is meant to assist the reader. It is expressed solely in terms of average annual amounts. All values are expressed in terms of a volume of water, expressed in "million cubic metres per year (Mm^3/yr)".

A total of 3,852 Mm^3/yr falls as precipitation, of which 2,120 Mm^3/yr is returned to the atmosphere by evapotranspiration (or about 55% is lost). This leaves 1,732 Mm^3/yr as a surplus, available for runoff or recharge. By way of comparison the average streamflow out of the watershed is 1,951 Mm^3/yr which is made up of both runoff and baseflow. There is about an 11% difference in these values, with the measured streamflow being higher than the calculated surplus. This difference is considered to be an acceptable margin of error, given the uncertainties in parameter estimation, measurement error and meteoric distribution of precipitation.

Table 2-28. Summary of the Conceptual Water Budget (Total Drainage Area: 3,963 km^2)

Parameters	Annual Depth (mm)	Annual Volume (10^6 m^3)	Description
Precipitation (mm)	972	3,852	Interpolated from an area-averaged annual mean precipitation. Precipitation calculated by arithmetic average of the 13 stations is 965.6 mm
Actual ET (mm)	535	2,120	Interpolated from an area-averaged annual average actual ET. (Arithmetic average of AET calculated using Thornthwaite and Mather (1957) is 520.2 mm)
Surplus (mm)	437	1,732	Spatially distributed average value. (Arithmetic average value is 445.4)
Recharge	208	824	Determined in GIS platform
Runoff	229	908	Determined in GIS platform
Max Streamflow	721.4	2,859	Area weighted maximum annual streamflow
Mean Streamflow	492.4	1,951	Area weighted mean annual streamflow
Min Streamflow	294.4	1,166	Area weighted minimum annual streamflow
Consumptive Surface Water Takings	8.5	33.63	According to PTTW Database
Non-Consumptive Surface Water Takings	74	293.3	According to PTTW Database
Consumptive Groundwater Takings	0.38	1.49	According to PTTW database and include water takings from private wells for about 19,173 people consuming water at a rate of 335 L/day/capita
Non Consumptive Groundwater Takings	0.76	3.01	According to PTTW Database

The Surplus of 1,732 Mm^3/yr was partitioned between runoff and recharge in the following way. A total of 52.4% of the surplus, or 908 Mm^3/yr directly runs off, while 824 Mm^3/yr goes to recharge the water table (to later appear as baseflow).

Maximum permitted surface and groundwater takings total 333.35 Mm^3/yr, or about 19.2% of the overall surplus. Of this, approximately 296 Mm^3/yr is comprised of non-consumptive uses. For the purpose of this summary, both ground and surface water sources are considered together. As previously defined, non-consumptive uses involve the use of the water that is returned to the local watershed of origin in a reasonable timeframe. In the context of source water protection water budget, consumptive uses refer to the amount of water removed from a hydrological system and not returned back to the same system in a reasonable time period. The consumptive use, including North Bay's maximum permitted withdrawal from Trout Lake, is about 34.83 Mm^3/yr or about 2.01% of the surplus.

Trends in Water Quantity

When considering water volumes for the entire SP Area, annual consumptive surface and groundwater takings equal 33.6 and 1.5 million cubic metres, respectively, for a total of 35.1 million cubic metres per year. When compared with the available annual surplus, which is about 1,732 million cubic metres, there appears to be ample drinking water supplies within the SP Area. Given the large watershed and renewable nature of the water supply, there are no serious concerns in water availability. Annual fluctuations are significant enough to cause local stresses, however these generally have been temporary.

Further discussion on trends in water demand is discussed in the individual Municipal sections below.

Limitations

Although more than 40 meteorological stations have operated within and in the vicinity of the North Bay-Mattawa SP Area over the years, most of them have only recorded daily precipitation (as rainfall and snowfall depths), with a handful of them including daily maximum and minimum air temperatures. There have been no pan evaporation measurements in the study area from which to estimate lake evaporation, which constitutes a data gap in the present analysis. Few stations were in operation for more than 25 years, although a sufficient number have been open long enough to make some general conclusions about the overall climate of the region. The only long-term climate stations still collecting data are at the North Bay Airport and one located near Powassan.

The geology surrounding the municipal wells in Mattawa and Powassan indicates aquifers of potential limited local extent. Therefore, on a SP Area basis, the % consumptive groundwater use value may be misleading, and likely underestimates the stress placed on the local aquifers. Also, overburden thickness may be subdued due to the limited amount of water well data used in this assessment.

Finally, total actual water takings are probably lower based on the fact that the MOE PTTW database currently does not report actual takings, only maximum permitted amounts. This would be reflected in the overall surface or groundwater takings portion of the water budget. Likewise, information on the amounts of water taken without a PTTW was not made available within this analysis.

2.6 Water Quantity Stress Assessment

2.6.1 Tier One Water Quantity Analysis

The Tier One Water Budget and Subwatershed Stress Assessment require a quantitative analysis at the subwatershed level. That is, it looks at the ratio of water demand to the available water supply (termed the “Percent Water Demand”) within a specific subwatershed. Subwatersheds with Percent Water Demand values above the specified Provincial thresholds are classified as having a Moderate or Significant potential for stress. The Tier One analysis largely utilizes available data collected and analyzed in the Conceptual Understanding phase, and evaluates the potential for water taking related impacts within a subwatershed.

Initially, Tier One Assessments were focused on subwatersheds that provided a municipal supply of drinking water. Tier One Assessments were completed for the subwatersheds containing the groundwater supply for the Town of Mattawa and the Municipality of Powassan (WESA, 2010), and for the surface water supply for the City of North Bay (Gartner Lee, 2008b) and the Village of South River (WESA, 2010). A Tier One Assessment was not required for the subwatershed supplying the Municipality of Callander as per Technical Rule 4 where the source is a Great Lake or other very large water body (ie. Lake Nipissing).

Following the release of the Technical Rules (MOE, 2009b), a Tier One Water Budget and Water Quantity Stress Assessment is required for each subwatershed within a Source Protection Area, not just those subwatersheds that provide municipal supply. This report summarizes the Tier One Water Budget and Stress Assessment for all subwatersheds in the

North Bay – Mattawa Source Protection Area. More detailed summaries of the subwatersheds supplying municipal systems are found in the relevant municipal Sections later in the report.

