Approved Assessment Report

Sault Ste. Marie Region

Source Protection Authority

CHAPTER 1

WATERSHED CHARACTERIZATION

November 25, 2011

Prepared as per - Technical Rules: Assessment Report - Clean Water Act, 2006 (November 2009)

ASSESSMENT REPORT
WATERSHED CHARACTERIZATION

Table of Contents

Table of Contents
List of Figures
List of Tables
Appendices
List of Acronyms

EXECUTIVE SUMMARY I

ACKNOWLEDGEMENTS II

1.0 INTRODUCTION 1

1.1 DATA SOURCES 1

2.0 WATERSHED DESCRIPTION 3

2.1 SOURCE PROTECTION AREA 3
2.1.1 History of Development in Sault Ste. Marie 3
2.1.1.1 Urban and Industrial Development 3
2.1.1.2 Municipal drinking water services 7
2.1.1.3 Historical environmental studies and initiatives 7
2.1.2 Stakeholders and Partners 9
2.1.2.1 Municipalities 9
2.1.2.2 Provincial Agencies 10
2.1.2.3 Federal Government 10
2.1.2.4 First Nations 10
2.1.2.5 Interested Stakeholders, Engaged Public and Non-Governmental Organizations 11
2.2 PHYSICAL DESCRIPTION 12
2.2.1 Bedrock Geology 12
2.2.2 Bedrock Surface Elevation 15
2.2.2.1 Archean Rocks 15
2.2.2.1.1 Metavolcanic Rocks 15
2.2.2.1.2 Granitic Rocks 15
2.2.2.2 Early Proterozoic Rocks 16
2.2.2.3 Huronian Supergroup 16
2.2.2.3.1 Livingstone Creek Formation 16
2.2.2.3.2 The Thessalon Formation 17
2.2.2.3.3 Aweres Formation 17
2.2.2.3.4 Mississagi Formation 17
2.2.2.3.5 Espanola Formation 17
2.2.2.3.6 Gowganda Formation 18
2.2.2.3.7 Lorrain Formation 18
2.2.2.3.8 Nipissing Diabase 18
2.2.2.4 Keweenawan Supergroup 18
2.2.2.4.1 Igneous Rocks 18
2.2.2.4.2 Jacobsville Group 18
2.2.2.5 Metamorphism and Structural Geology 18
2.2.2.6 Faulting 19
2.2.2.7 Mineral Occurrences 19
2.2.2.7.1 Lead and Zinc Deposits 20
2.2.2.7.2 Copper 20

2.2.2.7.3 Uranium, Thorium 20
2.2.2.7.4 Iron 21
2.2.2.7.5 Sulfur 21
2.2.2.8 Reliability of geological mapping and other data 21
2.2.3 Surficial Geology 22
2.2.3.1 Quaternary History 22
2.2.3.2 Quaternary Deposits 23
2.2.3.3 Quaternary Summary 26
2.2.4 Topography 26
2.2.5 Physiography 27
2.2.6 Soils Characteristics 28
2.3 HYDROLOGY 31
2.3.1 Surface Water Hydrology 31
2.3.1.1 Big Carp River 31
2.3.1.2 Little Carp River 31
2.3.1.3 Leigh Bay Creek 32
2.3.1.4 Bennett Creek 34
2.3.1.5 West Davignon Creek 34
2.3.1.6 Central Creek 34
2.3.1.7 East Davignon Creek 34
2.3.1.8 Fort Creek 35
2.3.1.9 Clark Creek 35
2.3.1.10 Root River 35
2.3.1.11 Flow Monitoring Stations 36
2.3.2 Groundwater and Hydrogeology 37
2.3.2.1 Recharge and Discharge Areas 37
2.3.2.2 Flow Direction of Major Aquifers 38
2.3.2.3 Characteristics of Major Aquifers 39
2.3.2.3.1 Overburden Aquifers 39
2.3.2.3.2 East Basin – Shannon and Lorna Wells 40
2.3.2.3.3 Central Basin – Goulais and Steelton Wells 40
2.3.2.3.4 West Basin 40
2.3.2.4 Bedrock Aquifers 41
2.3.2.5 Conceptual Hydrostratigraphic Model 41
2.3.2.6 Summary of Aquifer Characteristics 43
2.3.3 Surface – Groundwater Interactions 46
2.3.4 Climate 46
2.3.5 Climatic and Meteorological Trends 47
2.4 NATURALLY VEGETATED AREAS 50
2.4.1 Wetlands 50
2.4.1.1 Evaluated Wetlands 52
2.4.1.1.1 Carp River 52
2.4.1.1.2 Bell's Point East 52
2.4.1.1.3 Bell's Point West 52
2.4.1.1.4 Shore Ridges 53
2.4.1.1.5 Mary Ann Lake 53
2.4.2 Woodlands and Vegetated Riparian Areas 54
2.5 AQUATIC ECOLOGY 56
2.5.1 Fisheries 56
2.5.2 Aquatic Macroinvertebrates 60
2.5.3 Species and Habitats at Risk 60
2.5.4 Invasive Species 61
2.6 HUMAN CHARACTERIZATION 62
2.6.1 Population Distribution and Density 62
2.6.2 Land Use 67
2.6.3 Settlement Areas 68
2.6.3.1 Designated Growth Areas 69
2.6.3.2 Rural Areas 70
2.6.3.3 Urban Residential Development 70
2.6.3.4 Rural Residential 70

2.6.3.5 Cottage and Camp Development 70
2.6.3.6 Industrial / Commercial Sectors Distribution 70
2.6.3.7 Managed Lands 71
2.6.4 Brownfields 72
2.6.5 Landfills 72
2.6.5.1 Existing 72
2.6.5.2 Proposed 72
2.6.5.3 Abandoned 73
2.6.6 Mining and Aggregate Extraction 73
2.6.7 Oil and Gas 73
2.6.8 Forestry 73
2.6.9 Transportation 74
2.6.10 Wastewater Treatment 74
2.6.10.1 East End Wastewater Treatment 75
2.6.10.2 West End Wastewater Treatment 75
2.6.10.3 Serviced Versus Non-serviced Areas 76
2.6.10.4 Septic Systems and Wastewater Treatment Facilities 76
2.6.10.5 Stormwater Management 76
2.6.11 Agricultural Resources 76
2.6.11.1 Agricultural Sector Distribution 77
2.6.11.2 Trends in Agriculture 77
2.6.11.3 Livestock Density 78
2.6.11.4 Impervious Surfaces 79
2.6.12 Recreation 79
2.6.13 Protected Areas 79
2.6.14 Other Land Use Related Issues 80
2.7 WATER USE 80
2.7.1 Drinking Water Sources 81
2.7.1.1 Municipal Wells 83
2.7.1.2 Sault Ste. Marie Wells and Water Treatment Plant 84
2.7.1.3 Private Groundwater Supplies 84
2.7.1.4 Surface Water Intakes 84
2.7.2 Recreational Water Use 85
2.7.3 Ecological Water Use 86
2.7.4 Agricultural Water Use 86
2.7.5 Industrial Water Use 86

3.0 WATER QUALITY 87

3.1 SELECTING INDICATOR PARAMETERS 88
3.2 SURFACE WATER QUALITY DATA ANALYSIS AND REPORTING 90
3.2.1 Source of Water Quality Data 90
3.2.1.1 MOE Provincial Water Quality Monitoring Network 91
3.2.1.2 Municipal Water Supply 91
3.2.2 Surface Water Quality 93
3.2.2.1 Root River Water Quality 93
3.2.2.2 Fort Creek 96
3.2.2.3 Big Carp River 97
3.2.2.4 Little Carp 98
3.2.2.5 East Davignon 99
3.2.2.6 Clark Creek 100
3.2.2.7 Lake Superior Gros Cap Intake 101
3.3 GROUNDWATER QUALITY DATA ANALYSIS AND REPORTING 102
3.3.1 Sources of Groundwater Quality Data 102
3.3.1.1 Municipal Groundwater Wells of Sault Ste. Marie 102
3.3.1.2 Provincial Groundwater Monitoring Network 103
3.3.1.3 City of Sault Ste. Marie Landfill Site 103
3.3.1.4 City of Sault Ste Marie Groundwater Supplies 105
3.3.2 Groundwater Quality 105
3.3.2.1 Municipal Supplies 105
3.3.2.2 Domestic Wells 107

3.3.2.3 Provincial Groundwater Monitoring Network (PGMN) ... 109
3.4 RAW WATER CHARACTERIZATION FOR DRINKING WATER INTAKES ... 109
3.5 MICROBIAL SOURCE WATER CHARACTERIZATION ... 110
3.6 GREAT LAKES CONSIDERATIONS ... 110

4.0 WATER QUANTITY ... 112

4.1 WATER USE ... 112
4.1.1 Drinking water Supply ... 112
4.1.2 Industrial ... 113

5.0 DESCRIPTION OF VULNERABLE AREAS ... 116

5.1 IDENTIFICATION OF SOURCE PROTECTION AREA ... 116
5.2 GROUNDWATER WELLHEAD PROTECTION AREAS (WHPA'S) ... 117
5.3 SURFACE WATER INTAKE PROTECTION ZONES (IPZS) ... 118
5.3.1 Great Lakes and Interconnecting Large River System ... 118
5.3.2 Other Vulnerable Areas: Highly Vulnerable Aquifer ... 118
5.3.2.1 Intrinsic Susceptibility Index (ISI) ... 118
5.3.2.2 Aquifer Recharge/Discharge Areas ... 119
5.3.2.3 Potential Future Drinking Water Sources ... 120

6.0 SUMMARY ... 121

7.0 REFERENCES ... 122

List of Figures

Figure 2.1.1: The Rapids Area of the St. Marys River - 1888 (A) and 1990 (B). ... 6
Figure 2.2.1: Rock Time Chart – Southeast Lake Superior Region ... 14
Figure 2.2.3.1: Example of Abrupt Termination at the Lake's Edge ... 27
Figure 2.3.4: Climate Normal of Sault Ste. Marie (Monthly Avg. 1970-2001) ... 48
Figure 2.3.5: Time Series Trend in Climate of Sault Ste. Marie (1945-2005) ... 49
Figure 2.3.6: Time Series Trend in Precipitation of Sault Ste. Marie (1945-2005) ... 49
Figure 2.6.1: City of Sault Ste. Marie Population Distribution (2006 Census) ... 63
Figure 2.6.2: Township of Prince population distribution (2006 Census) ... 63
Figure 2.6.3: Garden River First Nation Population Distribution (2006 Census) ... 64
Figure 2.6.4: Batchewana First Nation Population Distribution (2006 Census) ... 64
Figure 2.6.5: Sault Ste. Marie population forecast for 2026 (Hemson, 2006). ... 65
Figure 2.6.6: Sault Ste. Marie unemployment rate (Hemson, 2006). ... 66
Figure 2.6.7: Building permits issued by the City of Sault Ste. Marie (SSM) ... 66

List of Tables

Table 2.1.1: Chronology of Engineering Changes; ... 5
Table 2.2.1 General Stratigraphy of the SSM DWSP Area ... 12
Table 2.2.2: Description of Soil Characteristics ... 30
Table 2.3.1 Peak Flood Flows for Major Drainage Basins ... 33
Table 2.3.2 Summary of Environment Canada HYDAT Data ... 36
Table 2.3.3 - Conceptual Hydrostratigraphic Model ... 42
Table 2.3.4 - Summary of Aquifer Characteristics ... 44
Table 2.3.5 - Environment Canada Weather Station Recording History ... 46
Table 2.3.6 - OMNR Fire Weather Station Recording History ... 47
Table 2.3.7 - Environment Canada Data from Station 6057592 Sault Ste. Marie A . 47
Table 2.4.1: Sault Ste. Marie District Wetlands ... 51
Table 2.4.2: Summary of Wetlands within SSMRCA watershed ... 53
Table 2.5.1: Fish Species within SSM Source Protection Area ... 57
Table 2.5.2: Lakes, Rivers and Streams within SSMR Source Protection Area ... 59
Table 2.6.1: Comparative Census Statistics for Sault Ste. Marie, Prince Township and Garden River First Nation. ... 62
Table 2.6.2: Sault Ste. Marie population forecast. ... 65
Table 2.6.3: City of Sault Ste. Marie Land Use Codes. ... 67
Table 2.6.4: Managed Lands within Sault Ste. Marie ... 71
Table 2.6.5: Effluent Discharged into the St. Marys River ... 75
Table 2.6.6: Canada Land Inventory ... 78
Table 2.6.7: Livestock Density in Nutrient Units per Acre ... 78
Table 2.7.1: Summary of Water Users ... 81
Table 2.7.2: Water Use Summary ... 82
Table 3.1: Surface Water Quality of Root River (13001100202) ... 94
Table 3.2: Surface Water Quality of Root River (13001100102) ... 95
Table 3.3: Surface Water Quality of Root River (13001100402) ... 95
Table 3.4: Surface Water Quality of Fort Creek (13000900102) ... 97
Table 3.5: Surface Water Quality of Big Carp River (13000300102) ... 98
Table 3.6: Surface Water Quality of Little Carp River (13000001002) ... 99
Table 3.7: Surface Water Quality of East Davignon Creek (13000800102) ... 100
Table 3.8: Surface Water Quality of Clark Creek (13001000102) ... 101
Table 3.9: Surface Water Quality of Raw Water at Lake Superior Gros Cap ... 102
Table 3.10: Summary of Chloride Study of SSM Groundwater Supply ... 106
Table 3.11: Summary of Raw Groundwater Quality (ODWSP) ... 107
Table 3.12: Treated Groundwater Quality of Municipal Wells ... 107
Table 3.13: Summary of Domestic Well Quality in SSM Watershed ... 108
Table 3.14: Summary of Provincial Groundwater Monitoring Network (PGMN) ... 109
Table 4.1.1: Surface Water Permits to Take Water ... 115
Table 4.1.2: Groundwater Permits to Take Water ... 115
Table 4.1.3: Groundwater Use Summary ... 116

Appendices

Appendix 1: Summary of Existing Watershed Resource Documents Including Assessments and Reports

Appendix 2

- **2A – Summary of Available Water Quality Data**
- **2B – Provincial Groundwater Monitoring (PGMN) Data**
- **2C – Ontario Drinking Water Surveillance Program (ODWSP) Data**

Appendix 3

- **3A – Source of Water Quality Information and Sampling Locations**
- **3B – Water Quality Trend Graphs**
- **3C – Water Quality Box Plots**
- **3D – Summary of Flow vs Quality of Root River**
- **3E – Summary of Raw Water Quality of Lake Superior Gros Cap Intake**
- **3F – Summary of Raw Water Quality of WTP of SSM**
- **3G – Summary of Water Quality of PGMN**
- **3H – Summary of Microbiological Quality**
- **3I – Summary of Domestic Groundwater Quality of SSM**
- **3J – Summary of Domestic Groundwater Quality (Chloride) of SSM**