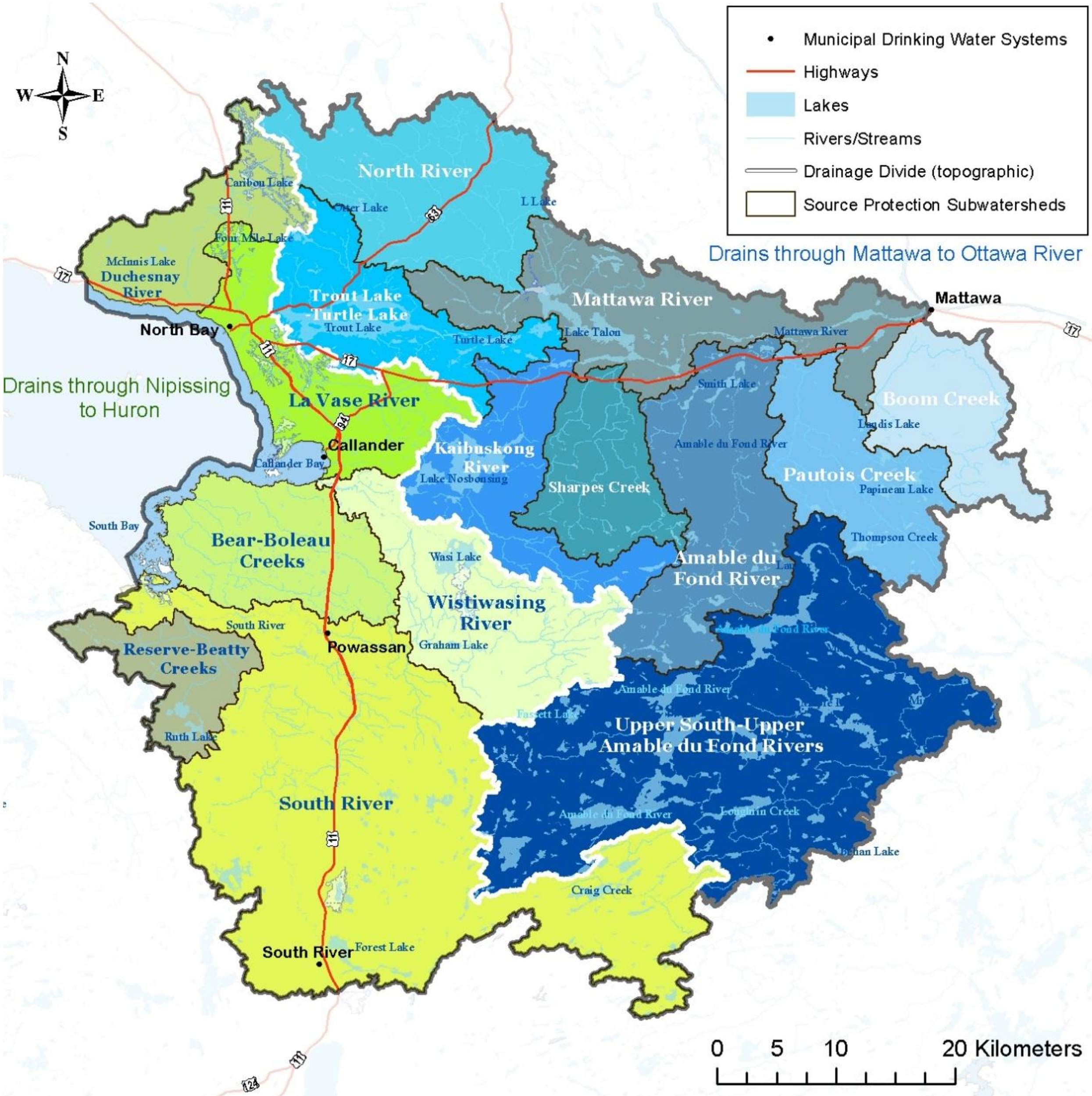
Tier One Watersheds

The subwatersheds used in the Tier One Assessment are generally based on the quaternary watersheds in the North Bay - Mattawa SP Area. In total, 15 subwatersheds were considered for this assessment, as shown on Figure 2-46 and summarized in Table 2-29 below.

Table 2-29. North Bay – Mattawa Source Protection Area Watersheds

Watershed I.D.	Quaternary Watershed	Estimated Drainage Area (km^2)
2DD-19	Duchesnay River	144
2DD-20	LaVase River	182
2DD-21	Bear-Boileau Creeks	178
2DD-23	South River	827
2JE-04	Upper South - Upper Amable du Fond River	706
2JE-02	Mattawa River	273
2JE-03	Amable du Fond River	258
2JE-09	North River	248
2DD-22	Wistiwasing River	234
2JE-07	Kaibuskong River	182
2JE-01	Trout / Turtle Lake	177
2JE-05	Pautois Creek	176
2JE-17	Boom Creek	138
2JE-06	Sharpes Creek	137
2DD-25	Reserve-Beatty Creeks	102
Total	North Bay – Mattawa SP Area	**3962**

Figure 2-40. North Bay – Mattawa Source Protection Area Tier One Subwatersheds



Water Budget Elements

Water Supply

For surface water sources, the estimated monthly water supply was calculated as the monthly median streamflow. The monthly median value is a typical monthly baseflow or low flow value (MOE, 2007). Seven streamflow gauges located throughout the SP Area were used to estimate streamflow. The location of the seven streamflow gauges is shown on Figure 2-47 (and as already mentioned, the locations of dam structures are also within the same figure).

Figure 2-41. Streamflow Gauge Locations and Dam Structures

Streamflow records were obtained from the Water Survey of Canada website. A summary of stream gauge information is presented in Table 2-30.

Streamflow gauges are located in five subwatersheds. The remaining ten subwatersheds are ungauged. Therefore in order to provide a reliable estimate of the water supply in each subwatershed, the total streamflow was estimated using a simple proportional analysis. For ungauged subwatersheds, streamflow stations closest to the subwatershed in question and with similar physiography were chosen to pro-rate the drainage area. The stream gauging stations selected for each subwatershed and the applied scaling factors are listed in Table 2-31.

Table 2-30. Streamflow Gauging Stations used in the Tier One Assessment

Station Name	Station ID	Drainage Area (km^2)	Latitude	Longitude	Period of Records	Number of Years	Max Annual Flow Rate (m^3/s)	Mean Annual Flow Rate (m^3/s)	Min Annual Flow Rate (m^3/s)
Duchesnay River Near North Bay	02DD008	90.4	46°19'53" N	79°30'20" W	(1956-1982)	26	2.32	1.65	0.93
Chippewa Creek at North Bay	02DD014	37.3	46°18'42" N	79°26'54" W	(1974-2003)	29	0.82	0.62	0.44
LaVase River Near North Bay	02DD013	70.4	46°15'48" N	79°23'42" W	(1974-2003)	29	1.33	0.93	0.56
South River Near Nipissing	02DD005	787	46°05'49" N	79°28'45" W	(1937-1984)	47	17.9	11.8	6.36
South River at South River Prov-Terr-State	02DD009	316	45°50'54" N	79°22'46" W	(1956-1991)	35	7.33	5.34	2.93
Amable Du Fond River at Samual Du Champlain Provin	02JE019	1130	46°18'0"N	78°52'45" W	(1972-1995)	23	22.6	16.1	9.05
Mattawa River Below Bouillon Lake	02JE020	909	46°17'56" N	78°54'26" W	(1971-1998)	27	20.6	15.4	9.31

Table 2-31. Streamflow Gauging Stations and Scaling Factors used to Prorate

HYDAT Station Used to Prorate		Quaternary Subwatershed Prorated		Scaling Factor
HYDAT Station Name	HYDAT station ID	Subwatershed Name	Sub-watershed ID	
Mattawa River Below Bouillon Lake	02JE020	North River	2JE-09	3.665
		Trout/Turtle Lake	2JE-01	5.136
		Mattawa River (excluding Trout/Turtle contributing area)	2JE-02	3.33
Amable Du Fond River At Samuel De Champlain Provincial Park	02JE019	Boom Creek	2JE-17	8.188
		Amable Du Fond River	2JE-03	4.38
		Pautois Creek	2JE-05	6.42
		Sharpes Creek	2JE-06	8.248
		Kaibuskong River	2JE-07	6.209
		Upper South-Upper Amable Du Fond Rivers	2JE-04	1.601
		Wasi River	2DD-22	4.829
South River Near Nipissing	02DD005	South River	2DD-23	0.952
		Reserve-Beatty Creeks	2DD-25	7.716
		Bear-Boileau Creeks	2DD-21	4.421
Duchesnay River Near North Bay	02DD008	Duchesnay Creek	2DD-19	0.628
LaVase River At North Bay, Chippewa Creek At North Bay	02DD013, 02DD014	LaVase River	2DD-20	0.592

For groundwater sources, the estimated monthly water supply for each subwatershed was the calculated annual recharge rate divided evenly over 12 months. The Tier One analysis for groundwater supplies does not consider aquifer storage, so the water supply terms are assumed to be constant on an average annual basis (MOE, 2006). The annual recharge distribution for the entire SP Area was determined in the Conceptual Water Budget (Map 14a)

(Gartner Lee, 2008a). Through GIS, this information was used to estimate annual recharge rates for each subwatershed under consideration. Due to the regional nature of the subwatersheds investigated at this scale, it is unlikely that groundwater divides differ significantly from surface water divides. Based on this, groundwater inflow was assumed to be negligible, and was not considered as part of the groundwater supply component.

Water Reserve

Water reserve is an estimate of the amount of water that needs to be reserved to support other uses of water within the watershed, including both ecosystem requirements as well as other human uses. For surface water, the reserve was estimated as the stream flow that was exceeded 90% of the time (Q_{P90}). Data from streamgauges assigned to each subwatershed, as discussed above, were used to calculate Q_{P90}.