Appendix 4: Canadian Water Quality Index Guideline

Appendix 5: List of Lakes and Rivers

Appendix 6: Drinking Water Quantity Analyses – SSM Water Filtration Plant

Appendix 7 Glossary

Appendix 8 Watershed Characterization Maps

- **WC Map 01 : Source Protection Area**
- **WC Map 01A : First Nation Lands**
- **WC Map 02A : Bedrock Geology**
- **WC Map 02B : Bedrock Topography Contour**
- **WC Map 02C : Quaternary Geology**
- **WC Map 02D : Topography (DEM)**
- **WC Map 02E : Overburden Thickness**
- **WC Map 03 : Physiography**
- **WC Map 04 : Soils**
- **WC Map 04A : Land Use CLI Data**
- **WC Map 05A : Hydrologic Features**
- **WC Map 05B : Recharge Areas and Discharge Areas**
- **WC Map 06 : Wetlands**
- **WC Map 06A : Wetland Shoreridge**
- **WC Map 06B : Wetland Carp Rivers**
- **WC Map 07 : Woodlands**
- **WC Map 07A : Riparian Area (Modelled)**

WC Map 08 : Fisheries
WC Map 09 : Population
WC Map 10 : Land Use
WC Map 10A : Aggregates
WC Map 11 : Municipal Service
WC Map 12 : Municipal/Communal Wastewater Treatment Facilities
WC Map 12A : Protected Areas
WC Map 13 : Wells Municipal/Communal Treatment Facilities
WC Map 13A : Water Monitoring Sites
WC Map 14 : Surface Water Intakes and Treatment Facilities
WC Map 15 : Water Taking Volume (PTTW)
WC Map 16 : Water Taking Use (PTTW)
WC Map 17 : Well Head Protection Areas
WC Map 18 : Watershed of Intake
WC Map 18A : Surface Water Intake Protection Zones
WC Map 19 : Vulnerable Aquifers
WC Map 20 : Potential Future Drinking Water Sources
WC Map 21A : Livestock Density
WC Map 21Ba: Managed Lands – Nutrient Application
WC Map 21Bb: Managed Lands – NonAgricultural
WC Map 21C : Impervious Surfaces

List of Acronyms

a	annum
ACR	Algoma Central Railway
amsl	above mean sea level
AOC	Area of Concern
bgs	below ground surface
d	day
DEM	Digital Elevation Model
FMP	Forest Management Plan
GIS	Geographic Information System
GUDI	Groundwater Under the Direct Influence of Surface Water
GL	Giga or billion litres
GW	Groundwater
HYSEP	Hydrograph Separation
IPZ	Intake Protection Zone
IJC	International Joint Commission
INAC	Indian and Northern Affairs Canada
IR IPZ-1	Primary Inland River Intake Protection Zone
IR IPZ-2	Secondary Inland River Intake Protection Zone
ISI	Intrinsic Susceptibility Index
km	kilometre
km^2	square kilometre
LIO	Land Information Ontario
LSB	Local Services Board
m	metre
mg/L	milligram per litre (ppm)
µg/L	microgram per litre (ppb)
MIGD	Million Imperial Gallons Per Day
MGD/mgpd	Million Gallons Per Day
mm	millimetre
m^3/s	cubic metres per second
m^3/d	cubic metres per day
MNR	Ministry of Natural Resources
MODFLOW	A Three-Dimensional Finite-Difference Ground-Water Flow Model
MOE	Ministry of the Environment
OBBN	Ontario Benthos Biomonitoring Network
ODWS	Ontario Drinking Water Standards
OFAT	Ontario Flow Assessment Techniques
OGS	Ontario Geological Survey
OMNR	Ontario Ministry of Natural Resources
OPG	Ontario Power Generation
ODWSP	Ontario Drinking Water Surveillance Program
PCB	Polychlorinated Biphenyls
PGMN	Provincial Groundwater Monitoring Network
PTTW	Permit To Take Water
PWQMN	Provincial Water Quality Monitoring Network
PWQO	Provincial Water Quality Objectives
RAP	Remedial Action Plan
RJB	RJ Burnside
SARO	Species at Risk of Ontario
SCADA	Supervisory Control and Data Acquisition

SDWA	**Safe Drinking Water Act**
SPA	**Source Protection Authority**
SP	**Source Protection**
SPC	**Source Protection Committee**
SSM	**Sault Ste. Marie**
SSMRCA	**Sault Ste. Marie Region Conservation Authority**
SSMR	**Sault Ste. Marie Region**
SSMWFP	**Sault Ste. Marie Water Filtration Plant**
St. Dev.	**Standard Deviation**
SWAT	**Surface to Well Advection Time**
TDS	**Total Dissolved Solids**
TOT	**Time of Travel**
TTOR	**Technical Terms of Reference**
TWCA	**Total Water Contributing Area**
VOC	**Volatile Organic Compounds**
WHPA	**Wellhead Protection Area**
WTP	**Water Treatment Plant**
WPCP	**Water Pollution Control Plant**
WC	**Watershed Characterization**
WSC	**Water Survey of Canada**

Executive Summary

The Ontario Government has introduced legislation to protect drinking water at the source as part of an overall commitment to human health and the environment. A key focus of the legislation is the production of locally developed, science-based Source Assessment Reports and Protection Plans. The objective of a Source Protection Plan (SPP) is to establish measures to protect both the quality and quantity of sources of drinking water within a watershed. The SPP is considered the first step in a multi-barrier approach to ensuring safe drinking water. Subsequent barriers are expected to occur with safeguard implementation during treatment, distribution, monitoring and response to emergencies. To prepare the Assessment Report, a Source Protection Committee (SPC) of representatives from the watershed community will work together at the local level (e.g., municipalities, conservation authorities, water users and land owners). Representation on the committee will vary depending on local needs.

The Watershed Characterization is one in a series of chapters that will assist watershed communities to develop the Assessment Report. The Watershed Characterization is a description of the watershed region. A “watershed” is the entire area of both land and water that is drained by a river and its tributaries. The Sault Ste. Marie Region Conservation Authority (SSMRCA) has developed a watershed description by accumulating all of the available information about the area. It includes information compiled on the area’s physical, sociological and economic makeup. This report also includes the facts and figures on population distribution, climate, land use, water use, existing water-related monitoring systems and the natural characteristics of the SSMR Source Protection Area’s watershed.

Maps have also been produced to provide a visualization of the watershed. These watershed characterization maps are designated throughout the report as WC Map # and they can be found in Appendix 8 at the end of this report. The watershed characterization provides the foundation for the remaining chapters of the Assessment Report.

A section on water quality is included as part of the characterization. It describes the water quality conditions and trends in the watershed region. Simple statistical analysis was carried out. Maps and graphics were produced to illustrate these trends. This section describes the quality of surface water, groundwater, domestic wells, Provincial Groundwater Monitoring Network (PGMN), raw/treated water of the city’s Water Treatment Plant (WTP) and municipal groundwater wells.

An inventory of water use in the watershed region was prepared from the Ministry of the Environment’s (MOE) Permit To Take Water (PTTW) database, Municipal Water Use database (Environment Canada), Industrial Water Use database (Statistics Canada) and location of private water use database (from census and MOE well water records). It shows the current draw on the water, as well as historical takings and can be used to illustrate where most of the water is being extracted. The population growth was also estimated for the watershed area to determine if there may be any significant impact on future water demands.

Vulnerable areas in the watershed were also identified. These are areas which are particularly sensitive to impacts on the quality or quantity of the drinking water sources. Vulnerable areas include Wellhead Protection Areas (WHPAs), Intake Protection Zones (IPZs), Highly Vulnerable Aquifer (HVAs), and Significant Recharge Areas (SGRAs).

Vulnerability score has been assigned in all vulnerable areas in SSM SPA (IPZs, HVAs, SGRAs, and WHPAs). The IPZs for the study area (IPZ-1 and IPZ-2) were all ranked as having low vulnerability. WHPA delineation and scoring has been completed for every municipal groundwater system within the SSM SPA, identifying areas where certain types of activities may pose drinking water threats.

Vulnerability is considered together with provincial hazard scores outlined in the Table of Drinking Water Threats (Technical Rules, MOE, 2009) for the various activities and their associated chemicals and pathogens to determine a risk score. Using both the natural vulnerability and hazard scores, potential drinking water threats are ranked as significant, moderate, or low in each one of the vulnerable areas (IPZs, HVAs, SGRAs, and WHPAs).

Acknowledgements

The SWP team gratefully acknowledges the contributions to this study made by several important groups and individuals. The SSMRCA greatly appreciate the support given to this project by the Ontario Ministry of Environment and Ontario Ministry of Natural Resources. The SSMRCA acknowledges and thanks the following people for their dedication, hard work and persistence in the preparation of this Watershed Characterization Report for the Sault Ste. Marie Watershed Region:

Rhonda Bateman –SSMRCA
Anjum Amin –SSMRCA
Marlene McKinnon –SSMRCA
Trisha Westman –SSMRCA
Frank Tesolin –SSMRCA
Christine Aasen –SSMRCA
Loralei Premo –SSMRCA
Mike Lundrigan – PUC Services Inc.
Dominic Parrella – PUC Services Inc.
Catherine Taddo – Corporation of City of Sault Ste. Marie
Jennifer Hallett – Fisheries and Oceans Canada
Jim McLaughlin - Ontario Forest Research Institute (OFRI)
Sandra Wawryszyn – Ontario Forest Research Institute (OFRI)
Gerry Bennett – Author, Geology Section
Dick Cowen – Author, Geology Section

SPC Members – Subhash Verma, Chair
Ralph Yanni, Larry Woolley, Peter McLarty, Susan Hamilton-Beach, Peter Tonazzo, Andrew Hallett, Roy Bertolo, Hal McGonigal

1.0 INTRODUCTION

The Sault Ste. Marie Region Conservation Authority (SSMRCA) has completed Watershed Characterization Report and compiled preliminary information regarding physical, sociological, and economic characteristics of the Sault Ste. Marie Region watershed. The purpose of the watershed characterization portion of the technical assessment is to provide the background necessary to undertake the threat, vulnerability and risk assessment phases of the Assessment Report. Available information and pertinent data from various sources have been compiled and analyzed to complete the watershed characterization. A series of maps has been produced to illustrate watershed characteristics (See Appendix-9, Map01 to Map21).

1.1 Data Sources

Every effort was made to collect, compile and use the most recent data available for the watershed according to fulfill the requirements of the Technical Rules: Assessment Report, *Clean Water Act, 2006* (Nov., 2009). An Excel file called SWP Data Requirements Matrix that was created by Conservation Ontario has been used to acquire portions of the relevant data. Required datasets for the Watershed Characterization Report were requested from various Provincial and Federal departments, ministries and agencies, Conservation Ontario and several Engineering Consultants. Datasets were also acquired from local PUC Inc. and City of Sault Ste. Marie Engineering Office as needed. Datasets that were collected and used in this report have been documented in the Excel file *SSMRCA SP DATA MATRIX METADATA V0L_1* related Studies and reports were obtained from the SSMRCA and Algoma University library were fully utilized.

The following data sources have been used in the preparation of this report:

- Agriculture and Agri-Food Canada
- Algoma Public Health
- Essar Steel Algoma Inc. (formerly Algoma Steel Corporation Limited)
- Census Canada
- Chiefs of Ontario
- Conservation Ontario
- Environment Canada
- HEMSON Consulting Ltd.
- Land Information Ontario
- MacViro Consultants
- Ministry of Environment
- Ministry of Natural Resources
- Ministry of Northern Development and Mines
- Ministry of Agriculture, Food and Rural Affairs
- Ontario Forest Research Institute (OFRI)
- R. J. Burnside and Associates Limited
- Sault Ste. Marie Innovation Centre
- Statistics Canada

- St. Marys Paper Ltd.
- The Chamber of Commerce of Sault Ste. Marie
- The Corporation of the City of Sault Ste. Marie
- Sault North Planning Board
- Public Utilities Commission of the City of Sault Ste. Marie
- PUC Services Inc.
- The Corporation of the Township of Prince
- Department of Fisheries and Oceans, Sault Ste. Marie District Office
- National Resources Canada, Canadian Forest Service

A number of reports have also been used in the preparation of this report including the Sault Ste. Marie Watershed Plan; the Regional Groundwater Study for SSM, 2003; the Municipal Groundwater Supply Vulnerability Pilot Studies – SSM, 2005; and the SSMRCA Conceptual Water Budget. Additional studies and reports have also been used and these are documented in Appendix 1 - Summary of Existing Watershed Resource Documents including Assessments and Reports.

2.0 WATERSHED DESCRIPTION

The watershed description is considered to be an assessment of the watershed's fundamental natural and man-made characteristics. The collected information describes the identified point and non-point threats, vulnerability of watershed, drinking water threats, significant recharge areas, potential groundwater quality and quantity impacts, specific actions that can be taken to protect the quality and quantity of water supplies, and supports future public consultations. This description is developed by compiling available background information for the watershed, including natural characteristics, population distribution and land use. This information provides the context for the broad understanding of the water quality and quantity conditions within the watershed that are discussed in the subsequent sections.

2.1 Source Protection Area

The Source Protection Area delineated by WC Map 01 is situated within the District of Algoma, along the north shore of the St. Marys River and Lake Superior. The planning area encompasses the municipality of Sault Ste. Marie and the Township of Prince and includes portions of the townships of Dennis, Pennefather, Aweres, Jarvis and Duncan as well as areas of the Garden River and Batchewana First Nations. Both Lake Superior and the St. Marys River are shared resources of Canada and the United States. The boundary of the Source Protection Area extends out to the international border along its entire width. The land-based area of the planning area is 522 km^2. The planning area is 775 km^2 which includes both land and water based areas.

The City of Sault Ste. Marie depends on surface water from Lake Superior above the St. Marys River and groundwater from 6 wells within the St. Marys River watershed. The SSMR Source Protection Authority's vision is to provide an ecosystem-based management plan to reduce the anthropogenic and natural impacts on water sources used by City of Sault Ste. Marie and surrounding area. The SSMR Source Protection Area was delineated to encompass the St. Marys River watershed as well as a number of smaller watersheds draining the northern shore of Lake Superior above the mouth of St. Marys River (WC Map 01).

2.1.1 History of Development in Sault Ste. Marie

2.1.1.1 Urban and Industrial Development

Historical artifacts dating back to 7000 B.C. found within the source protection area suggest that the St. Marys River basin has been inhabited for thousands of years by Anishinabek people. However, significant impact from human activity would have been minimal until the late 1600s when the first European settlements were established by French fur traders.

The St. Marys River is the only water connection between Lake Superior and the lower Great Lakes. The St. Marys Rapids posed a natural barrier between Lake Superior and Lake Huron with a vertical drop of approximately 6.1 m (IJC, 1992). In order to overcome this barrier and expand the fur trade to the interior of the continent, the Northwest Company constructed the first canal and lock in 1798. The lock enabled the community to grow as a major transportation corridor and trading point. The lock was destroyed by American troops in the War of 1812.

In 1855, the American Canal was completed and development on both sides of the river began to increase. Prompted by tension with the United States which resulted in the denial of passage of a Canadian ship through the lock in 1870, an all-Canadian water route from the Atlantic Ocean to the head of Lake Superior was constructed and completed in 1895. In 1887, a rail spur was constructed connecting the town to the main rail line in Sudbury. An international rail bridge was also constructed, connecting Canada and the US via rail rendering the area accessible year-round.

In 1894, the arrival of American industrialist Frances H. Clergue brought Sault Ste. Marie into the industrial era. Clergue realized the potential of the St. Marys River as a means to provide hydro electric power for domestic as well as industrial consumption. He inspired the development of new pulp and paper mills, hydro-electric plants, rail and marine transportation, mines and a steel plant, thereby increasing the physical size and population of the community. In 1902 the first steel made in Ontario was cast at the Sault Steel Plant. By the early 1900s, Sault Ste. Marie was booming as a result of the rapidly expanding market for steel and other resources.

The Provincial Air Service established in the Sault in 1924 put the city on the map around the world as a centre of excellence for fire fighting technology and techniques. The 1950's brought the post war industrial boom and the construction of the St Lawrence Seaway which increased the traffic into the Great Lakes and enhanced the market for steel, lumber and paper. The downtown waterfront at the time was a major industrial transfer point for coal, oil, lumber and people and was populated with a number of large bulk fuel storage facilities to support the harbour's traffic (Ref 1 & Burnside, 2003).

The Trans-Canada Highway was built in the 1960's in addition to the international bridge linking the Canadian highways to the U.S. Interstate Highway system. The bridge construction marked the shift from water based to land based transport for the area. Historically, the St. Marys River has been the sight of significant modification in order to improve transportation between Lake Superior and Lake Huron. As shipping activity increased, so did the hydroelectric developments, railway construction and industrial activity along the St. Marys River shoreline (Figure 2.1.1). The effect of this development has had substantial impact on the river's ecosystem. Table 2.1.1 outlines the chronology of the construction which has occurred on the St. Marys River channel.

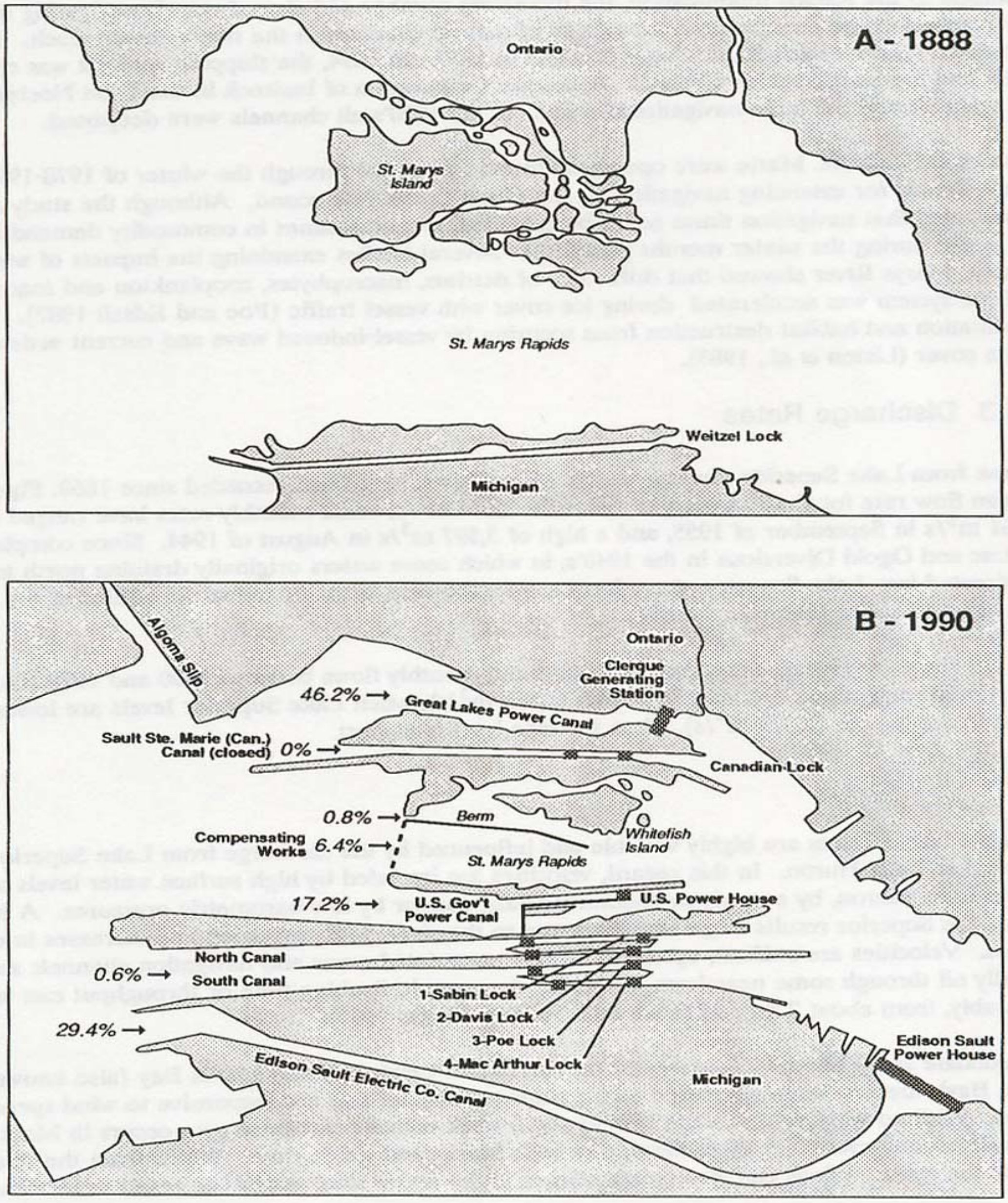
Table 2.1.1: Chronology of Engineering Changes; associated with the St. Marys Rapids, 1797 to 1986 (Duffy et al., 1987 and Kauss, 1991)

Year	Event
1797	Navigation lock 11.5m long constructed on Canadian side.
1839	Navigation canal started on American side, construction later aborted.
1855	Navigation lock completed on American side, construction begun in 1853.
1859	Lower Lake George Channel dredged.
1881	Weitzel Lock on American side completed.
1888	International railway bridge completed.
1894	Dredging of Lake Nicolet Channel completed.
1896	Canadian government canal and lock completed.
1901	Construction of compensating works begun.
1902	Sault Edison Hydroelectric Canal and power plant completed; canal diverted enough water to operate 41 turbines, each using approximately 10.6 m^3/s, total capacity 435 m^3/s.
1914	Davis Lock on American side completed.
1915	Additional 37 turbines added to Sault Edison hydroelectric plant.
1916	Hydroelectric canal and plant completed on Canadian side.
1919	Sabin Lock on American side completed.
1921	Construction of 16 gate compensating works completed. IJC sets monthly river discharges.
1943	MacArthur Lock on American side completed, replacing Weitzel Lock.
1969	Abitibi Paper Company water use reduced from 198 to 1 m^3/s permanently.
1982	Great Lakes Power hydroelectric plant (i.e. Clergue Generating Station) on Canadian side redeveloped and capacity increased from 510 to 1076 m^3/s.
1985	Berm constructed to maintain water level over rapids along Canadian shore (St. Mary's Rapids-Whitefish Island Remedial Works for Fishery).

The rapids area of the St. Marys River between 1888 (A) and in 1990 (B)

Annual average flow of the St. Marys River in 1990 was 1.8 x10^3 m^3/s with the annual average flow distribution represented as percent next to the arrows.

(modified after Duffy et al. 1987, DFO, Sea Lamprey Control Data Files and International Lake Superior Board of Control 1991)



Industrial Use	**Domestic Use**
Algoma Steel - 0.24%	Michigan and Ontario - 0.02%
St. Marys Paper - 0.02%	

Note: Flow distribution represented as percent next to the arrows (MOE & DNR, 1991)

Figure 2.1.1: The Rapids Area of the St. Marys River - 1888 (A) and 1990 (B).

2.1.1.2 Municipal drinking water services

Prior to the development of the municipal water supply in the early 1900's, residents in the area depended on individual domestic wells. Municipal water in the area has always been supplied by a mix of surface and groundwater. In 1918 the Huron Street pumping station was built at the corner of Queen and Huron Street. The station pumped water from a surface water intake located in the St. Marys River in the south side of the headrace of Brookfield Renewable Power's (formerly Great Lakes Power) Francis H. Clergue hydroelectric generating station. This intake and pumping station remained active until the mid 1980's. It was replaced in 1982 by the current intake located in Lake Superior off of the point at Gros Cap, west of the city (Burnside, 2003). The relocation of the intake was driven by concerns over water quality and quantity. The Gros Cap site was selected "owing to deep water relatively close to shore, which is well removed from the shipping lanes and other potential sources of contamination" (Proctor & Redfern, 1982).

The Steelton well field, located in the present day city's west end, was perhaps the earliest municipal groundwater source. In 1913 when the well field in the area was being developed, the well constructed served the town of Steelton. It was not until 1918 that Steelton was incorporated into the City. There have been a number of wells constructed within the Steelton well field. In the early years, a system of artesian wells was used to feed a reservoir. The stored water was distributed to the city using a system of booster pumps (Lundrigan, 2005). In 1934, the original well at the current Steelton well location was constructed.

Additional wells were commissioned in the 1970's in both the west and east ends of the city. The Goulais wells #1 and #2 were constructed in the west end and in the east end, the Shannon well and the Lorna well were commissioned in 1973 and 1979, respectively (Burnside, 2005). An additional well was constructed in the Lorna well field in 1982 due to a decline in the water levels. During the time of this development of the city's groundwater supply, studies also investigated the potential of the groundwater resources to entirely supply the city's water needs. The study conducted by International Water Supply determined that additional groundwater was available but not in sufficient supply to replace the Gros Cap surface water supply. The investigation also concluded that further development of ground water supply around the perimeter of the city limits may have a negative effect on private wells outside the municipal service boundary. This problem had previously been encountered in the Steelton area. The study also flagged the potential for contamination of groundwater from the landfill site situated at the toe of the Pre-Cambrian Shield northeast of the city (Proctor & Redfern, 1982).

2.1.1.3 Historical environmental studies and initiatives

From its earliest beginnings, the heart of the industrial and downtown core of the city of Sault Ste. Marie has been situated along the St. Marys River. As a result, the St. Marys River corridor is perhaps the most environmentally degraded area within the Source Protection Area. For this reason, much of the historical environmental assessment work within the area has been focused on the St. Marys River basin.

"The International Joint Commission's (IJC) first examination of water quality conditions in the St. Marys River took place in 1912 in response to a request from the governments of the United States and Canada to examine the extent and causes of pollution in the Great Lakes. Water quality problems related to raw sewage were identified in the St. Marys River and other connecting channels in the basin. Although problems relating to raw sewage have been substantially corrected in most areas and water borne disease epidemics eliminated, other problems, such as the presence of persistent toxic substances, have been subsequently identified in the St. Marys River and in other areas of the Great Lakes basin" (IJC, 1998).

These problems became the subject of the 1978 Great Lakes Water Quality Agreement between Canada and the United States and a binational protocol was signed by the two countries in 1987. The protocol includes a commitment to report on progress and an obligation for the IJC to review Remedial Action Plans (RAPs) which at the time were being developed and implemented for the 42 identified Areas of Concern (AOCs) in the Great Lakes basin. The St. Marys River basin is listed as an AOC. The goal of Remedial Action Plans is to restore and protect beneficial uses in 42 identified Areas of Concern within the Great Lakes basin. AOCs are geographic areas where human activities have caused or are likely to cause impairment of beneficial uses or the area's ability to support aquatic life (IJC, 1998).

A Stage-1 RAP (problem identification) for the binational St. Marys River Area of Concern was submitted for IJC review on May 11, 1992. The following sources of pollution were identified: contaminated sediment; point source discharges from municipal and industrial sources including sanitary and combined sewer overflows; and non point sources of pollution from such sources as urban storm-water runoff including air deposition of toxic substances. Environmental issues of concern included: changes in fish community structure; loss of fish and wildlife habitat; impact on biota from impaired sediment quality; and adverse impacts of exotic species (IJC, 1998). The current status of RAP implementation was reviewed in 2004 by Kresin et al.

The majority of inland surface water assessment work within the watershed has been related to flood control and associated with the Sault Ste. Marie Region Conservation Authority (SSMRCA). Technical studies have been carried out on the main tributaries of the St. Marys for a variety of reasons since SSMRCA was established in 1963. Watershed inventories, capacity reviews and environmental assessments of flood control systems are among the engineering reports available for the major streams and rivers within the area. Surface water quality assessment for the inland tributaries to the St. Marys River however, is limited.

Groundwater quality data on the other hand is more comprehensive. In 2003, a municipal groundwater management and protection study was carried out as a result of a joint effort by the PUC Services Inc., the City of Sault Ste. Marie (the City), Prince Township, Sault Ste. Marie North Planning Board and Batchewana First Nation Rankin Reserve (Rankin). The technical terms of reference for groundwater studies developed by the Ministry of the Environment (MOE, Nov., 2001) were used to direct the course of the study. This study is a significant building block used in the development of the Source Protection Plan.

A system of eleven monitoring wells has been established within the SSMR Source Protection Area as part of the Provincial Groundwater Monitoring Network. Sampling stations for the Provincial Surface Water Quality Monitoring Network have been selected and sampling began in 2007. Water quality information collected from these two programs will be used to assess and monitor the status of the region once the Source Protection Plan is implemented.

In addition to the above water quality monitoring initiatives, the Conservation Authority underwent the process of revising its generic regulations. Ontario Regulation 176/06 Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses became effective May 8, 2006. Previous regulations focused on the protection of provincially significant wetlands, shore areas and permanent waterways. Under the revised regulations, the Conservation Authority's area of jurisdiction was expanded to include all wetlands and intermittent streams as well as valley lands. The expanded jurisdiction will assist in greater source protection.

Land use planning within the Municipality of Sault Ste. Marie is governed by the City's Official Plan and the Comprehensive Zoning By-laws. The Official Plan came into force on September 17th, 1996 and has since undergone a number of revisions. The basis for the most recent amendment dated July 14th, 2005 was to incorporate the recommendations of the municipal groundwater study completed in 2003 and the new comprehensive zoning by-law which came into effect November, 2005.

In the Township of Prince, land use planning is governed by the township's official plan, zoning by-laws and the township council. Land use planning in the other neighbouring unorganized townships of Dennis, Pennefather, Aweres and Duncan is administered by the Sault North Planning Board. The planning board provides advice and assistance on matters referred by local councils and the Minister of Municipal Affairs and Housing for the unorganized area between Sault Ste. Marie and Wawa, Ontario. The board prepares official plans and administers a zoning by-law for the area. The board can grant consents to sever land and has been also been delegated subdivision, validations, foreclosures and powers of sale authority (Ref 2).

The eastern edge of the planning area includes lands of the Garden River and the Batchewana First Nations. Garden River First Nation is governed by an elected council consisting of a chief and twelve councillors. Councillors are appointed responsibility for a number of portfolios. Justice/Policing/By-laws are covered by one portfolio. Land use in general does not fall under one specific portfolio, but is related to a number of different portfolios. For example, issues under the economic development, housing, highway and parks portfolios could all be related to land use. Planning decisions are brought before the entire council for resolution. Land use in the Batchewana First Nation Rankin Reserve is also managed by an elected council consisting of a Chief and seven elected council members.