For groundwater, water reserve was estimated as 10% of the monthly calculated groundwater recharge.

Water Demand

Water demand relates to water that is taken as a result of an anthropogenic activity, such as municipal supply, private water takings, or agricultural use, that is a partial or total consumptive use. Water Demand was derived from the maximum permitted takings as noted in the Ministry of Environment's Permit to Take Water (PTTW) database (MOE, 2009a) (see Tables 2-32 and 2-33). Consumptive water demand refers to water that is taken from a source and not returned locally in a reasonable time frame.

Consumptive water demand was determined through analysis of the Ministry of Environment's Permit to Take Water (PTTW) database (MOE, 2009a). The analysis considered the seasonality of pumping, and applied consumptive use coefficients, based on the type and purpose of taking. Surface water and groundwater consumptive demand were estimated for each permit. The procedure followed meets the intent of Appendix D (Water Use) of Guidance Module #7: Water Budget and Water Quantity Risk Assessment (MOE, 2007).

Table 2-32. Permitted Surface Water Takings According to PTTW Database (MOE 2009a)

Permit No.	Source	Watershed	Category	Period of Taking (days)	Maximum Permitted Takings (L/day)
03-P-5018	Long Lake	Mattawa R	Water Supply-Campgrounds	150	220,000
3030-5Z4NMS	Long Lake	Mattawa R	Water Supply–Municipal	365	220,000
98-P-5023	Mattawa River	Mattawa Rr	Industrial-Manufacturing	365	975,000
6565-7T6PTN	Trout Lake	Trout Lake	Water Supply-Municipal	365	79,500,000
4187-6P2HR4	Trout Lake	Trout Lake	Industrial-Cooling Water	365	10,682,784
4187-6P2HR4	Trout Lake	Trout Lake	Water Supply-Communal	365	54,504
0251-6ADRGZ	LaVase River	La Vase R	Commercial-Golf Course Irrigation	183	654,240
4755-72DQRV	10 Inter-Connected Ponds	La Vase R	Commercial-Golf Course Irrigation	184	981,936
7615-7G8KQR	C1 / Culvert	La Vase R	Dewatering-Construction	20	4,665,600
7615-7G8KQR	C2 / Culvert	La Vase R	Dewatering-Construction	20	9,676,800
7615-7G8KQR	Surface Water Management Pond / Excavation Area	La Vase R	Dewatering-Construction	20	400,000
81-P-5226	Beaver Dam	South River	Agricultural-Field & Pasture Crops	10	378,500
0121-6GWG8B	South River	South River	Commercial-Golf Course Irrigation	182	1,022,000
99-P-5010	South River	South River	Water Supply-Municipal	365	1,680,000
8634-7FKH55	South River	South River	Construction–Road Building	215	1,728,000
03-P-5011	South River	South River	Agricultural-Field & Pasture Crops	30	3,928,000
3111-5WVLPX	South River	South River	Agricultural-Field & Pasture Crops	30	3,928,000
8315-6ADM8M	Headwater Spring of Balsam Creek	North River	Commercial-Aquaculture	365	4,032,000

Table 2-33. Permitted Groundwater Takings According to PTTW Database (2009)

Permit No.	Source	Watershed	Category	Period of Taking (days)	Maximum Permitted Takings (L/day)
02-P-5002	Well No. 1	La Vase River	Water Supply-Communal	365	59,803
02-P-5002	Well No. 2	La Vase River	Water Supply-Communal	365	59,803
02-P-5002	Well No. 3	La Vase River	Water Supply-Irrigation	122	13,075
02-P-5002	Well No. 4	La Vase River	Water Supply-Communal	365	59,803
2265-6KXLMZ	Well 1	La Vase River	Industrial–Power Production	365	80,000
5182-63SS2B	Well #1	La Vase River	Water Supply-Campgrounds	365	91,368
5182-63SS2B	Well #2	La Vase River	Water Supply-Campgrounds	365	91,368
4458-7DRQ7C	Dewatering System	La Vase River	Dewatering	30	160,000
2654-7LHMP6	1 Wellpoint System / 40-50 Wellpts	La Vase River	Dewatering-Construction	30	400,000
04-P-5008	Leachate Collection & Pump Station	La Vase River	Remediation-Groundwater	365	1,200,000
1136-63CRCK	Leachate Collection & Pump Station	La Vase River	Remediation	365	1,200,000
03-P-5018	Well #1	Pautois Creek	Water Supply-Campgrounds	365	69,120
3030-5Z4NMS	Well #1	Pautois Creek	Water Supply - Municipal	365	69,120
82-P-5292	Well #1 (Powassan)	South River	Water Supply - Municipal	365	1,313,280
82-P-5292	Well #2 (Powassan)	South River	Water Supply - Municipal	365	1,313,280
02-P-5059	Well # 1 (Mattawa)	Mattawa River	Water Supply - Municipal	365	4,582,080
02-P-5059	Well # 2 (Mattawa)	Mattawa River	Water Supply - Municipal	365	1,964,160

To generate monthly consumptive water demand estimates, the permitted values were distributed to the month in which they were most likely to be active (e.g. golf course irrigation May-Oct), while also considering the number of days the permit is authorized to be active. A sector specific consumptive use factor, which estimates how much water is not returned to the original source, is then applied. The consumptive use factors are included in Table 2-34. This calculation results in monthly estimates of consumptive water demand. This is seen as a conservative approach and is consistent with Guidance Module 7 (MOE, 2007). Reporting pumping rates were not made available to this study.

Table 2-34. Consumptive Water Use Factors

Category of Water Taking	Groundwater	Surface Water*
Agricultural-Field and Pasture Crops	0.85	0.85
Commercial-Aquaculture	*NA*	0.008
Commercial-Golf Course Irrigation	*NA*	0.70
Construction-Road Building	*NA*	0.90
Dewatering	1	0.008
Industrial-Cooling	*NA*	0.02
Industrial-Manufacturing	*NA*	0.10
Industrial-Power Production	1	*NA*
Remediation	1	0.25
Water Supply-Campground	0.20	0.20
Water Supply-Communal	1	0.20
Water Supply-Municipal	1	0.20

*Assumes water is discharged back to original source. Where this is not the case, factor is 1.

The North Bay- Mattawa SP Area Conceptual Water Budget (Gartner Lee, 2008a) estimated the rural population of the SP Area to approximately 19,000. This population would be reliant on a combination of groundwater and surface water supplies for domestic use, although the division of supply is not known. Applying a per capita domestic use rate of 175 L/cap/day (MOE, 2001), yields a total unserviced demand of 3,325 m^3/day. This demand, expressed in terms of depth over the SP Area is about 0.3 mm/yr. However, for the purpose of this report, consumptive water demand from rural users was considered to be minimal since this water is likely returned to the groundwater system through septic tanks and tile drains, and therefore not considered.

Agriculture is a relatively minor land use within the SP Area, comprising only 6% of the land area. Due to this relatively minor proportion of agricultural land, it is assumed that consumptive water demand associated with livestock watering, and other agricultural practices, is negligible.

Subwatershed Stress Assessment

Overview

The Tier One Stress Assessment is a screening exercise to determine whether or not the ratio of consumptive water demand to available water supply is greater than Provincial thresholds, on a subwatershed basis. This exercise indicates where there is a higher likelihood of water taking related impacts and thus where further study is required. The assessment is completed using the Percent Water Demand calculation. As outlined in the MOE Guidance Module for Water Budgets (MOE, 2007), and the Technical Rules (MOE, 2009b), the Percent Water Demand is calculated using the following formula:

$$\textit{Percent Water Demand} = \frac{Q_{DEMAND}}{Q_{SUPPLY} - Q_{RESERVE}} \times 100$$

where Q_{DEMAND} is the consumptive demand, Q_{SUPPLY} is the water supply, and $Q_{RESERVE}$ is the water reserve.

The Percent Water Demand was evaluated independently for groundwater and surface water supplies in each subwatershed. As indicated in the Technical Rules (MOE, 2009b), groundwater sources are evaluated for both average annual and monthly conditions, whereas surface water sources are evaluated monthly. Based on the Percent Water Demand and the thresholds listed in Table 2-35, each subwatershed was assigned a level of potential stress for groundwater and for surface water. Those subwatersheds receiving a low level of potential stress require no further water budgeting work. Those subwatersheds experiencing a moderate or significant level of potential stress, and have a municipal water supply, are subject to further water budget evaluation at the Tier Two level.

Table 2-35. Surface Water and Groundwater Stress Thresholds

Stress Level Assignment	Surface Water	Groundwater	
	Maximum Monthly % Water Demand	Average Annual % Water Demand	Monthly Maximum % Water Demand
Significant	≥ 50%	≥ 25%	≥ 50%
Moderate	> 20% and < 5 0%	> 10% and < 25%	> 25% and < 50%
Low	≤ 20%	≤ 10%	≤ 25%

The Technical Rules (MOE, 2009b) require that the subwatershed stress be estimated for current and future municipal water demands. This section only discusses current demands. Tier One studies completed specifically for subwatersheds supplying municipal systems investigated the impact of future municipal demands, and are discussed separately in sections to follow.

Stress Assessment

Utilizing the water supply and demand components previously quantified, a stress assessment was carried out for every subwatershed in the SP Area. Water demands in the subwatershed were determined through the PTTW database (MOE, 2009a). Of the 15 subwatersheds studied, only six have active Permits to Take Water. Stress assessments for these six sub-watersheds are described in the following sections. Without a permit, percent demand is zero which constitutes a low potential for stress.

LaVase River

Surface Water

There are five permitted surface water takings located in the LaVase River subwatershed. Two of the takings are associated with golf course irrigation, and are active May – Oct. The other three takings are associated with construction dewatering, and are authorized to be active for 20 days per year. It is assumed that these takings would be active during the month of April.

The maximum monthly consumptive water demand is 13 L/s and occurs throughout the months of May – Oct. For the remaining months, the consumptive water demand is zero, or less than 0.1 L/s.

The maximum monthly percent water demand calculated for LaVase River is 6%, well below the Moderate threshold of 20% for surface water (Table 2-36). As such, the LaVase River subwatershed is classified as having a low potential for stress.

Table 2-36. LaVase River Surface Water Stress Assessment

Month	Water Supply (m^3/s)	Water Reserve (m^3/s)	Water Demand (m^3/s)	% Water Demand	Stress Level Assigned
Jan	0.64	0.39	0.00	0	Low
Feb	0.48	0.00	0.00	0	Low
Mar	1.34	0.39	0.00	0	Low
Apr	5.04	1.29	0.001	0.03	Low
May	1.99	0.57	0.013	0.92	Low
Jun	0.74	0.26	0.013	2.71	Low
Jul	0.45	0.19	0.013	5	Low
Aug	0.39	0.16	0.013	5.65	Low
Sep	0.62	0.19	0.013	3.02	Low
Oct	1.36	0.44	0.013	1.41	Low
Nov	2.02	0.71	0.00	0	Low
Dec	1.08	0.58	0.00	0	Low

Groundwater

There are 11 groundwater withdrawals permitted within the LaVase River subwatershed. Four withdrawals are for communal water supplies; two are for campground water supplies; two are for dewatering; two for groundwater remediation; one withdrawal is for irrigation; and one withdrawal is for power production purposes. The average annual consumptive water demand associated with these permits is 30 L/s, with a maximum monthly demand of 36 L/s.

The maximum monthly percent water demand for LaVase River is 4% (Table 2-37), indicating a low potential for stress.

Table 2-37. LaVase River Groundwater Stress Assessment

Month	Water Supply (m^3/s)	Water Reserve (m^3/s)	Water Demand (m^3/s)	% Water Demand	Stress Level Assigned
Jan	1.19	0.12	0.03	2.8	Low
Feb	1.19	0.12	0.03	2.8	Low
Mar	1.19	0.12	0.03	2.8	Low
Apr	1.19	0.12	0.04	3.8	Low
May	1.19	0.12	0.03	2.8	Low
Jun	1.19	0.12	0.03	2.8	Low
Jul	1.19	0.12	0.03	2.8	Low
Aug	1.19	0.12	0.03	2.8	Low
Sep	1.19	0.12	0.03	2.8	Low
Oct	1.19	0.12	0.03	2.8	Low
Nov	1.19	0.12	0.03	2.8	Low
Dec	1.19	0.12	0.03	2.8	Low

South River

Surface Water

There are six surface water takings within the South River subwatershed. Three of the water takings are for agricultural purposes, along with a construction withdrawal, a golf course irrigation permit, and a municipal supply. The municipal supply permit is associated with the village of South River. It is estimated that the total maximum consumptive demand reaches 110 L/s during the month of July, then declining to a stable consumptive demand of 4 L/s throughout the winter months. The maximum monthly percent water demand is calculated to be 4% (Table 2-38), and indicates that the subwatershed has a low potential for stress.

Table 2-38. South River Surface Water Stress Assessment

Month	Water Supply (m^3/s)	Water Reserve (m^3/s)	Water Demand (m^3/s)	% Water Demand	Stress Level Assigned
Jan	8.37	4.40	0.00	0	Low
Feb	8.04	4.64	0.00	0	Low
Mar	9.41	5.36	0.00	0	Low
Apr	31.36	11.01	0.02	0.1	Low
May	14.82	7.69	0.03	0.42	Low
Jun	7.50	3.76	0.03	0.8	Low
Jul	4.75	1.93	0.11	3.9	Low
Aug	4.34	1.69	0.03	1.13	Low
Sep	5.57	2.31	0.03	0.92	Low
Oct	6.98	3.36	0.03	0.83	Low
Nov	10.08	4.43	0.02	0.35	Low
Dec	8.77	4.46	0.00	0	Low

Groundwater

There are two groundwater takings located in South River, both being associated with Powassan's municipal supply. Consumptive demand is assumed to be constant throughout the year at a rate of approximately 15 L/s. This consumptive demand corresponds to a percent water demand of less than one percent (Table 2-39), indicating a low potential for stress.

Table 2-39. South River Groundwater Stress Assessment

Demand Scenario	Water Supply (m^3/s)	Water Reserve (m^3/s)	Water Demand (m^3/s)	% Water Demand	Stress Level Assigned
Average Demand	7.5	0.75	0.02	0.3	Low
Maximum Demand	7.5	0.75	0.02	0.3	Low

The subwatersheds contributing to the water supplies for the Municipality of Powassan and Village of South River are contained within the South River watershed. A separate Tier One investigation into these subwatersheds was conducted to refine the percent water demand calculations and stress identification. A summary of these findings is provided in Section 7 for the Powassan subwatershed and in Section 8 for the South River subwatershed.

Trout / Turtle Lake

Surface Water

There are three surface water takings from Trout Lake; a taking to supply water to the City of North Bay, and two takings for industrial cooling purposes. As wastewater from the City of North Bay is not returned to Trout/Turtle Lake, 100% of the municipal supply taking is consumptive, and therefore dominates the subwatershed total consumptive demand. The consumptive demand for the subwatershed results in the percent water demand being above 20% in January through March, and June through September. This results in the subwatershed being identified as having a Moderate potential for stress (Table 2-40). Further details on the Tier One Assessment are found in Section 6.

If stress levels are shown to be either moderate or significant, a more robust Tier Two Subwatershed Stress Assessment is completed and, similarly if that reveals moderate or significant stress, a Tier Three Local Area Risk Assessment must be undertaken. The Tier Two and Tier Three assessments for the Trout/Turtle Lake subwatershed are presented in Section 6.