WC Map 01: Source Protection Area
WC Map 01A: First Nation Lands

2.1.2 Stakeholders and Partners

2.1.2.1 Municipalities

The entire City of Sault Ste. Marie lies within the Source Protection Area; therefore the Drinking Water Source Protection Planning team at the Sault Ste. Marie Region

Conservation Authority is in close partnership with the municipality of Sault Ste. Marie. Four elected city council members sit on the Conservation Authority Board.
Prince Township also lies entirely within the source protection planning area. A member of the township council sits on the Conservation Authority's board. The planning team will be working with the Township of Prince closely throughout the planning process.

The unorganized townships which comprise the northern portion of the planning area are represented by the Sault North Planning Board and have consulted with the Conservation Authority in regard to vulnerable areas within the Planning Board area and the revisions of the areas Official Plan development. The Sault North Planning Board is overseen by the Ontario Ministry of Municipal Affairs and Housing.

Algoma Public Health, the Algoma district's public health agency, will also be significant contributors to the source protection planning process. The planning team will be working on a number of initiatives focusing on wells and septic beds in the areas without municipal services.

2.1.2.2 Provincial Agencies

The Ontario Ministries of the Environment, Northern Development and Mines, Natural Resources and Municipal Affairs and Housing have all been and will continue to be instrumental with providing the Conservation Authority with the data and historical information required to build the Source Protection Plan. The Ontario Forest Research Institute (OFRI), a provincial institute under the Ministry of Natural Resources has also assisted in the soil data analysis and writing of the watershed characterization report.

Conservation Ontario (CO) also plays a key role in facilitating the development of the plan and provides the Conservation Authority with financial, technical and leadership support in this endeavour. Conservation Ontario has represented all of the Conservation Authorities in the province during the Source Protection Planning legislation building process with the Ministry of the Environment of Ontario.

2.1.2.3 Federal Government

Data, technical expertise and equipment support have been obtained from a number of federal agencies including:

- Department of Fisheries and Oceans – Sea Lamprey Control
- Department of Fisheries and Oceans, Sault Ste. Marie District Office
- National Resources Canada, Canadian Forest Service
- Agriculture and Agri-Food Canada
- Environment Canada

2.1.2.4 First Nations

The Garden River and Batchewana First Nations on the eastern border of the Source Protection Area have been contacted regarding the source protection planning project. The planning team is hopeful for First Nation participation in the development of the source protection plan. Location of both First Nations is shown on WC Map 01A.

2.1.2.5 Interested Stakeholders, Engaged Public and Non-Governmental Organizations

The Public Utilities Commission of the City of Sault Ste. Marie (the PUC) was originally created by the citizens of Sault Ste. Marie under the Public Utilities Act in 1917 to provide the city with reliable drinking water and electricity. Today the PUC carries on as a "local services board" under the Municipal Act, which holds the drinking water assets in trust for the citizens of Sault Ste. Marie.

PUC Services Inc. (PUC Services) is a private company created under the Ontario Business Corporations Act in 2000 as a result of electricity deregulation in Ontario. PUC Services is wholly owned by PUC Inc. which is a city-owned holding company. All of the former employees of the PUC were transferred to the newly created PUC Services in 2000. PUC Services operates, maintains and manages Sault Ste. Marie's water supply and associated infrastructure under long-term contract with the PUC. PUC Services also operates and maintains the city's wastewater treatment plants and its lift stations.

PUC Services has worked closely with the Conservation Authority in the past on both the municipal groundwater study and the creation of the network of groundwater monitoring wells in the area which are part of the Provincial Groundwater Monitoring Network (PGMN). Prior to the commencement of drinking water source protection planning, the Conservation Authority relied on PUC Services to provide the technical staff required for the groundwater study and PGMN work. PUC Services continues to provide technical support for the Conservation Authority and the source protection team. The source protection team will be partnering with PUC Services on future research projects.

The Conservation Authority is an active member of the Community Geomatics Centre facilitated by the Sault Ste. Marie Innovation Centre. The Geomatics Centre allows the Conservation Authority to share data with other community members such as the Algoma Public Health and PUC Services.

There have been many opportunities to deliver presentations to interested groups and organizations throughout the watershed. As a result of these presentations and discussions, many new partnerships and programs have been established that benefit the continued education and data collection for this program while supporting the needs of the other organizations.

Local professionals in the fields of hydrology, geology, hydrogeology and biology are also involved in the development of the watershed characterization and review on an ongoing basis.

2.2 Physical Description

Landforms and physical features play a vital role in the movement of ground and surface water throughout a watershed. Table 2.2.1 presents a general overview of the geology within the planning area. A more detailed description of the bedrock and surficial geology, topography, physiography and soil characteristics is discussed in the following sections.

Table 2.2.1 General Stratigraphy of the SSM DWSP Area

Type of Formation	Description	Comments
Overburden	Recent alluvium	Mainly found along and within the streambeds
	Glaciolacustrine beach sands and gravel	Along the slopes of the Precambrian uplands
	Glaciolacustrine shallow water sand	Discontinuous
	Glaciolacustrine deep water clay	Extensive over large part of the low lands surrounding the city of Sault Ste Marie, provides protection to the underlying aquifer
	Sand and gravel	Principal aquifer
	Till	Discontinuous
Bedrock	Cambrian sandstone	Bedrock aquifer, generally contiguous to overlying sand and gravel aquifer
	Precambrian granite	Upper fractured and weathered portions may provide limited groundwater source

Taken from Burnside, 2003

2.2.1 Bedrock Geology

The bedrock geology potentially dictates the deep aquifer distribution and groundwater flow within the planning area. By describing the bedrock units within the area, it is possible to determine the location of regional aquifers.

The bedrock geology of the area is illustrated by WC Map 02A. In very general terms, Precambrian granite and Migmititic rocks overlain by Jacobsville Sandstone lies beneath the entire study area (Burnside, 2003). Because the Precambrian rocks are resistant to weathering and glaciation, they comprise the topographic high running along the northern portion of the planning area. This area is referred to as the Precambrian Uplands. The Jacobsville Sandstone flanks the uplands to the north and south. The main bedrock aquifers within the planning area consist of this sandstone material (Burnside, 2003).

More in depth descriptions of the bedrock elevation, rock units, formations and groups within the area are outlined below. Faulting and mineral occurrences are also discussed toward the end of this section. Most of the information provided below is from Bennett et al, 1975, Bennett et al, 1978, Frarey 1977, and Bennett et al 1991. Other references are provided in the text.

All rocks of outlined in WC Map 02A are of Precambrian age. The Proterozoic rocks form part of the Southern Structural Province of the Canadian Shield. The Archean rocks are part of the Superior Structural Province of the Canadian Shield. Figure 2.2.1 is a rock-time chart for the Sault Ste Marie area showing the general time relationships between rocks of Sault Ste Marie area and those of surrounding areas.

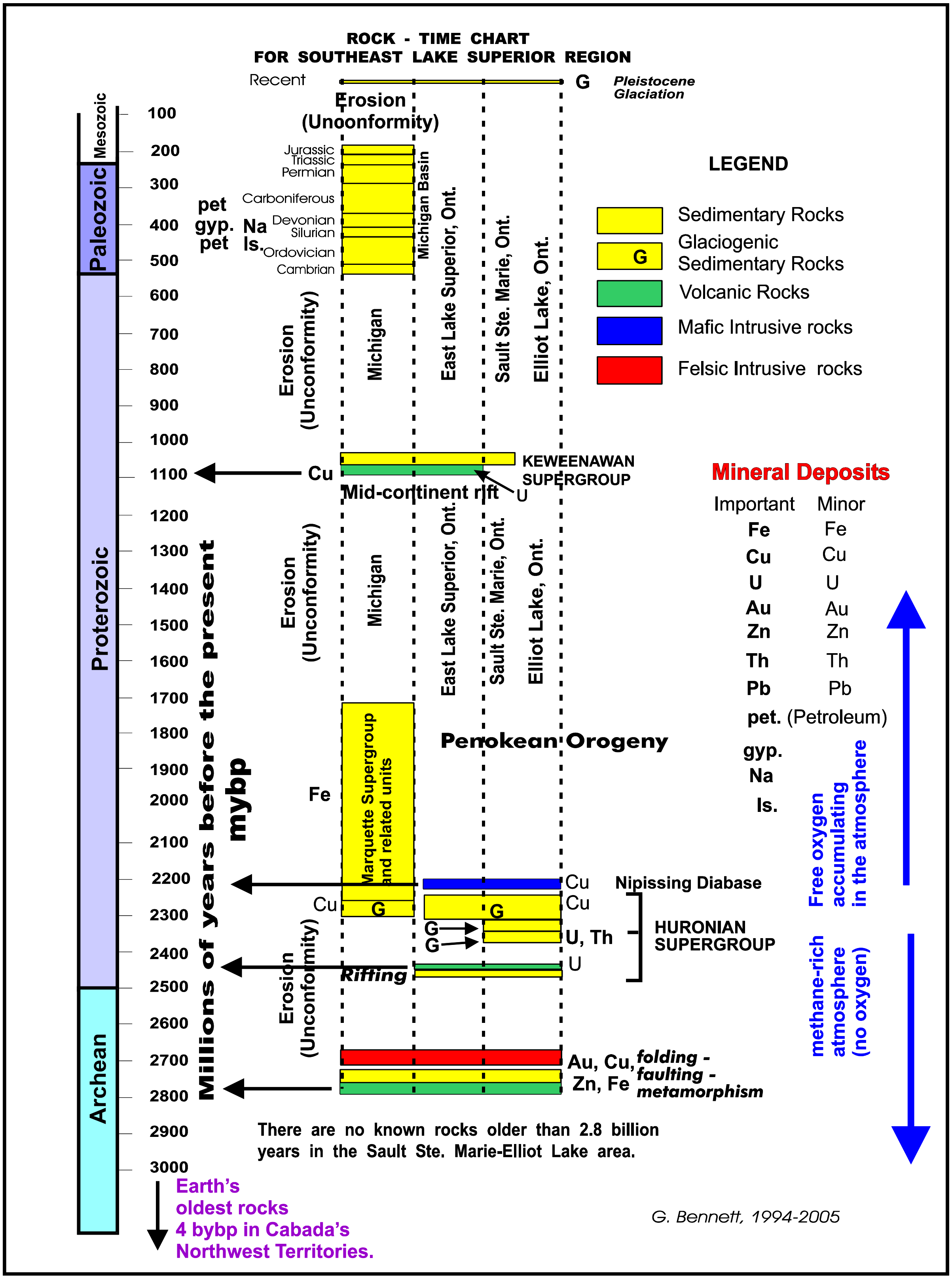


Figure 2.2.1: Rock Time Chart – Southeast Lake Superior Region

2.2.2 Bedrock Surface Elevation

Bedrock highs and lows can control groundwater movement through the subsurface. For example, bedrock basins can contain permeable overburden which can act as aquifers. WC Map 02B outlines the bedrock topography and elevation for the planning area. The highest bedrock elevations (up to 440 m above mean sea level) are found in the Precambrian uplands (identified by the red contoured area). There is also very little overburden material in this area (WC Map 02E, 0-20 m). The lowland area south of the uplands underlain by sandstone has a significantly lower bedrock elevation. Within the lowland area there are three bedrock highs as identified by the contouring on the map. Between the highs lie three bedrock lows which are referred to in this report as the West, Central and East Basins respectively. These low lying bedrock valleys are filled with overburden material (Burnside, 2003).

The West Basin lies in the area east of the bedrock high extending north from Leighs Bay. The Central Basin lies to the west of the bedrock high running south from the uplands area and through the core of the city just east of Essar Steel Algoma Inc. The East Basin lies just to the east of the high dividing it from the Central Basin and west of the bedrock high extending from the uplands east of Lake George (Burnside, 2003).

2.2.2.1 Archean Rocks

2.2.2.1.1 Metavolcanic Rocks

The oldest rocks of the area are Archean metavolcanic rocks which underlie the north central portion of the area. These are for the most part fine-to medium-grained, dark-grey weathering rocks with black freshly broken surfaces (Avm). Within a few hundred meters of granitic intrusions most are amphibolites containing mainly hornblende and andesine as essential mineral constituents. There is commonly a weak to well-defined foliation or lineation (Ava).

Thin beds of chert-magnetite iron-formation (IF) are intercalated with mafic metavolcanic rock south and west of Maple Lake in Vankoughnet Township. Sulfide facies iron formation was not noted in the area.

2.2.2.1.2 Granitic Rocks

The plutonic rocks of the area may be subdivided into three main groups:

1. Massive to faintly foliated, equigranular and porphyritic granitic rocks (Agm) underlie much of the east-central portion of the area. These are generally pink on recently broken surfaces. The essential minerals are microcline, albite-oligioclase and quartz with accessory biotite and/or hornblende, which have generally undergone partial or complete alteration to chlorite. Most are quartz monzonite but local varieties include syenite and granodiorite. (Bennett et al, 1975) There are no absolute ages for granitic rocks of the area but most granitic plutons in adjacent areas range in age from 2.670 to 2.700 Ga (Williams et al 1991).

2. Granitic gneiss (Agg), predominantly grey, gneissic granodiorite, is visible along Highway 17 and for several kilometres west. These rocks are grey-weathering medium to coarse-grained rocks with a distinct gneissic layering of dark-coloured (mafic) and light-coloured (felsic) minerals (Hay, 1963).

3. Much of Prince Township and parts of Pennefather and Korah Townships are underlain by equigranular, medium to coarse-grained diorite (Agd). Oligioclase feldspar and hornblende are the essential minerals. Quartz, biotite and magnetite are accessory minerals (Beach, 1987).

2.2.2.2 Early Proterozoic Rocks

The Archean rocks of the area are intruded by numerous mafic dikes (Pdm) generally referred to as “diabase dikes”, although most are more properly classified as “gabbro”. It is likely that, because of their relatively narrow width, only a minority of these dikes were observed in the field.

It has been determined by geochronologists that the Algoma region has been intruded by three swarms of mafic dikes. The oldest recognized dikes are those of the Hurst and Matchewan swarms which have returned radiometric dates of 2.45 Ga (Heaman, 1988). It is assumed that most of the many dikes intruding the Archean rocks belong to one or both of these swarms but absolute age determination are available for dikes of the area. Dikes and sills off Nipissing gabbro (2.220 Ga) intrude the Huronian rocks and older Archean terrain (Corfu and Andrew, 1986).

Keweenawan diabase dikes (1.10 Ga) and olivine diabase dikes (1.140 Ga) are undoubtedly present but often difficult to distinguish from older dike sets (Krogh et al, 1987). A few lamprophyre dikes and distinctive pink to orange weathering felsic dikes of similar age are more easily identified but are rare (Osmani, 1991).

2.2.2.3 Huronian Supergroup

The contact relationship between supracrustal rocks of the Huronian Supergroup and the Archean plutonic and volcanic rocks is locally a fault or unconformity. A northeast trending fault contact is well defined along the north shore of Upper and Lower Island Lakes and is visible immediately west of the intersection of Highway 556 and the ACR tracks. The age of the Huronian rocks lies between 2.45 Ga and 2.22 Ga.

2.2.2.3.1 Livingstone Creek Formation

The Livingstone Creek Formation is exposed along the shores of Reserve Lake in Jarvis Township and southwest of Elizabeth Lake in Duncan Township. The formation is comprised almost entirely of well-sorted, medium to fine-sand-sized gray sandstone (Hlcs). The formation has a maximum thickness of 400 m in drill holes in Duncan Township (Assessment files, Sault Ste Marie, District Geologist’s Office). The polymictic conglomerate member is rare in outcrop but is up to 200 m were intersected in drill holes in Duncan Township (Assessment files, Sault Ste Marie, District Geologist’s Office).