Table 2-40. Trout Lake Surface Water Stress Assessment

Month	Water Supply (m^3/s)	Water Demand (m^3/s)	% Water Demand	Stress Level Assigned
Jan	1.781	0.5483	31	Moderate
Feb	1.651	0.5549	34	Moderate
Mar	2.742	0.5543	20	Moderate
Apr	8.545	0.5443	6	Low
May	5.063	0.5893	12	Low
Jun	2.242	0.6435	29	Moderate
Jul	1.565	0.6154	39	Moderate
Aug	1.389	0.6396	46	Moderate
Sep	1.698	0.5657	33	Moderate
Oct	2.670	0.5256	20	Low
Nov	3.728	0.5256	14	Low
Dec	2.750	0.5069	18	Low

Groundwater

There are no permitted groundwater takings from the Trout/Turtle Lake subwatershed. This results in a percent water demand of zero, and indicates a low potential for stress.

Mattawa River

Surface Water

There are a total of three water takings within the Mattawa River subwatershed. Two of these takings are for water supplies, with the third being for industrial manufacturing. The total consumptive demand is 2 L/s and is dominated by the industrial manufacturing taking. The maximum monthly percent water demand is less than 1% (Table 2-41):a low potential for stress.

Table 2-41. Mattawa River Surface Water Stress Assessment

Month	Water Supply (m^3/s)	Water Reserve (m^3/s)	Water Demand (m^3/s)	% Water Demand	Stress Level Assigned
Jan	2.44	1.87	0.002	0.35	Low
Feb	2.03	1.59	0.002	0.45	Low
Mar	2.73	1.55	0.002	0.17	Low
Apr	12.93	3.78	0.002	0.02	Low
May	6.19	2.80	0.002	0.06	Low
Jun	2.70	0.74	0.002	0.1	Low
Jul	1.54	0.56	0.002	0.2	Low
Aug	1.33	0.41	0.002	0.22	Low
Sep	1.94	0.70	0.002	0.16	Low
Oct	3.19	1.25	0.002	0.1	Low
Nov	4.73	2.19	0.002	0.08	Low
Dec	3.48	2.09	0.002	0.14	Low

Groundwater

One groundwater permit with two sources is located within the Mattawa River subwatershed, and is associated with the municipal supply of Mattawa. There is not a significant difference in water demand between months as municipal/communal and industrial/commercial water use is consistent throughout the year. There is a slight increase in demand in July and August as a result of water used for crop irrigation.

The average annual percent water demand is 0.6%, indicating a low potential for stress. The maximum percent water demand is also 0.6%, indicating a low potential for stress (Table 2-42). Further details on this Tier One Assessment are found in Section 5.

Table 2-42. Mattawa River Groundwater Stress Assessment

Month	Water Supply (m^3/s)	Water Reserve (m^3/s)	Water Demand (m^3/s)	% Water Demand	Stress Level Assigned
Jan	17.9	1.79	0.09	0.58	Low
Feb	17.9	1.79	0.08	0.53	Low
Mar	17.9	1.79	0.09	0.58	Low
Apr	17.9	1.79	0.09	0.56	Low
May	17.9	1.79	0.09	0.58	Low
Jun	17.9	1.79	0.09	0.56	Low
Jul	17.9	1.79	0.10	0.64	Low
Aug	17.9	1.79	0.10	0.64	Low
Sep	17.9	1.79	0.09	0.59	Low
Oct	17.9	1.79	0.09	0.58	Low
Nov	17.9	1.79	0.09	0.56	Low
Dec	17.9	1.79	0.09	0.58	Low

Annual	215	21.5	1.12	0.58	Low

Pautois Creek

Surface Water

There are no permitted surface water takings from the Pautois Creek subwatershed. This results in a percent water demand of zero, and indicates a low potential for stress.

Groundwater

There are two groundwater takings located within Pautois Creek subwatershed. The permits are for a campground water supply, and a municipal water supply. The average annual and maximum monthly consumptive demand is 1 L/s. Both demand scenarios result in a percent water demand less than one, indicating a low potential for stress (Table 2-43).

Table 2-43. Pautois Creek Groundwater Stress Assessment

Demand Scenario	Water Supply (m^3/s)	Water Reserve (m^3/s)	Water Demand (m^3/s)	% Water Demand	Stress Level Assigned
Average Demand	1.05	0.10	0.001	0.11	Low
Maximum Demand	1.05	0.10	0.001	0.11	Low

North River

Surface Water

There is a single aquaculture surface water taking located within North River. The consumptive demand associated with this taking is 0.4 L/s thoughout the year. The percent water demand associated with this consumptive demand is less than one percent, indicating a low potential for stress (Table 2-44).

Table 2-44. North River Surface Water Stress Assessment

Month	Water Supply (m^3/s)	Water Reserve (m^3/s)	Water Demand (m^3/s)	% Water Demand	Stress Level Assigned
Jan	2.21	1.70	0.0004	0.08	Low
Feb	1.84	1.44	0.0004	0.1	Low
Mar	2.48	1.41	0.0004	0.04	Low
Apr	11.74	3.44	0.0004	0.005	Low
May	5.62	2.54	0.0004	0.01	Low
Jun	2.45	0.67	0.0004	0.02	Low
Jul	1.40	0.51	0.0004	0.04	Low
Aug	1.21	0.37	0.0004	0.05	Low
Sep	1.77	0.64	0.0004	0.04	Low
Oct	2.90	1.14	0.0004	0.02	Low

Nov	4.30	1.99	0.0004	0.02	Low
Dec	3.16	1.90	0.0004	0.03	Low

Groundwater

There are no permitted groundwater takings within the North River subwatershed. This results in a percent water demand of zero, and indicates a low potential for stress.

Other Subwatersheds

The remaining subwatersheds which were not mentioned above do not have any known active PTTWs, and as such have a water demand and percent water demand of zero for surface water and/or groundwater. The water supply and reserve for both these surface water and groundwater sources are presented in Tables 2-45 and 2-46, respectively.

Table 2-45. Subwatersheds with Zero Percent Water Demand – Surface Water

Subwatershed (Supply & Reserve in m^3 / s)		**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Duchesnay River	Supply	0.65	0.53	0.68	8.1	2.71	1.02	0.61	0.48	0.99	1.94	2.17	1.26
	Reserve	0.34	0.25	0.32	1	0.92	0.36	0.14	0.12	0.18	0.61	0.95	0.59
Bear-Boileau Creeks	Supply	1.8	1.73	2.02	6.75	3.19	1.61	1.02	0.93	1.2	1.5	2.17	1.89
	Reserve	0.95	1	1.15	2.37	1.66	0.81	0.42	0.36	0.5	0.72	0.95	0.96
Upper South - Upper Amable du Fond River	Supply	6.72	5.4	6.31	24.61	19.15	9.56	4.85	3.17	3.91	5.21	9.78	8.68
	Reserve	3.61	3.72	3.56	8.82	10.11	4.82	2.37	1.68	1.76	2.18	3.39	3.89
Amable du Fond River	Supply	2.46	1.97	2.31	8.99	7	3.49	1.77	1.16	1.43	1.9	3.58	3.17
	Reserve	1.32	1.36	1.3	3.22	3.7	1.76	0.87	0.61	0.64	0.8	1.24	1.42
Wistiwasing River	Supply	2.21	1.77	2.07	8.09	6.29	3.14	1.59	1.04	1.29	1.71	3.21	2.85
	Reserve	1.19	1.22	1.17	2.9	3.32	1.58	0.78	0.55	0.58	0.72	1.11	1.28
Kaibuskong River	Supply	1.73	1.39	1.63	6.34	4.94	2.47	1.25	0.82	1.01	1.34	2.52	2.24
	Reserve	0.93	0.96	0.92	2.27	2.61	1.24	0.61	0.43	0.45	0.56	0.87	1
Pautois Creek	Supply	1.68	1.35	1.57	6.14	4.77	2.38	1.21	0.79	0.98	1.3	2.44	2.16
	Reserve	0.9	0.93	0.89	2.2	2.52	1.2	0.59	0.42	0.44	0.54	0.85	0.97
Boom Creek	Supply	1.31	1.06	1.23	4.81	3.74	1.87	0.95	0.62	0.76	1.02	1.91	1.7
	Reserve	0.71	0.73	0.69	1.72	1.98	0.94	0.46	0.33	0.34	0.43	0.66	0.76
Sharpes Creek	Supply	1.3	1.05	1.22	4.78	3.72	1.86	0.94	0.62	0.76	1.01	1.9	1.68
	Reserve	0.7	0.72	0.69	1.71	1.96	0.94	0.46	0.33	0.34	0.42	0.66	0.75
Reserve-Beatty Creeks	Supply	1.03	0.99	1.16	3.88	1.83	0.93	0.59	0.54	0.69	0.86	1.25	1.08
	Reserve	0.54	0.57	0.66	1.36	0.95	0.46	0.24	0.21	0.29	0.42	0.55	0.55
*Surface Water Demand/Percent Water Demand is **0** for all months within each subwatershed listed above.*													