2.2.2.3.2 The Thessalon Formation

Mafic metavolcanic flows of the Thessalon Formation, Huronian Supergroup, are exposed between Highway 556 in the Belleview area and the northern portion of the Garden River Reserve. The formation is estimated to be from 650 to 820 m thick in the Sault Ste Marie area (Frarey 1977). It is comprised entirely of massive- to faintly-foliated, very dark grey-green basalt (Htvm) and basaltic andesite (Htva). The essential minerals are albite, chlorite, epidote, stilpnomelane, and actinolite. Amygdaloidal flow tops are common. Most flows are equigranular, however a glomeroporphyritic flow outcrops on Highway 556 in the Belleview area (Bennett et al. 1974, 1975, 1991).

Hay (1963) reported thin units of coarse arkosic sandstone and radioactive, pyritic, quartz-pebble conglomerate near the base of the Thessalon Formation near Maud Lake in Duncan Township (See Mineral Occurrences in this report).

2.2.2.3.3 Aweres Formation

The Aweres Formation (McConnell, 1927) is a sequence of conglomerates and sandstones, up to 1700 m thick, which unconformably overlie the volcanic rocks of the Thessalon Formation.

The base of the Aweres Formation is comprised mainly of clast-supported pebble to boulder conglomerate with over 90% clasts of the underlying Thessalon Formation with scattered clasts of sandstone of the Livingstone Creek formation and rarely, grey to red granitic pebbles (Hac). This member can be seen on Highway 556 a few kilometres west of the ACR trestle. The proportion of mafic volcanic clasts decreases with stratigraphic height so that along the shores of Trout Lake the uppermost portion of the Aweres Formation consists mainly of grey sandstone and pebbly sandstone with interbeds of grey granite cobble conglomerate (Has).

2.2.2.3.4 Mississagi Formation

The Mississagi Formation (Hms) underlies part of the Garden River First Nation in the southeast portion of the area. It is probably a distal equivalent of the Aweres Formation. As such, it is comprised mainly of medium to coarse sand-sized, grey, cross-bedded sandstone with minor intercalated quartz–pebble and chert-pebble conglomerate. The total thickness in the Sault Ste Marie area is about 1500 m.

2.2.2.3.5 Espanola Formation

The Espanola Formation (Hel) is the earliest, significant, carbonate-bearing unit within the Huronian Supergroup (Bennett et al, 1991). Only the lower carbonate member was recognized in the Sault Ste Marie area. It is probably only a few meters thick on the Garden River First Nation. The Espanola Formation is typically thinly interbedded pale grey calcitic marble and grey siltstone.

2.2.2.3.6 Gowganda Formation

The Gowganda Formation is comprised of grey siltstone, wacke, mudstone, pinkish-grey sandstone (Hga) and till-like, matrix supported pebble to boulder conglomerate (Hgc). Exposures of all of these units can be observed in rock-cuts along Highway 556 in the Belleview area where it unconformably overlies volcanic conglomerate of the Aweres Formation. The maximum thickness of the formation in the Sault Ste Marie area is about 1000 m.

2.2.2.3.7 Lorrain Formation

Within the area of interest the Lorrain Formation is comprised mainly of pale-grey to white quartz arenite with quartz-pebble conglomerate interbeds (Hlq). Jasper-quartz pebble conglomerate (“puddingstone”) (Hlc) is exposed in rock cuts along Highway 556 west of the road to Northland Lake. The lower members found in the Desbarats area are not present. The thickness of the Formation is uncertain, as most contacts are probably faults.

2.2.2.3.8 Nipissing Diabase

A thick sill of Nipissing gabbro (Ng) intrudes the Lorrain Formation in the Northland Lake area and as dikes intruding the Huronian rocks. This is mainly a dark grey gabbro with local pinkish granophyric phases.

2.2.2.4 Keweenawan Supergroup

2.2.2.4.1 Igneous Rocks

Mafic dike rocks of the Keweenawan Supergroup (1.1 Ga) cannot be reliably subdivided from older dikes, however a large gabbroic intrusion (Km) which underlying Prince Lake in Prince Township is probably of Keweenawan age (Beach 1983).

Basaltic flows (Kvm) of Keweenawan age overlie Archean rocks on the shore of Lake Superior in Prince Township.

A small, pink porphyritic felsic stock (Ks) is exposed in the Gros Cap area, Prince Township. A few orange weathering, Keweenawan felsic dikes (not show on the map) intrude the Huronian rocks near Trout Lake.

2.2.2.4.2 Jacobsville Group

Red sandstone and conglomerate of the Jacobsville Group (Ks) (ca. 1.0 Ga) are exposed in the bed of Root River at Highway 17 and on the shores of Lake Superior in the Red Rock area. Most of the low-lying area in the Goulais River area and along the St. Marys River is assumed to be underlain by Jacobsville sandstone.

2.2.2.5 Metamorphism and Structural Geology

All rocks older than the Keweenawan age (1.1 Ga) have undergone folding, faulting and metamorphism. The Archean rocks were subjected to the Kenoran Orogeny (6.8 – 7.3 Ga), which involved early faulting, tight folding and the intrusion of granite plutons. The metamorphic grade varies from upper-greenschist facies to amphibolite facies near granite plutons.

The Penokean Orogeny (1.8 Ga) affected the Archean rocks and those of the Huronian Supergroup. Metamorphism attributed to the Penokean Orogeny is sub-greenschist in the Belleview area but increases gradually to middle-greenschist in the Garden River First Nation.

The metamorphic recrystallization of all Archean and Huronian rocks has effectively eliminated any of the porosity all sedimentary rocks, however, the original megascopic texture and structure is mainly unchanged allowing the application of a sedimentary rock classification.

2.2.2.6 Faulting

Within the Precambrian uplands, faults and lineaments generally follow a northwest – southeast (NW-SE) orientation. This is reflected in the elongated nature of the numerous lakes in the area which also run NW-SE. A few structural zones run in an east-west direction particularly in the area running west from Trout Lake. Within the uplands area, these structural zones house deposits of sand and gravel which control groundwater discharge into surface watercourses. For example, the Highway 17 corridor near Heyden hosts thick sand and gravel deposits which are likely to indicate the presence of a north-north east structural zone (Burnside, 2003).

Most faults indicated on the accompanying geological map, are inferred or assumed from formation boundaries, topographic features, local shearing and in a few cases, linear arrays of mineralized hydrothermal veins. The age of faulting is again is generally unknown but many of the major northeast trending faults are now generally thought to be later than Keweenawan age.

The above orogenic (mountain building) events and ensuing metamorphism have resulted in the recrystallization of all rocks older than the Keweenawan. The porosity in these rocks is essentially eliminated so that groundwater movement is restricted to that along fractures (joints and faults).

2.2.2.7 Mineral Occurrences

The locations of mineral occurrences within the area are shown on the accompanying digital map on layers Min_occur and Mdir. The former includes mineral occurrences shown on published geological maps (Bennett, 1975 and Bennett, 1978). There is no accompanying database for these occurrences. However element symbols are shown on the map. Brief descriptions of the more significant of these prospects and past producing mines are given below.

The layer Mdir shows the location deposits selected from the AFRI (or MDIR) mineral deposit database of the Ontario Geological Survey. The UTM coordinates in the file are of the NAD 27 datum. A correction of 222 m was added to the northing and a correction of 4.6 m was subtracted from the easting to plot the locations on the digital map of NAD 83 datum.

2.2.2.7.1 Lead and Zinc Deposits

Numbers are keyed to locations on Min_occur layer. Jarvis Township has long held a fascination with local prospectors since the discovery of vein-type lead-zinc deposits in Duncan and Jarvis Townships in 1870. Between 1885 and 1917 lead and zinc was mined intermittently from shafts of the Victoria and Cascade mines. Mining on these veins was resumed by Jardun Mines Limited in 1954 and continued until 1957. The total ore mined was variously reported as 130 536 and 145 029 tons (Frarey, 1977), (Assessment files, Sault Ste Marie District Geologist's Office.

The lead-zinc deposits of Jarvis and Duncan Townships are hydrothermal veins and replacements found mainly along a north-northwest trending fault zone between Sandy Lake in Northern Duncan Township and Weashkog Lake in Jarvis Township. The earliest stage of mineralization produced the main ore minerals, sphalerite (Assessment files, Sault Ste Marie District Geologist's Office) and galena (PbS). Later brecciation was accompanied by the deposition of pyrite (FeS_2), chalcopyrite ($CuFeS_2$), hematite (Fe_2O_3) (Hay, 1963). Observations by the writer of the waste rock at the Jadun Mine suggests that gangue minerals (quartz (SiO_2) and Calcite ($CaCO_3$) are commonly subordinate to the sulfide minerals.

From 500 to 2000 tons of copper ore was extracted from pits near the north shore of Jarvis Lake in Jarvis Township. Some of this was smelted in a small furnace on the site. Galena was the main ore mineral with subordinate chalcopyrite, pyrrhotite, pyrite and arsenopyrite (FeAsS) (Burns, R.D. 1956) and Hay, 1963) (Assessment files, Sault Ste Marie District Geologist's Office).

A number of small vein-type base metal deposits also occur in the Maple Lake area, Deroche Township. The deposits known as the Kirby-Legge and Kerr-Scott deposits) were drilled by Teck Exploration Company in 1951-52. The main economic mineral is galena (PbS) with some sphalerite, with some chalcopyrite and pyrrhotite. The writer observed narrow veins of coarsely crystalline arsenopyrite (FeAsS) in these deposits in 1974 (Assessment files, Sault Ste Marie District Geologist's Office).

2.2.2.7.2 Copper

The Island Lake copper prospect consists of replacement veins of chalcopyrite within altered Archean granitic rocks on a hill at the intersection of Highway 556 and 552. Chalcopyrite is the main economic mineral. Much stripping, diamond drilling and some geophysical surveys have been done on this deposit over the past 50 years (Assessment files, Sault Ste Marie District Geologist's Office).

2.2.2.7.3 Uranium, Thorium

Geological mapping in Duncan Township by the Geological Survey of Canada discovered radioactive, pyritic, quartz pebble-conglomerate within mafic flows near the base of the Thessalon Formation near Maud Lake in Duncan Township. The conglomerate beds are less than a meter thick. The radioactive is from 2 to 10 times background. This is a very low concentration of radioactive elements in a very minor deposit and should not be an environmental problem.

2.2.2.7.4 Iron

The occurrences shown as Fe on the map are quartz veins bearing specular (crystalline) hematite (Fe_2O_3). As iron deposits go today, these are insignificant deposits. The “Britung Mine” south of Northland Lake is reported to have had some production around the turn of century.

2.2.2.7.5 Sulfur

The few occurrences indicated by S are small deposits of pyrite that in the past have seen evidence of some work by early prospectors. These are small, local occurrences.

2.2.2.8 Reliability of geological mapping and other data

Geological boundaries, faults etc were digitized to the digital base map from published and unpublished geological maps using a 12 by 18 inch (30 by 45 cm) Summagraphics digitizing tablet. The original map scale was 1 inch to ¼ mile (1:15 840) (Bennett et al. 1975 and Bennett et al. 1978) and 1:20 000 (Beach 1983).

The locations of most mineral occurrence locations compiled in the Ontario Geological Survey MDIR database were based on pre-1980 geological maps or unsurveyed mining claims (i.e. no GPS) and the accuracy of locations may be in error by more than 100 hundred meters.

The mineral occurrence locations shown on Layer Min_occur are from Bennett et al, 1975. These locations were located one inch to ¼ mile air photos and are believed to be accurate to within 75 meters.

A map (as layer “Reliability)” is included which indicates the general relative reliability (accuracy) of geological data.

The area considered to be of highest reliability, shown on layer “Reliability 1”, shows bedrock geology based on 1: 15 840 scale geological mapping of the Ontario Geological Survey (Bennett et al, 1975, 1976, 1977) and unpublished maps by P.E. Giblin and E.J. Leahy.

Layer “Reliability 2” is based on 1: 63 360 scale mapping by the Geological Survey of Canada (Frarey, 1977) and the 1:20 000 scale map included in the unpublished B.Sc. thesis (Beach, 1987).

Layer “Reliability 2a” has very few rock exposures. This area is assumed to be underlain by sandstones of the Jacobsville Group as indicates by its low topographic relief and drill hole data in some areas.

Layer “Reliability 3” is based mainly from M. J. Frarey, 1963 and 1977 1 inch to 1 mile reconnaissance map of the Algoma Central Railway.

2.2.3 Surficial Geology

In general, both the topography and surficial geology within the area are a result of glacial advance and subsequent retreat. Surficial materials within the watershed consist of glacial and postglacial materials deposited during and following the last glaciation which is generally referred to as the Late Wisconsinan Glaciation in the Great Lakes Region. These materials are known interchangeably as Quaternary age or surficial geological materials. No older glacial or interglacial materials have been reported within the watershed indicating that any such materials were eroded away during the last glaciation. To put this into an historical context the glacial sediments can be considered to be between approximately 25 000 and 11 000 years old and the postglacial materials younger than 11 000 years old. Cowan and Broster mapped the distribution of these surficial materials in 1976 and this distribution of these materials is portrayed on WC Map 2C (Cowan and Broster, 1988). An overview of the geology of the Sault Ste. Marie area can be found in Cowan, McAuley and Bennett, 1998. These geologic materials play a fundamental role in both the groundwater and surface hydrology of the Source Protection Area..

2.2.3.1 Quaternary History

This section will describe the Quaternary history of the Source Protection Area and the following section will describe the related sediments. As described in the introduction all materials present in the area are considered to relate to the most recent glaciation and postglacial time, i.e. less than 25 000 year in age.

Glacial striations in the vicinity of Sault Ste. Marie indicate that the most recent glaciation was generally in a southerly direction. Within the lake basins themselves the topography of the lake influenced subsequent ice flow. It can be assumed that ice cover the project area continuously from about 25 000 to 11 000 years ago by which time the Gros Cap highlands were ice free though ice is known to have occupied parts of the Lake Superior basin until about 10 000 years ago.

Following deglaciation, a combination of land rise due to unweighting of the land through disappearance of the glaciers and opening and closing of drainage outlets for the Great Lakes, lead to a complex history of lake levels within the Source Protection Area. About 10 500 –11 000 years ago, receding ice and glacio-isostatic depression allowed a lake known as Lake Algonquin to inundate the Sault Ste. Marie area – this lake occupied the Lake Huron, Lake Michigan and eastern Lake Superior basins. This lake rose to a level which is now about 309 m above sea level; this is evidenced by a large barrier bar – deltaic system fronting the Gros Cap Highlands. Terraced sand and gravel deposits in the Pre-Cambrian uplands area are beach deposits from the ancient Lake Algonquin and are referred to as the Algonquin Terraces throughout this report.

During this high-level phase, deep-water clays, shallow-water sands and beach sediments were deposited at Sault Ste. Marie in an off-lap arrangement. Subsequent shallowing of the lake caused by isostatic uplift of the land as well as opening of lower eastern outlets south of North Bay about 10 000 years ago led to a series of shoreline and near shore features representing short-lived stillstands in the water level. The key feature between 198 and 312 masl are listed below; they are related to classic shoreline studies in the Huron Basin:

- 295 m – base of bluff – Upper Orillia shoreline
- 275m – Wyebridge shoreline
- 265m – Penetang shoreline
- 257m – strong bluff – Cedar Point shoreline
- 253m – base of bluff
- 247m – base of bluff – Payette shoreline
- 233m – strong bluff – Sheguindah shoreline
- 229m – base of bluff
- 210m – base of bluff – Korah shoreline
- 200m – base of 4m bluff

These features may be observed within the Sault Ste. Marie area though they are by no means continuous. Most represent short-lived events, perhaps in some instances only a single major storm. Insignificant shorebluff and bar features represent other minor events.

About 9 000 years ago, the North Bay area became free of ice and was depressed due to previous ice loading. During this time, a low outlet of the post-Algonquin phase lake to the east of North Bay allowed the waters of the Huron Basin to drain to a very low level. By 8500 years ago, forest growth had been established in areas now occupied by Lake Huron. This low level is known as Lake Stanley or Lake Hough. Subsequently uplift of this outlet caused lake levels to rise again generating a new phase called the Nipissing Great Lakes, culminating in the development of a very strong erosional bluff at Sault Ste. Marie known as the Nipissing Terrace. This terrace occurs at about 198 masl and has been dated at about 4 500 years ago. The rising waters are evidenced in the area by lacustrine and alluvial sediments in the Goulais, Root and Garden River valleys. Organic materials (twigs, wood, detritus) contained within older alluvium related to the rising waters have been dated at between 7 400 and 5 000 years ago (Cowan, 1978). The erosional bluff is primarily developed in clay materials deposited in deep water during high water levels described above. Further fluctuations, mainly due to the lowering of the Nipissing water level, produced scattered shoreline fragments between the Nipissing level and present day St. Marys River. These fragments have not been surveyed.

2.2.3.2 Quaternary Deposits

Till materials deposited directly by glaciers occurs throughout the area and is present in two phases. In the first till phase, the Precambrian uplands (Section 2.2.1) comprise a rock-drift complex dominated by rock outcrops and shallow subcrop; however, a discontinuous till cover is present throughout. This till, in fresh outcrops, occurs as grey, stony to bouldery, sandy to sandy silt till. Upon weathering this till material loses its cohesion and consists of a pale brown to light brown bouldery fine sand. Thicknesses are highly variable ranging from 1 or 2 m adjacent to outcrops and up to 10m on side slopes. The highly variable bedrock topography on the upland makes estimating till thickness very difficult. Here, till is of little significance within the regional hydrologic regime.

The second till phase occurs in the low land areas and is a reddish brown, stony, sandy silt till derived from and usually overlying the Jacobsville Formation red sandstone from which the till takes its reddish hue. Compositionally this till is similar in texture to autogenously ground Jacobsville sandstone. There is no evidence to suggest that these two till phases represent any age difference and that the differences are entirely related to the rock materials from which they are derived. This till phase is sporadic and thin and is generally of little significance within the regional hydrologic regime. Both till phases have low to no plasticity, are dense to very dense in their unweathered state, and loose in their weathered state. In the lowland area till outcrops occur at the surface infrequently.

Ice-contact stratified drift deposits indicated on WC Map 2C as Quaternary Geology Unit 4 represents stagnant ice conditions during ice retreat within the area. Within the study area these are mapped only in small fragments in the Garden River Valley. Here these fragments have been interpreted by Cowan (2005) as minor recessional moraines indicating ice-recessional positions as the last glaciers retreated up the Garden River Valley. These materials consist of sand gravel and silt and are of little significance to the water supply in the region due to their sparse distribution.

Glaciofluvial outwash deposits (Quaternary Geology Unit 7) are present along most major watercourses as terraced valley fills and in upland areas as fine sand wash. In the valley fills, gravelly sand is the predominant material with few deposits consisting of high percentage gravel, the principal exceptions being deposits along West Root River north of Sault Ste. Marie. Many outwash deposits form top-set deltaic beds along the edge of the highlands where glacial rivers debouched into high level early phase Great Lakes. These areas form groundwater recharge areas as well as groundwater reservoirs; they are especially important in transferring water from the upland area into the regional aquifer fronting the Gros Cap Highland. In addition to the outwash materials occurring on surface, some older materials underlying the glaciolacustrine clays have a role either as a buried aquifer or as a contributor to recharging the underlying Jacobsville sandstone aquifer.

Glaciolacustrine sediments were deposited into the proto-Lake Superior basin during late glacial and postglacial high water events. Though these sediments occur predominantly in the lowland and river valleys, they rise to more than 100 metres above present day Lake Superior, the highest occurring at about 309 masl. Quaternary Geology Units 5,6, and 8 portray the distribution of three sediment types – fine grained laminated to varved silt and clay deposited in deep water, shallow water sands, near shore, beach sands and gravels.

The deep-water clays are up to 60 metres in thickness and range from massive clays, through laminated to varved silt and clay to weakly laminated silt with little clay. Clay contents ranges up to 84%. These sediments range from non-plastic (silts) to clays of high plasticity. Some of the clay is pink to reddish brown in color, apparently due to the ratio of ferric to ferrous iron being greater, i.e. greater than 1.5. These sediments have generally low transmissivity and form aquitards or aquicludes depending on the location, altitude and their position in the stratigraphic sequence. Burnside (2003) identified this material as being important in protecting an underlying aquifer from contaminants.

Near shore and shallow water sands are widespread (Quaternary Geology Unit 6) in the lowlands. These are dominantly fine to medium grained sands with minor gravel. They are transitional with the beach deposits. Thicknesses range from less than one metre to more than 15 metres in deltaic sequences. Numerous flights of poorly developed shoreline features are present in these, e.g. near Carp Lake, which represent falling water levels. These deposits may form groundwater recharge or discharge areas depending on their location and altitude. Artesian conditions may occur and these can create problems with maintaining excavations. Dewatering for some excavations may be achieved with wellpoint dewatering; in other instances complex drainage systems are required to reduce water pressure around engineered structures. Older units of this material underlying the clay may form an aquifer or play a role in recharging the underlying Jacobsville Sandstone.

The most notable Quaternary (surficial) feature in the area is a massive barrier bar-deltaic feature developed on the south margin of the Gros Cap Highland. This evolved when high lake levels were in existence (circa 309-312 masl) and glacial melt waters carrying much glacial debris from the Gros Cap Highland area (Root River, West Root River etc.) The melt waters deposited debris in the lake and this material was worked into beach features and near shore deposits up to 15 metres or more in thickness. In places the combined thickness of the beach/deltaic feature and the subjacent near shore sands may reach 90 metres in thickness. Long shore currents and wave action developed a barrier bar system along the highland front. The well-sorted and rounded beach gravels may be up to 6m in thickness and comprise a magnificent granular aggregate resource. Most gravel occurs in the upper few metres as a result of reworking of sediment and subsequent deposition of sandy gravel on the beach face during lowering of water levels. These materials comprise a very significant groundwater recharge area receiving rainfall and snow melt from the highland to the north as well as via discharge of surface and groundwater from the interconnected outwash materials which extend into the Gros Cap Highland, especially along the Highway 17 corridor.

Eolian (windblown) sediments occur on the surface of the lacustrine sands in the vicinity of the Sault Ste. Marie airport. These consist of reworked lacustrine fine sands and some low sand dunes are present (Quaternary Geology unit 9). Minor evidence or reworking occurs elsewhere but the development and thickness did not allow map differentiation from the lacustrine sand.

Organic deposits (peat and muck - Quaternary Geology Unit 10) occur in closed depressions and along low velocity streams. Generally, the thickness of these is less than two metres. Shallow organics may be associated with flights of offshore bars such as those near Carp Lake. In these situations the organics are usually less than one meter thick in inter-bar depressions and only a few centimetres thick on bar tops. In the uplands sand or rock usually underlies the organics. The organics may pose problems for road building – if so shallow thicknesses are generally excavated; in deeper deposits the roads are floated over the organics with the assistance of geotextiles or geogrids.

Quaternary Geology Units 11 and 12 are alluvial sands, gravels, silts and organics deposited in or immediately adjacent to modern river and stream valleys. Quaternary Geology Unit 10 is classified as older alluvium that occurs in high terraces. Within the Sault area it occurs only in the Garden River Valley; it is also prominent in the Goulais River Valley north of Sault Ste. Marie. These materials are of historic interest as they have been age dated at between 7 400 and 5 000 radiocarbon years before present. They are deemed to represent deposition of alluvium during a rise of Great Lakes waters from low levels to the Nipissing shoreline that is dated at Sault Ste. Marie at 4600 radiocarbon years before present (Cowan, 1978).

Modern alluvium represented in Quaternary Geology Unit 10 consists of materials deposited in modern river and stream channels and their floodplains. These materials consist of channel sands and gravels and overbank silt, sand and organics. These materials are usually less than two metres thick. Neither Quaternary Geology Unit 11 nor 12 is significant in groundwater recharge and storage for the project area.

Finally, Quaternary Geology Unit 13 consists of man made deposits such as slag, fill waste rock etc. They are of limited aerial extent.

2.2.3.3 Quaternary Summary

The Quaternary or surficial geological materials within the Source Protection Area play a very important role in the provision for and protection of groundwater resources so important to the area. In particular, the barrier-bar deltaic complex fronting the Gros Cap Highland is invaluable both as a groundwater recharge zone and as a magnificent source of granular construction aggregates.

WC Map 02A: Bedrock Geology
WC Map 02B: Bedrock Topography Contour
WC Map 02C: Quaternary Geology

2.2.4 Topography

The general topography and surface water drainage of the planning area is illustrated by WC Map 02D. The surface topography can be seen to mimic that of the bedrock topography presented in WC Map 02B. In general, the area consists of a band of elevated rugged, knobby Precambrian bedrock extending across the northern half of the region. The elevation range within this northern band is between 300 and 440 masl. South of this band is undulating, rolling, more subdued terrain with occasional rises formed by small bedrock escarpments which extend to the St. Marys River. These two regions will be referred to as the “uplands” and “lowlands”, respectively, throughout this report (Burnside, 2003 & IJC, 1992).

The western and southern edges of the uplands area terminates in steep slopes. The Precambrian bedrock is exposed in some areas along the south face and terminates in sand and gravel beach deposits. These areas of overburden deposits have been historically identified as groundwater recharge areas. Along the western and north western edge of the planning area, the uplands slope down to terminate very near or right at the shore of Lake Superior. The Gros Cap area shown in Figure 2.2.3.1 is an example of this abrupt termination at the lake’s edge. Rocky bluffs in the area plunge 90 metres to the shoreline (Burnside, 2003).

Watercourses in the Precambrian uplands generally reflect the major structural features in the exposed granite terrain and predominantly drain to south toward the St. Marys River. Along the western edge of the uplands, the watercourses drain westward toward Lake Superior. Where individual watercourses cross from the uplands to lowland areas underlain by beach deposits consisting of sand and gravel, the streams' flows can be reduced due to significant groundwater recharge. At lower elevations, this zone of sand and gravel can also act as headwaters of small streams, as some recharged water is discharged to the surface through the coarse grained material, depending on the local topography. As a result, numerous small streams exist in the southern third of the planning area with their small watersheds oriented toward the St. Marys River. WC Map 02D outlines the subwatershed areas within the planning area. The majority of the subwatersheds drain southward, drawing flow off from the upland and the lowland areas. Descriptions of the subwatersheds are presented in Section 2.2.6, which discusses the hydrology of the planning area (Burnside, 2003).

Figure 2.2.3.1: Example of Abrupt Termination at the Lake's Edge

2.2.5 Physiography

The two ecoregions comprise the planning area are the Chapleau Plains and the Nipissing ecoregion. The Chapleau Plains comprise the northern uplands portion of the planning area and the Nipissing ecoregion consists of the southern lowland area (Environment Canada, 1987).

The Chapleau Plains area in the uplands area consists of moderately broken terrain with bedrock exposure. There are pockets of till within this northern region which generally surround lakes and wetland areas. Along the northwestern edge of the planning area lies a strip of Wartburg till. Through the heart of this Wartburg till runs a significant escarpment which follows the Lake Superior shoreline. The other significant feature in the uplands area is the band of gravel deposits running north-south roughly following the Highway 17 North corridor.

The lowland and upland areas are roughly divided by escarpments running in a southwest to northeast direction. Moderate to strongly broken sandy loam till plains are characteristic in the Nipissing ecoregion area of the lowlands. The majority of the till in the area is Mornignton Till with a number of the watercourses being associated with Dunkfeld Till.

There are two notable beach head areas in the lowlands. The first follows the shoreline between Sunnyside and Pointe des Chênes. There are a number of beach heads identified along this stretch of Lake Superior shore line. Another nearly continuous terrace encircles the city of Sault Ste. Marie to the north and also follows the general shape of the present day shoreline of the St. Marys River. This escarpment dips south moving closer to the river just east of the city's downtown, extends eastward for approximately three kilometres and then curves north. This curve in the terrace forms a plateau within the city that is locally known as "the top of the hill."

WC Map 02D: Topography (DEM)

2.2.6 Soils Characteristics

As mentioned in Section 2.2.5, two of the ecoregions are prominent within the planning area (Environment Canada, 1987). Soils in the Chapleau Plains area of the uplands tend to be podzols and luvisols. The lowlands areas are part of the Nipissing ecoregion whose soils are characterized as podzols, brunizols and luvisols.

The City of Sault Ste. Marie is located predominantly on terraced clay lowland, bounded by a zone of surficial sand and gravel abutting the Precambrian uplands to the north and the St. Marys River to the south. The area immediately adjacent to the Precambrian uplands in the south is known as the Algonquin Terrace, and consists of several benches developed during various stages of glacial Lake Algonquin's development. The clay lowland between this terrace and the St. Marys River is referred to as the Nipissing Terrace. The topography is gently sloping, and the surficial material consists of fine-textured silty soils of lacustrine origin. Most urban development has occurred within the Nipissing Terrace area.

The City of Sault Ste. Marie, thus, lies within former Lake Algonquin basin. The terraces along the Precambrian uplands formed the shorelines of the former glacial Lake Algonquin and typical beach sand and gravel deposits are found in this area. Further south, towards the central part of the former glacial lake, fine-grained glaciolacustrine deposits of clay and silt have been identified. A more detailed description of the surficial formations is provided in Section 2.2.3.

Soil composition and distribution can directly affect many aspects of the hydrologic cycle. It can influence such factors as rates of infiltration, runoff and evaporation which ultimately can affect the quality and quantity of the water resource. For the purposes of this study, surficial soils mapping made available through the Agriculture and Agri-Food Canada Soil Survey and was used to define the distribution of soil types in each sub basin. This mapping shows there is small variability in soil types throughout the watershed region (nine soil types observed).

In the SSMR Watershed, glacial activity has been largely responsible for the evolution and distribution of soil types. The northern reaches of the watershed are composed mainly of Rockland. The Albany clay and Delamere clay deposits were formed on the west side of the watershed near Lake Superior. Soil textures vary from coarse sands to fine clays, depending on the method of deposition, the parent material, climate and the time over which these deposits have been allowed to develop.