*Surface Water Stress Level is **Low** for all months within each subwatershed listed above.*

Table 2-46. Subwatersheds with Zero Percent Water Demand – Groundwater

Subwatershed	Average/Maximum Monthly Supply and Reserve (m^3/s)		Water Demand/ % Demand	Stress Level
Duchesnay River	Supply	1.36	0	Low
	Reserve	0.14		
Bear-Boileau Creeks	Supply	1.24	0	Low
	Reserve	0.12		
Upper South - Upper Amable du Fond River	Supply	5.49	0	Low
	Reserve	0.55		
Amable du Fond River	Supply	1.55	0	Low
	Reserve	0.16		
North River	Supply	2.18	0	Low
	Reserve	0.22		
Wistiwasing River	Supply	1.68	0	Low
	Reserve	0.168		
Kaibuskong River	Supply	1.2	0	Low
	Reserve	0.12		
Trout / Turtle Lake	Supply	2.44	0	Low
	Reserve	0.244		
Boom Creek	Supply	0.88	0	Low
	Reserve	0.09		
Sharpes Creek	Supply	0.87	0	Low
	Reserve	0.09		
Reserve-Beatty Creeks	Supply	0.82	0	Low
	Reserve	0.08		

Limitations

A data gap exists in that streamflow gauges are located in only five of the 15 subwatersheds. Regardless, total streamflow was estimated using a simple proportional analysis. For ungauged subwatersheds, streamflow stations closest to the subwatershed in question and with similar physiography were chosen to pro-rate the drainage area.

Similar to the Conceptual Water budget, total actual water takings are probably lower based on the fact that the MOE PTTW database currently does not report actual takings, only maximum permitted amounts. Likewise, information on the amounts of water taken without a PTTW was not available within this analysis.

Uncertainty

The Technical Rules (MOE, 2009b) require that an uncertainty classification of either "High" or "Low" be assigned to each subwatershed undergoing a stress assessment. Given the low water demand associated with each subwatershed (calculated using the PTTW maximum permitted rates, which tend to overestimate the amount of use), the uncertainty level assigned to each subwatershed is low.

Summary
Meeting the requirements of the *Clean Water Act (2006)*, a Tier One Water Quantity Stress Assessment has been completed for all subwatersheds within the North Bay-Mattawa SP Area. Water supply and reserve estimates have been generated by available streamflow data, as well as estimates of groundwater recharge produced as part of the Conceptual Water Budget Study. Consumptive water demand estimates have been generated by applying seasonal use and consumptive use factors to information in the Province's PTTW database (MOE, 2009a).

Results of the Surface Water Stress Assessment indicate that only the Trout/Turtle Lake Subwatershed has percent water demands that are above the Provincial thresholds. The identification of Trout/Turtle Lake as being potentially stressed confirms the assessment carried out by Gartner Lee (2008b). Basd on the groundwater stress assessment all subwatersheds were assigned a low level of stress. Surfacewater and groundwater subwatershed stress is illustrated by Figure 2-48 and Figure 2-49 respectively.

Figure 2-42. Surface Water Stress Assessment in the North Bay-Mattawa SP Area

Figure 2-43. Groundwater Stress Assessment in the North Bay-Mattawa SP Area

2.7 Climate Change

There is now broad international scientific agreement that human activities are primarily responsible for recently documented climate change (see for example IPCC 2007a). This has largely been attributed to the release of greenhouse gases (GHGs) into the atmosphere, which have caused warming temperatures, which in turn have changed precipitation regimes and increased extreme weather events. Since the Intergovernmental Panel on Climate Change (IPCC) released its first report in 1990, average global temperature increases of about 0.2°C per decade have been observed, contributing to an average global temperature increase of 0.74°C during the period 1906-2005 (IPCC 2007a).

Long-term changes to temperature and precipitation are expected as a result of climate change. Under low GHG emissions scenarios, the IPCC (2007a) predicts a likely global temperature increase of 1.1°C to 2.9°C by 2100. In their worst case GHG emissions scenarios, however, the IPCC (2007a) predicts that average global temperatures could increase as much as 6.4°C by 2100. Increases in temperature and the amount of precipitation are most likely to occur in high latitude regions (IPCC 2007a). Furthermore, it is almost assured that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent. Importantly, scientific observations are increasingly showing that many impacts of climate change are occurring faster and sooner than projected (Pearson and Burton 2009). In this sense, some current projections of climate change likely represent conservative estimates.

While these trends are expected to continue well into the future, the extent of climate change will largely depend on the level of GHG emissions mitigation around the world. Failure to reduce international GHG emissions will lead to more significant changes and increased risk of impacts. However, even if GHGs were dramatically reduced today, anthropogenic warming and sea level rise would continue for centuries due to the time scales associated with climate processes and feedbacks. For example, the IPCC (2007a) has predicted that even with concentrations of all GHGs and aerosols kept at year 2000 levels, a further warming of about 0.1°C per decade is expected. These predictions point to the need for adaptation to climate change as well as for reducing sources of GHG emissions.

Overview

Existing Climate Data

Existing climate data for the Source Protection Area (SP Area) have been provided by Gartner Lee (2008a). From a climate change perspective, these data are valuable for the climate baseline they provide and for comparing observed climate trends against projected trends.

For the SP Area, Gartner Lee (2008a) has provided data on climate stations, average annual precipitation, precipitation distribution, metrological zones, evapotranspiration, and long-term historic temperature and precipitation trends and averages. This information is contained within the Section 2.2 Conceptual Water Budget of this document. Estimated annual precipitation and evapotranspiration within the SP Area is provided in Figures 2-48 and 2-49, respectively.

Figure 2-44. Precipitation in the North Bay-Mattawa SP Area

Figure 2-45. Evapotranspiration in the North Bay-Mattawa SP Area

These data will be useful for conducting region-specific analyses of climate change scenarios, which is beyond the scope of this report. For example, using temperature and precipitation data from the North Bay weather station, OCCIAR (2010) found that annual mean temperature in the North Bay area increased over the period 1938 to 2008, and that total annual precipitation increased by 110 mm during this same time period.

Future climate change projections

Using global climate models (GCMs), scientists are able to produce climate change projections for various regions of the earth. An ensemble approach of running many models together reduces the uncertainty associated with any individual model by minimizing individual model biases. When evaluated using historical empirical data, ensemble results also come closest to replicating historical climate conditions. Although not a guarantee, the results of an ensemble model collection are most likely to represent future climate conditions (CCSN 2009).

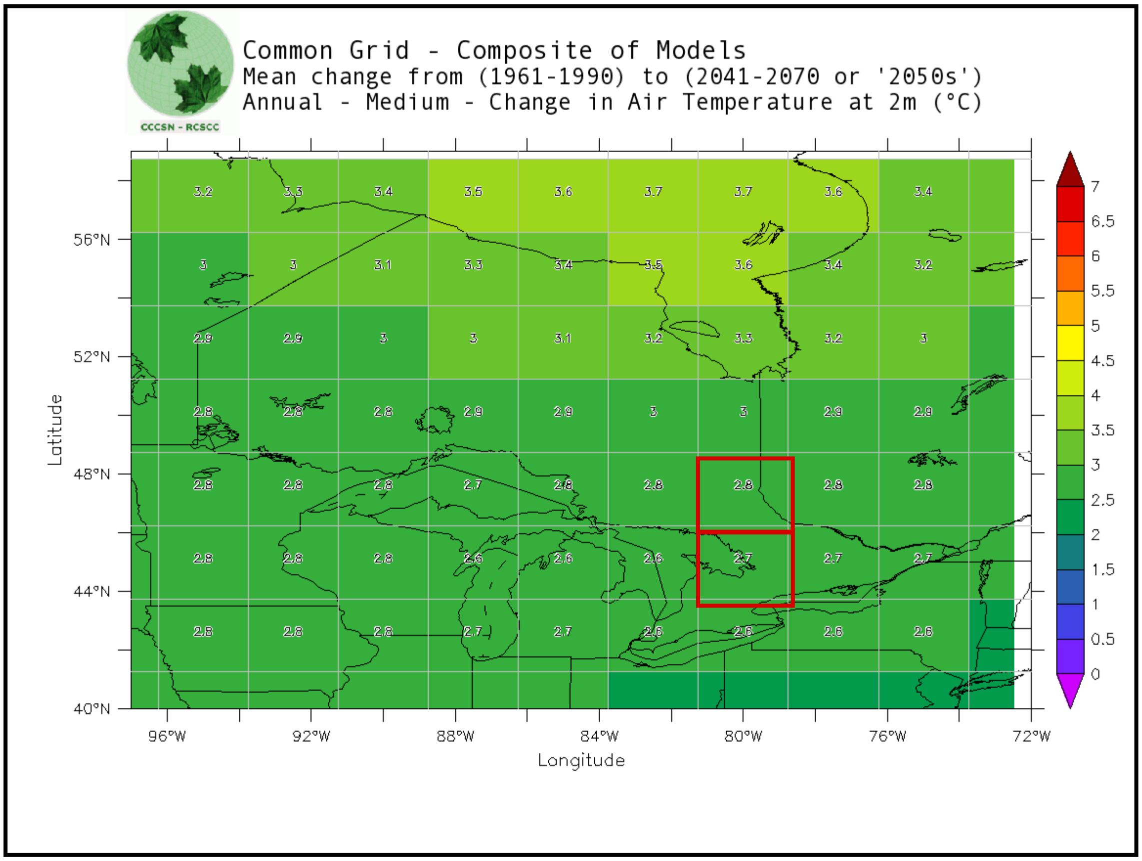
The climate projections for the SP Area discussed below are derived from models developed by 24 international climate modelling centres. These models have been combined by Environment Canada scientists, working as members of the Canadian Climate Change Scenarios Network (CCSN), to compute projections for different regions of Ontario (CCSN 2009). These projections have been based on different assumptions about future volumes of GHG emissions and have been grouped into low, medium, and high scenarios. These models provide a generalized projection of expected changes in a given region, but do not provide detailed projections that consider local influences on climate (e.g., effects of local water bodies and changes in relief).

Climate change projections for the SP Area have been assembled using the CCSN model data. The '2050s' is a term used by the CCSN to describe the period from 2041-2070. All CCSN projections used in this report are for the 2050s period. Furthermore, all data are presented as a mean change from 1961-1990 climate averages. Because the SP Area straddles two grid cells in the model (highlighted in red on Figure 2-50), the mean of these two cell values is used in the following discussion.

In the SP Area, average annual temperatures are expected to rise 2.4°C (under a low emissions scenario) to 3.1°C (under a high emissions scenario) by the 2050s. Winter temperature projections are the most striking, as these expected changes are measurably larger than for other seasons. They are expected to rise 2.7°C (low emissions) to 3.7°C (high emissions) by the 2050s.

Model projections for total precipitation in the 2050s indicate that a 5.7% (low emissions) to 6.3% (high emissions) change in annual average precipitation is expected. The greatest seasonal increase in precipitation will occur in the winter with increases of 10.5% (low emissions) to 12.2% (high emissions) projected. Relatively large precipitation increases are also projected for the SP Area during the spring season, with increases of 9.7% (low emissions) to 10.5% (high emissions). Changes in summer and autumn precipitation are much smaller by comparison.

Figure 2-46. Example output from a CCSN model for the region that includes the North Bay-Mattawa SP Area (CCSN 2009)



Anticipated Changes in Water Quantity and Quality Due to Climate Change

In Ontario, climate change is expected to affect water quality, stream flow, lake levels, groundwater infiltration, and patterns of groundwater recharge to streams (de Loe and Berg 2006, Chiotti and Lavender 2008, Pearson and Burton 2009). More specifically, changes to the hydrologic cycle as a result of climate change may influence the vulnerability and reliability of source water for drinking. For example, changes in seasonal and annual flow variability may alter the groundwater recharge, which is critical to the supply of drinking water. Increased water temperature, reduced stream flow, and changing lake levels may also influence the water quality of a surface water source (Ontario Ministry of Environment 2006).

Generally, annual runoff is expected to decrease, although increased winter runoff and high flows due to extreme precipitation events throughout the year are expected. Lake levels are expected to decline and groundwater recharge is expected to decrease. There will be changes to groundwater discharge in the amount and timing of baseflow to streams, lakes, and wetlands, and ice cover on lakes is expected to be reduced or eliminated completely over time. Snow cover will also be reduced and water temperature in surface water bodies will increase. Finally, it is expected that soil moisture will increase in the winter, but decrease in the summer and autumn.

Impacts on Source Protection Planning

Potential impacts from climate change (Table 2-47) that may be pertinent to source water protection planning in Ontario have been summarized by de Loe and Berg (2006). They draw on a number of previous studies (e.g., Lavender et al. 1998, Bruce et al. 2000, Great Lakes Water Quality Board 2003, Kling et al. 2003, Auld et al. 2004, Bruce et al. 2006) with a focus primarily on the Great Lakes Basin.

Table 2-47. Potential Impacts of Climate Change

Type of Change	Potential Impacts of Change
Frequency of extreme rainfall events	• greater frequency of waterborne diseases • increased transportation of contaminants from the land surface to water bodies
Runoff	• increased stress on fish habitat due to reduced streamflows • reduced water quality because less water is available for dilution of sewage treatment plant effluents and runoff from agricultural and urban land • increased erosion from flashier stream flows • increased water treatment costs due to decreased water quality • increased competition and conflict over reduced water supplies during drought periods • increased frequency of flooding-related damage due to more high intensity storms
Groundwater recharge and discharge	• changes to wetland form and function as discharge decreases • greater costs for groundwater-dependent communities, industries and rural residents associated with deepening wells • increased conflict because of additional competition for scarcer supplies • increased frequency of shallow wells drying up in rural areas • greater frequency of low flows in streams dependent on baseflow, causing increased competition and conflict, and increased stress on aquatic ecosystems
Lake levels	• changes to coastal wetland form and function because of declining lake levels • decreased water quality resulting from lower water volume, increased non-point source pollution, and increased chemical reactions between water, sediments and pollutants • increased water treatment costs due to reduced lake water quality • increased costs associated with moving water supply intakes • increased need for dredging of harbours and channels • reduced cargo capacity for commercial navigation due to shallower water levels • reduced hydropower production due to lower flows between connecting channels
Ice cover	• longer navigation season due to reduced ice thickness and shorter ice cover season • increased shore erosion and sedimentation • increased water temperatures due to decreased ice cover
Water temperature	• increased stress on fish habitat due to increases in water temperature • reduced water quality (e.g., increased algae production) as water temperature increases • greater frequency of taste and odour problems in drinking water supplies
Soil moisture	• increased stress on plants due to decreased summer soil moisture • increased demand for irrigation to supplement soil moisture on drought prone soils

The findings presented in Table 2-47 are also consistent with more recently published work on climate change and water resources in Ontario (e.g., Chiotti and Lavender 2008, Pearson and Burton 2009). However, in some cases, other studies provide additional context and information.

For example, the Expert Panel on Climate Change Adaptation (2009) notes that streams flowing in and out of some small lakes may also dry up for as long as several weeks in the summer. More frequent spring, summer, and fall rainstorms will increase the risk of flooding, and will increase the erosion of riverbanks and the turbidity of drinking water sources. Increased lake effect precipitation is also likely to occur in the lee of the Great Lakes because of more ice-free, open water in winter. Along with an earlier spring, this may in turn lead to a greater volume of spring run-off.