To the south, the soil type most frequently occurring is the Dockside Sand, Wendigo sandy load, medium to coarse sand. Soil depth varies over the watershed with the deeper soils restricted to the north, becoming much shallower towards the Height of Land. Soil drainage is much better developed in the sand till areas.

The Chapleau Plains area in the uplands consists of moderately broken terrain with bedrock exposure. There are pockets of till within this northern region which generally surround lakes and wetland areas. Along the northwestern edge of the planning area lies a strip of Wartburg till. Through the heart of this Wartburg till runs a significant escarpment which follows the Lake Superior shoreline. The other significant feature in the uplands area is a band of gravel deposits running north-south roughly following the Highway 17 North corridor.

The lowland and upland areas are roughly divided by escarpments running in a southwest to northeast direction. Moderate to strongly broken sandy loam till plains are characteristic in the Nipissing ecoregion area of the lowlands. The majority of the till in the area is Mornignton Till with a number of the watercourses being associated with Dunkfeld Till.

There are two notable beach head areas in the lowlands. The first follows the shoreline between Sunnyside and Pointe des Chênes. There are a number of beach heads identified along the stretch of Lake Superior shore line. Further inland from the beach heads lies a terrace following the shoreline running in a northwest to southeast direction. This terrace curves around 180 degrees very roughly following the shape of the shore line around Pointe des Chênes, Pointe Louise and Pointe aux Pins. The other area of beach heads is at the eastern edge of this terrace just west of the Big Carp River near the shore of the St. Marys River.

A third beach head is a nearly continuous terrace which encircles the City of Sault Ste. Marie to the north and also follows the general shape of the present day shoreline of the St. Marys River as noted above. The Soil Characteristics as mapped in WC Map 04 are described as in Table 2.2.2.

Table 2.2.2: Description of Soil Characteristics as shown on WC Map 04

Map Unit	Soil Phases Surface Textures	Soil Classification	Soil Materials
Bradley	Sand, sandy loam, fine sandy loam, very fine sandy loam, loam	Gleyed humo-ferric podzol	Noncalcareous very find sandy outwash or deltaic
Delamere	Sandy loam, fine sandy loam, silt loam, clay loam, clay	Orthic gray luvisol	Calcareous clay loam or silty clay loam over clay lacustrine
Killaby	Sandy loam, very fine sandy loam, silt loam	Orthic humo-ferric podzol	Noncalcareous very fine sandy outwash or deltaic
Eakett	Sand, sandy loam, loamy sand, clay loam	Orthic humic-gleysol	Noncalcareous medium and course sand and gravely sand outwash
Denman	Sand, sandy loam, find sandy loam, loam	Orthic humo-ferric podzol	Noncalcareous very stony sandy loam glacial till of Precambrian origin
Warren	Sand, sandy loam, fine sandy loam	Orthic humic-gleysol	Noncalcareous fine sand outwash or deltaic
Medette	Sand, sandy loam, fine sandy loam, loamy sand, silt loam	Gleyed humo-ferric podzol	Noncalcareous fine sand outwash or deltaic
Kenabeek	Gravely sandy loam, sand, sandy loam, fine sandy loam, loamy sand, clay loam	Orthic gleysol	Noncalcareous medium and course sand and gravely sand outwash
Mallard	Gravely sandy loam, sand, sandy loam, fine sandy loam, very fine sandy loam, loamy sand, silt loam	Gleyed humo-ferric podzol	Noncalcareous medium and course sand and gravely sand outwash
Wendigo	Gravel, gravely sandy loam, sand, sandy loam, fine sandy loam, very fine sandy loam, loamy sand, silt loam	Orthic humo-ferric podzol	Noncalcareous medium to course sand or gravely sand outwash
Gouvereau	Sand, sandy loam, fine sandy loam, clay loam	Orthic humic-gleysol	Noncalcareous fine sandy outwash or deltaic
Dokise	Sand, sandy loam, fine sandy loam, loamy sand, silt loam, clay loam	Orthic humo-ferric podzol	Noncalcareous fine sandy outwash or deltaic
Albany	Sand, sandy loam, loam, silt, silt loam, clay loam, clay	Orthic humic-gleysol	Calcareous clay loam or silty loam over clay lacustrine
Rockland	Non soil		<10cm soil material overlying bedrock exposed bedrock
Tarentorous	Sandy loam, clay loam	Orthic gray luvisol	Noncalcareous clay loam, silty clay or clay lacustrine
Goulais	Gravely sandy loam, sand, sandy loam, loamy sand, silt loam	Rego gleysol	Noncalcareous fine sandy outwash or deltaic
Oulette	Sandy loam, fine sandy loam, silt loam, silty clay loam, clay loam, clay	Orthic gleysol	Noncalcareous clay loam, silty clay and/or clay lacustrine
Marsh	Non soil		Periodically flooded or continually wet areas not deeply submerged
Cutler	Sandy loam, silt loam	Orthic humo-ferric podzol	Noncalcareous medium to course sand and gravely sand outwash

WC Map 03: Physiography
WC Map 04: Soils

2.3 Hydrology

2.3.1 Surface Water Hydrology

The St. Marys River is the outlet from Lake Superior and water exits the lake from Whitefish Bay flowing in a south-easterly direction. The river is the connecting channel between Lake Superior and Lake Huron. The entirety of the St. Marys drainage basin includes the Lake Superior watershed as the lake drains directly into the river as shown in WC Map 18. There is currently a discussion as to whether a large portion of the watershed is actually considered located in the Lake Huron watershed. The immediate watershed however consists of a number of smaller sub-watersheds in both Canada and the United States which collectively include 2600 km^2 of land and 230 km^2 of water (MOE & DNR, 1992). The Source Protection Area includes the Canadian component of the St. Marys watershed consisting of 17 sub-watersheds which each independently drain into both the St. Marys River and Lake Superior as shown in WC Map 05A. Three of these 17 sub-watersheds drain into Lake Superior and the remaining 14 drain individually into the St. Marys River. Ten of the seventeen watersheds are substantial in area and described in more detail below. Details of these ten watersheds are outlined in Table 2.3.1 and a brief description for each is presented.

2.3.1.1 Big Carp River

This river is the first major watercourse east of Lake Superior and encompasses an area of 58.07 km^2. The Big Carp River originates at Walls Lake at an elevation of 312 masl in heavily forested terrain in the Precambrian Shield. Walls Lake is a small inland lake rimmed with wetland areas approximately 4 km in length. From the lake, the river flows south-easterly where it is joined by an 8 km easterly tributary. This confluence is approximately 2.4 km south of Highway 550. The river flows to the St. Marys just east of Carpin Beach (SSMRCA, 1969).

Surrounding the mouth of both the Big Carp and the Little Carp Rivers is a provincially significant wetland area known as the Carp River Wetland. The wetland extends along approximately 3 km of the St. Marys shore (Cooke, 2005). This wetland area is subject to flooding in times of elevated water on the St. Marys River and high surface runoff. Burnside (2003) determined that future development within this watershed would increase flooding at the mouth of the river.

The latest analysis of flood flows by Dillon (1997) utilized the Natural Resources Soil Conservation Service (SCS) Curve Number (CN) method. The characteristic CN for the Big Carp River watershed was found to be 70, resulting in a peak flow of 164 m^3/s. The peak flow was calculated using the Timmins Regional storm (Burnside, 2003).

2.3.1.2 Little Carp River

The Little Carp River runs approximately 12 km from its headwaters to its mouth just east of the Big Carp River along the St. Marys River. It originates in the Precambrian Shield in the Prince Landscape at a small lake of 1.8 ha north of Third Line. From this point it flows through a steep valley south to Second Line. After this point it meanders through the lowlands of the Algonquin and Nipissing Terraces and approaches the Big

Carp before meeting the St. Marys (SSMRCA, 1969, & Dingwall, 1982). Similar to the Big Carp, land use within this watershed is mainly undeveloped with some sparse residential and agricultural development (Burnside, 2003).

According to the Dillon Flood Plain Mapping report (Dillon, 1977), the peak flood flow at the mouth of the Little Carp River is 64 m^3/s based on the Timmins Regional Storm. In addition, the SSMRCA calculated a 100 year storm results in a flood flow of 39 m^3/s (SSMRCA, 1969). Dillon used the SCS CN method, while the unit hydrograph was used by the regional groundwater study (Burnside, 2003). Table 2.3.1 outlines the peak flood flows calculated for the Little Carp River and other major drainage basins within the SSMR Source Protection Area.

Flooding at the mouth of the Little Carp River occurs similarly to the flooding at the Big Carp because of the close proximity of the mouths of these two rivers. Remedial measures to alleviate this problem could include channel excavation and improvements as suggested by Dillon (Dillon, 1977). As with the Big Carp, development within this watershed should take into account the downstream impact on the flood issue and include measures to mitigate surface runoff (Burnside, 2003).

2.3.1.3 Leigh Bay Creek

Leigh Bay Creek borders the western edge of the urban area of the city. Its headwaters do not extend to the uplands area but originate in the flat lowland area just north of Second Line. The creek flow is south easterly across Second Line and Leigh's Bay Road. It then crosses Baseline and discharges to the St. Marys River. A diversion channel from the Bennett and West Davignon Creeks joins these two systems with the Leigh Bay Creek just north of the Base Line Road crossing. This diversion was built in 1979 in order to minimize flooding west of Goulais Avenue between Third Line and the St. Marys River. The outfall of the city's west end wastewater treatment plant (WWTP) is in the vicinity of the discharge point of Leigh Creek to the St. Marys River approximately 1.2 km offshore (Griffith, 2005).

The CN of 75 is characteristic of increased residential development within its contributing drainage area. Dillon (1977) reported a peak flood flow of 43 m^3/s and the SSMRCA (1969) reported a peak flow of 23 m^3/s, based on the Timmins Regional and 100-year return storms, respectively (Burnside, 2003). Historically, flooding has not been an issue within the Leigh Bay Creek watershed

Table 2.3.1 Peak Flood Flows for Major Drainage Basins

Watercourse	Location	Drainage Area	Slope	1966 Proctor & Redfern	1969 SSMRCA *	1977 Dillon Ltd **	1987 Wm.R. Walker	1988 Proctor & Redfern
		(km^2)	(m/km)	(m^3/s)				
Big Carp River	at St. Marys River	58	28.7		82	164		
Little Carp River	at St. Marys River	21	26.8		39	64		
Leigh Bay Creek	at Leigh Bay	7	18.5		23	43		
W & E Davignon Creek	at St. Marys River	66	36 & 38			223		
Central Creek	at E. Davignon	3	13.9	22	15	22		
Bennett Creek	at confluence with Davignon	22	41.3		37	72		
Fort Creek	at St. Marys River	7	20.0			38		27/37
Clark Creek	at St. Marys River	6	8.5	19				
Root River	at West boundary of Reserve lands	114	20.4			174	97/159	
West Root River	at confluence with Root River				35			
Coldwater Creek	at confluence with Root River	3				12		
Crystal Creek	at West boundary of Reserve lands	21				67		

*1 in 100 year storm flood
**Timmins Regional Storm
#/# - 1 in 100 year flood/Timmins Regional Storm
Table taken from Sault Ste. Marie Area Groundwater Management & Protection Study, R.J. Burnside, 2003

2.3.1.4 Bennett Creek

The Bennett Creek drainage basin originates in a vast marshy area in the Precambrian Shield. It flows south-easterly from its headwaters for approximately 14.5 km to its confluence with the West Davignon Creek just south of Wallace Terrace (SSMRCA, 1969). Initially, the creek's slope is gentle and it increases as the watercourse drops into the terraced lowlands area within the city. Flow of the creek is restricted within the urban area of the city due to road crossings prior to its confluence with the West Davignon. The Bennett-West Davignon diversion channel reduces the creeks flow just north of Wallace Terrace east of the Allan's Side Road intersection. The Bennett Creek discharges to the St. Marys River via a constructed channel.

2.3.1.5 West Davignon Creek

The main channel of the West Davignon Creek is approximately 11 km long. Similar to the Bennett system, the West Davignon headwaters are located high up within the Precambrian Shield. The main source for this system is Allard Lake, a lake edged by wetlands. Other wetland areas in the vicinity also contribute to the flow of this creek. Flow of the creek is generally south until it reaches Second Line at which point it swings south east. Just north of Second Line, a portion of the flow is diverted south to join the Bennett Creek. The remaining flow meanders south east until it hits Wallace Terrace. From this point the natural creek bed has been channelled west and then south to its confluence point with Bennett Creek.

2.3.1.6 Central Creek

This small watercourse contributes flow to the East Davignon Creek and is almost entirely within the urban area of Sault Ste. Marie (SSMRCA, 1969). The creek begins near the intersection of Moss Road and Third Line. It flows south to continuous concrete aqueduct at Wallace Terrace. Through the aqueduct it is discharged to the East Davignon Creek on Essar Steel Algoma property approximately 1 km upstream of the East Davignon discharge point to the St. Marys River. Central Creek collect residential and industrial run off from the west end of the city.

2.3.1.7 East Davignon Creek

The East Davignon Creek head waters are located north of the city limits high within the Precambrian Shield. Nettleton Lake is a small lake (12 ha) located along the main branch of the creek at Fifth Line. The East Davignon flows south through a steep ravine to Rossmore Road. South of Rossmore Road the urban development is very close to the creek. South of Second Line, the creek is channelled into a continuous concrete aqueduct which carries the creek across Wallace Terrace and then south-westerly through the Essar Steel Algoma property to the St. Marys River. Along this channel, discharges from Tenaris Algoma Tubes and Essar Steel Algoma Inc. contribute to the creek flow as well as the aqueduct carrying Central Creek.

Proctor and Redfern (1996) projected the 10-yr and 100-yr flood flows within the East Davignon Creek at the St. Marys River to be 27.5 m^3/s and 40 m^3/s respectively.

2.3.1.8 Fort Creek

Fort Creek originates at the northern limit of the Algonquin Terrace and flows through the heart of the urban district, located on the Nipissing Terrace. The Fort Creek dam was constructed in the 1970's upstream of the Second Line creek crossing to alleviate flood damage to the urban core. The upper two thirds of the watershed (i.e. upstream of the dam) are steeply sloped and have a number of steep sided ravines. Downstream of the dam at Second Line, the topography gently slopes south towards the St. Marys River.

Below the dam, Fort Creek is conveyed by a concrete aqueduct from Hudson Street to Queen Street. Below this point, Fort Creek flows along an open channel to the St. Marys River.