Intake Vulnerability under Climate Change Scenario

The literature review and climate change forecasting completed for the North Bay-Mattawa SP Area suggests that three major trends are expected:

1. Lake levels will decline as a result of decreased snow pack and longer dry periods.
2. Groundwater levels will decline, especially as intense storms produce rapid surface saturation and therefore increased runoff. Low groundwater levels also reduce stream baseflow.
3. Intense storms carrying the bulk of total precipitation will produce large runoff events, which could lead to flooding, property destruction, and transportation of contaminant materials.

Considerations of source vulnerability for surface water intakes include: depth of the intake from the water's surface, the length of the intake from the shoreline, the history of water quality concerns at the surface water intake. Conditions for area vulnerability relate to the delineation of the intake protection zones, and consider for IPZ-2 and IPZ-3 the percentage of the zone which is land; the land cover, soil type and permeability; hydrological and hydrogeological conditions of a transport pathway area; and for IPZ-3, the distance of the zone from the intake (can be in increments; Rules 88-96).

Based on declining lake levels, there is a potential for each intake to have a decreased distance from the water surface to the intake crib. This would increase vulnerability, though the other factors that influence the intake score have a moderating effect and thus there might be little change to any of the intake vulnerability scores.

Groundwater systems rely on a different analysis which uses a combination of an intrinsic susceptibility index (ISI), aquifer vulnerability index (AVI), surface to aquifer advection time (SAAT) or surface to well advection time (SWAT). The consultant for the Powassan and Mattawa groundwater systems used the ISI method, which utilizes available Water Well Information System (WWIS) database records to produce an index or numerical score. The index considers the overburden soil type and thickness above the aquifer, and the static water level in the well. This index value is then interpolated between the well locations to produce a complete spatial assessment (map) of the intrinsic vulnerability of the aquifer(s) (Guidance Modules Groundwater, 2006).

Local impacts to groundwater systems would likely be similar across the three communities of interest. The changes to vulnerability resulting from a climate change scenario will come from the likelihood of decreased water tables. The increase in depth to aquifer has the potential to raise the ISI, as there is increased material between the ground level and the water table. This may also result in a need for new wells. Drilling activity for these wells would create more pockets of increased vulnerability, as it is possible that the wells may become transport pathways if they are not drilled and sealed properly. The existing wells will require proper decommissioning to prevent the same issue.

Drought conditions present a probability of increased distance particles are able to travel in relation to the modelled time of travel. There is potential in certain situations for this to create broader wellhead protection areas (WHPAs), as those delineations are directly derived from time of travel calculations (except for WHPA-A).

Geophysical events could also be an outcome of the decrease in a water table level, combined with infrequent and intense precipitation events. It is possible for a combination of these factors to create localized subsidence. Subsidence is the process of compaction of soils which had previously been highly saturated. The effect is normally a gradual shift in the height of land, with compaction occurring over a long time period.

Assessment of Water Quantity

The stress placed on surface and ground water supplies increases as resources are depleted. The current water budget process identified the stress placed on the North Bay drinking water source due to the return of the water taken from the Trout/Turle Lake subwatershed to another watershed (Lake Nipissing). The actual stress on the drinking water source is not a concern following a Tier Three water quantity analysis of the North Bay sourse as described in Section 5.

The Mattawa and South rivers demonstrated Low stress conditions, which may be elevated under climate change scenarios. It would therefore be beneficial to monitor the stress of the various subwatersheds as time progresses and more signs of the predicted scenarios are noticed. Results of the Trout/Turtle Lake *Tier Two* & 3 studies will likely also be impacted by a climate change scenario, most obviously due to a decline in the streamflow contributions to the Lakes, and thus a decline in overall lake levels.

Future Work

As the resources become available, it would be beneficial for the North Bay-Mattawa Conservation Authority and its partners to become engaged in the local study of climate change impacts. The initial Climate Change report (Trailhead Consulting and P. Quinby Consulting, 2010) addresses the need to study the impacts of climate change on infrastructure systems, especially as the intensity of hydrometerological events increases. For a full analysis of the local implications, the consultants recommend a scientific downsampling of climate data which would give a better understanding of the conditions specific to the North Bay-Mattawa SP Area.

2.8 Great Lakes Agreements

With respect to Great Lakes agreements, the *Clean Water Act (2006)* (2006) includes the following Section:
14. (1) If a source protection area contains water that flows into the Great Lakes, the terms of reference for the preparation of the assessment report and source protection plan for the source protection area shall be deemed to require consideration of

- The Great Lakes Water Quality Agreement of 1978 between Canada and the United States of America, signed at Ottawa on November 22, 1978, including any amendments made before or after this Section came into force.
- The Great Lakes Charter signed by the premiers of Ontario and Quebec and the governors of Illinois, Indiana, Michigan Minnesota, New York, Ohio, Pennsylvania and Wisconsin on February 11, 1985, including any amendments made before or after this Section comes into force.

- The Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem 2002 entered into between Her Majesty the Queen in Right of Canada and Her Majesty the Queen the Queen in Right of Ontario, effective March 22, 2002, including any amendments made before or after this Section comes into force.
- Any other agreement to which the Government of Ontario or the Government of Canada is a party that relates to the Great Lakes Basin and that is prescribed by the regulations.

All of the watersheds that make up the North Bay-Mattawa Source Protection Area drain ultimately to either Lake Huron or the St. Lawrence River.

The Great Lakes Water Quality Agreement (GLWQA) is a commitment by Canada and the United States to address the pollution of the Great Lakes (Environment Canada, 2004a). The Agreement binds the parties to “restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem” through the development and implementation of remedial action plans and lakeside management plans within 43 identified areas of concern. In order to implement the GLWQA, a subsequent agreement between the governments of Canada and Ontario known as the Canada-Ontario Agreement Respecting the Great Lakes Ecosystem (or Canada-Ontario Agreement COA) was required. It sets out how the governments of Canada and Ontario will cooperate and coordinate their efforts to restore, protect and conserve the Great Lakes basin ecosystem. The agreement contributes to meeting Canada’s obligations under the GLWQA. No aspects or recommendations of this assessment report compromise the objectives of the GLWQA.

The Great Lakes Charter is a non-binding understanding between the provinces of Ontario, Quebec and the eight Great Lakes states that sets out broad principles for the joint management of the Great Lakes with respect to quantity (Environment Canada, 2005). The original Charter was developed in 1985 in response to the growing use of water and proposals to divert large quantities out of the Great Lakes basin (Ministry of Natural Resources (2005). The understanding is intended to:

- conserve the levels and flows of the Great Lakes and their tributaries 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
- provide a secure foundation for future investment and development within the region (Council of Great Lakes Governors, 1985).

The Great Lakes Charter Annex tabled in 2001 reaffirms the principles of the Charter and commits the governors and premiers of the Great Lakes states and provinces to a common management regime (Environment Canada, 2005). The Annex supports the principles of the Charter and serves as a commitment to develop and implement a new resource based conservation standard and apply it to any new water withdrawal proposal from the waters of the Great Lakes basin. Principle III identifies the need to establish programs to manage and regulate the diversion and consumptive use of basin water resources. Any diversions which would individually or cumulatively have significant adverse impacts on lake levels, in-basin uses, or the Great Lake ecosystem will not be allowed. The annex promotes more stringent bans on diversions. Exceptions are rare and tightly regulated and are primarily for communities that straddle the Great Lakes-St. Lawrence divide. The North Bay diversion is one of these exceptions and it is important that the City demonstrate sensitivity to the terms of the Annex.

Within the North Bay-Mattawa Source Protection Area, only the North Bay municipal water supply is relevant to the Great Lakes Charter or its Annex. North Bay draws its municipal water from the Ottawa River watershed and discharges the treated sewage to the Lake Huron watershed constituting an intra-basin transfer. Future expansions of the North Bay water taking would have to be compliant with the terms of the Annex.