Both Dillon (1977) and Proctor & Redfern (1988) have presented peak flood flows along Fort Creek at the St. Marys River using the SCS CN method. Based on the Timmins Regional Storm, Dillon (1977) and Proctor & Redfern (1988) reported peak flood flows of 38 m^3/s and 37 m^3/s, respectively. Proctor & Redfern (1988) also calculated the 100-year peak flow of 27 m^3/s. Proctor and Redfern (1988) concluded that several potential flooding issues still exist within this area. Their recommendations included several natural channel improvements and culvert replacements to alleviate flooding problems upstream of Wellington Street and at the river's discharge to the St. Marys River (Burnside, 2003)

2.3.1.9 Clark Creek

Clark Creek an engineered drainage channel which conveys storm water run-off from the east end of the city to the St. Marys River. The creek discharges into the St. Marys River south of the Drake Street and Queen Street East intersection (Walker, 1998). From the Drake/Queen Street intersection to the discharge point on the St. Marys the creek flows through a concrete box culvert. Upstream of this culvert the creek is an open channel which extends northeast for approximately 750 metres through the Gravelle Subdivision and the Sault Ste. Marie Golf Club and then north for approximately 900 metres to the southwest corner of Bennett Boulevard and Boundary Road (Walker, 1998)

The drainage area of the Clark Creek extends significantly further north than the intersection of Bennett Boulevard and Boundary Road due to the municipal storm sewer system in this area. There are two significant storm sewer discharges to the Clark Creek at the Bennett Boulevard and Boundary Road intersection. The creek's watershed is located in the terraced lowland area. Land use within the catchment is primarily residential resulting in high surface run-off. Development in the east end of the city has led to increased flows to the Clark Creek. In the mid nineties, a capacity review study was carried out by Wm. R. Walker Engineering (1994) as a result of near flood conditions during storm events at the time. The study determined that the capacity of the Clark Creek was only sufficient to contain a 1 in 10-year flood without overtopping its banks.

2.3.1.10 Root River

The Root River watershed is the largest catchment in the planning area. The basin originates in the northern uplands where a number of swamps, bogs and lakes, including

Upper and Lower Island, Aweres and Trout Lakes, feed into the three main tributaries of the river; the Root, the West Root and Crystal Creek. The West Root drains the western portion of the basin and joins the main river west of Highway 17 North near the Root River Golf Course. The Crystal Creek headwaters are in the north-eastern region of the basin. The Crystal Creek joins the main river north of Highway 17 East close to the eastern boundary of the Batchewana First Nation Rankin Reserve. The Root River discharges to the St. Marys River at Bell's Point on Little Lake George. Flooding issues not been reported within the Root River watershed although seasonal flow variation of the river is substantial. Dillon (1977) did however target the Algoma Central and Hudson Bay Railroad (ACR) culvert on the Root River at Highway 17 North to be insufficient. Flood peaks have historically occurred between October and December and April to May. Land use within the area is largely undeveloped with some rural residential and industrial activity (SSMRCA, 1969 & Burnside, 2003)

Peak flows for the Root River based on the Timmins Regional Storm were calculated at the point where the river enters the western boundary of the Batchewana First Nation Rankin Reserve. Dillon (1977) reported the peak flood flow to be 174 m^3/s using the SCS CN method and Walker (1987) calculated it as 159 m^3/s using a 3-parameter log-normal distribution analysis. Walker calculated the 100-year return flow to be 97 m^3/s.

2.3.1.11 Flow Monitoring Stations

There are two active Environment Canada HYDAT gauge stations monitoring flow of watercourses within the planning area. One is located at the Big Carp River and the other is located at the Root River. There are two additional gauge stations which have historically been used to monitor flow. Table 0.3.2 summarizes the data recorded at each station and the date range for which validated data is available. The location of the four stations is outlined on WC Map 13A.

Table 0.3.2 Summary of Environment Canada HYDAT Data

Station	Flow	Water Level	Sediment Depth
Bennett Creek	1971-1978	NA	NA
Root River	1971-2003	2002-2003	1989-2002
St. Marys River	1860-1993	NA	NA
Big Carp River	1979-2003	2002-2003	1990-2002

WC Map 05A: Hydrologic Features
WC Map 13A: Water Monitoring Sites
WC Map 18: Watershed of Intake

2.3.2 Groundwater and Hydrogeology

2.3.2.1 Recharge and Discharge Areas

Recharge areas are defined as zones having significant downward groundwater gradients (where the groundwater flow is predominantly vertical). Topographically elevated areas having permeable formations exposed at surface act as ideal recharge areas. An example of such an area is the exposed glaciolacustrine beach sands and gravels on the southern contact of the Precambrian uplands (Burnside, 2003).

Groundwater discharge occurs where the water table or piezometric surface intercepts the ground surface. In general, if the hydraulic head in the aquifer is higher than the ground surface or higher than the water table aquifer, the groundwater is in a discharging condition. Maintaining the natural balance of interflow between the groundwater and surface water flow systems is essential to ecological health.

The recharge/discharge zones within the planning area are illustrated in WC Map 05B. This map was created by subtracting the piezometric surface from the water table surface. All areas with negative values have been identified as discharge areas and those areas with positive values are designated as recharge areas. As can be seen from the map, a majority of the planning area is identified as a regional recharge zone. This indicates some recharge through the thin or fine-grained surficial material that covers the majority of the area.

One high recharge zone is located within the Precambrian uplands. This zone is a bedrock valley filled with sand and gravel, corresponding to the valley hosting the ACR railway and Hwy 17 North corridor. Two groundwater recharge areas occur within the municipal city limits; one in the area of Gros Cap along the shore of Lake Superior in the west (approximately 3.12 km^2), and a major area at the bedrock/overburden interface along the southern contact of the Precambrian uplands in the north portion of the City (approximately 37.5 km^2). The latter of the two is recognized as the main recharge zone within the Source Protection Planning Area, providing recharge to both confined and unconfined aquifers in the vicinity of the City.

This large zone of high groundwater recharge is associated with the gravel-rich glaciolacustrine beaches deposited adjacent to the uplands, and covers an area approximately 20 km long and 2 to 3 km wide. Groundwater recharge through these beach deposits occurs by direct infiltration of precipitation, and recharge from surface streams and wetlands flowing south from the impermeable bedrock highs in the north. The recharge through this area has been estimated to be in the order of 15 to 20M m^3/a (International Water Consultants, 1997). More recent groundwater modelling simulations carried out by Burnside (2003) noted that the total groundwater recharge over this area is considerable. The gravel pit operations in this area, in some cases, may also be facilitating increased recharge by collecting water in the gravel pits. However, if sand and gravel are excavated and removed to well below the water table, the total recharge to the deeper aquifers may impact the groundwater resources in the area.

WC Map 05B also delineates three large areas of groundwater discharge located near the City. These discharge zones are associated with areas of glaciolacustrine sand, as identified on the Quaternary Geology map (WC Map 02C), particularly in the south, adjacent to the St. Marys River. These main areas of groundwater discharge are located near Pointe des Chênes Park in the west, in the area of the Central bedrock valley (City centre) and between the City and Little Lake George, associated with the Eastern bedrock valley. This indicates that the bedrock valleys influence the groundwater flow and nature of the surficial deposits, focussing the areas of groundwater discharge. Smaller areas of groundwater discharge occur along the southern limits of the glaciolacustrine deposits near the uplands, and form the headwaters of numerous streams there. Within the Precambrian uplands, discharge zones occur along surface watercourses, as well as the area of sand and gravel located along the northern contact of the uplands. Discharge areas also occur along the southern limits of the sand and gravel deposits close to the Precambrian uplands, which form headwaters of numerous streams.

Evaluation of the extent of surface – groundwater interaction through quantification of base flow in surface water courses has not been researched. It is possible to quantify base flow by examining low flow watercourse conditions over time. To date however, the stream flow monitoring network is limited to only three stream flow gauge stations established within the watershed. Burnside (2003) deemed that based on the lack of data, it was not possible to quantify base flow and groundwater discharge. International Water Consultants (1997) estimated the groundwater recharge to be approximately 39 mm/year or 17, 500, 000 m^3/yr. The Water Budget Assessment Report will refine these early estimates.

2.3.2.2 Flow Direction of Major Aquifers

As part of the municipal groundwater study, static water levels obtained from individual water wells from the MOE water well records database within the shallow and deep subsurface were analysed to determine the groundwater flow patterns and potential interaction between the surface water and groundwater flow systems. Each well provided a data point and was used to generate contours of the water table elevation. Groundwater naturally flows from areas of higher to lower water table elevation, resulting in a flow direction perpendicular to water table contour lines. Thus, contouring of the water table elevations allows interpretation of the general groundwater flow direction across a region.

The water table surface elevation for the Source Protection Area is presented as WC Map 05A. This map is based on the static water levels observed in water wells drilled to shallow depths, and assumes all wells are under unconfined conditions. All wells drilled to less than 15 m depth were considered in this analysis, as per the Groundwater Studies 2001/2002 Technical Terms of Reference (MOE, November 2001). Because of the sparse number of wells over the Precambrian uplands, additional data points were introduced using the surface water body features. It was assumed that the water table would coincide with the water levels in the surface water bodies and streambeds. The existence of numerous lakes is suggestive of shallow groundwater flow discharge into those water bodies. In general, the elevation of the shallow groundwater table closely reflects the ground surface elevation. Water table elevations range from 176 m amsl along the St. Marys River in the south to about 435 m amsl in the north-eastern part of the watershed.

In general, the groundwater flows from the Precambrian uplands toward Lake Superior and the St. Marys River. Locally, the shallow groundwater flow is influenced by the thickness and distribution of coarser sand and gravel units within the overburden, and topographic highs in the surface of the underlying bedrock. The East, West and Central Basins which are depressions in the bedrock surface, locally influence the water table and direction of groundwater flow. Groundwater flow divides could possibly occur along the bedrock highs.

Groundwater equipotentials within the deeper wells in the planning area are presented as WC Map 05B, using data from all wells drilled to depths greater than 15 m. These wells are assumed to be under confined conditions. The resulting piezometric surface in WC Map 05A closely reflects the bedrock surface elevation contours. Equipotential elevations range from 177 m amsl adjacent to Lake Superior to 430 m amsl in the Precambrian uplands to the north. Steeper groundwater gradients occur adjacent to the areas where topographic changes are the greatest. Bedrock valleys that host confined aquifers also influence the potentiometric contours and groundwater movement locally.

2.3.2.3 Characteristics of Major Aquifers

2.3.2.3.1 Overburden Aquifers

WC Map 05B illustrates that there is thin overburden covering the Precambrian uplands in the northern part of the Source Protection Area. As such, overburden aquifers do not, generally, exist over the Precambrian uplands, with the exception of some areas along the Hwy 17 and Algoma Central Railway (ACR) corridor where overburden sand and gravel deposits have been mapped. South of the uplands, the majority of the area is underlain by 20 m to 60 m of overburden, with three isolated areas having overburden over 100 m thick; the western-most of these areas hosts the deepest overburden in the Source Protection Area, with approximately 147 m of material overlying the bedrock. These areas of thickest overburden correspond to depressions in the sandstone bedrock, infilled with unconsolidated surficial material.

In the low lands, unconfined or “water table” conditions exist within the shallow overburden. Residents outside of the municipal services zone within the recharge area are likely tapping the unconfined shallow aquifer to meet their water needs.

The deeper sand and gravel aquifers, as well as the sandstone bedrock aquifer, represent confined aquifer conditions. Flowing artesian wells are common within the central basin, from south of approximately the Fourth Line. Historically, local residents had installed a number of sand points into the lower sand and gravel overburden aquifers. Most of these sand points, it appears, have not been properly abandoned.

Based on the description of the overburden materials and the description of the three bedrock valleys, (the west, central and east basins), it is evident that there are potentially three separate overburden aquifer systems in the Source Protection Area. The 1978 groundwater supply study completed by International Water Consultants Ltd. (IWS) confirmed this and identified the west, central and east bedrock valleys as groundwater basins. The basins are depressions in the Cambrian bedrock, infilled with unconsolidated surficial material and are separated by topographic highs in the Precambrian bedrock, as discussed previously in this report. These cross sections also suggest that the deeper overburden aquifers in each of these three basins are potentially isolated.

The bedrock highs separating the three basins control the water table in the shallow flow system and the piezometric surface in the deeper confined aquifers. The bedrock high areas form the aquifer boundaries and the groundwater flow is generally divergent along these highs. A description of the overburden aquifer boundaries is provided below for each of the basin areas.

2.3.2.3.2 East Basin – Shannon and Lorna Wells

The lower aquifer within this basin consists of a sand and gravel layer of varying thickness and permeability and also the upper portion of the underlying sandstone bedrock. Artesian conditions within the aquifer are created by impermeable clay overlying this sand and gravel aquifer and the effect of the surrounding topography. Test drilling in 1978 indicated bedrock depth of 85 m near the St. Marys River, with the static water level at 8.5 m. Bedrock contours outline the basin as a pre-glacial valley in the sandstone, trending approximately north-south. The lower aquifer is recharged through glaciolacustrine sands and gravels adjacent to the Precambrian uplands to the north, with potential surface water recharge adjacent to the St. Marys River; however, bedrock is located at approximately 280 feet (85m) depth, and therefore the hydraulic connection with the river is likely poor. There is also an upper aquifer located along the north shore of the river. The degree of recharge from the river to this aquifer will be dependent on the degree of groundwater pumping and its effect on the groundwater gradient locally. Samples collected from test wells constructed for the 1970 groundwater investigation (IWS, 1970) returned results of less than 70 mg/L total hardness and less than 10 mg/L chloride. The approximate natural groundwater recharge, estimated in a 1978 groundwater investigation undertaken by IWS, ranges from 15,900 to 20,000 m^3/d (3.5 to 4.4 mgpd).

2.3.2.3.3 Central Basin – Goulais and Steelton Wells

This zone is similar to that described for the Eastern Basin, with the lower aquifer being a combination of the sand and gravel layer and the upper portion of the underlying sandstone. Artesian conditions are created by impermeable clay overlying the sand and gravel. The pre-glacial valley in the sandstone runs parallel to the Eastern basin trending approximately north-south. The two basins are separated by bedrock high extending south from the Precambrian uplands. The aquifer is recharged through glaciolacustrine sands and gravels adjacent to these uplands to the north, with potential surface water recharge adjacent to the St. Marys River. The approximate natural groundwater recharge, estimated by IWS (1978), ranges from 6.3 to 6.6 mgpd. Test drilling during the 1978 investigation approximately 1000 m west of the Goulais wells, intersected 40 m of clay and silt, underlain by 18 m of fine sand. The underlying sandstone bedrock is permeable, with a static water level of 1 m below ground surface (bgs). Pumping test data indicated the area was suitable for high capacity bedrock wells.

2.3.2.3.4 West Basin

A 1979 groundwater investigation outlined an upper sand formation in the shoreline area of this basin. The surficial aquifers were overlain by variable thicknesses of silt and clay, or contained significant quantities of silt and clay, reducing the potential for recharge from the river and making them less suitable for groundwater development. The approximate natural groundwater recharge, estimated in a 1978 groundwater investigation undertaken by IWS, ranges from 9,090 to 13,640 m^3/d (2.0 to 3.0 mgpd). There is currently no development of the groundwater resource for municipal purposes within this basin.

2.3.2.4 Bedrock Aquifers

The occurrence and distribution of groundwater in bedrock formations are governed by the rock type, structure, and, in some cases, by the thickness and type of the overburden. Most crystalline bedrock formations, such as the Precambrian granites underlying the planning area, have very little inherent or primary porosity and are considered impermeable. Groundwater in such formations occurs only in the weathered and fractured portions of the rock. However, sedimentary rocks such as the Jacobsville Formation in the planning area contain groundwater within weathered rock, bedding planes and fractures characteristic of the upper portions of these units.

The Jacobsville Formation comprises the most extensive bedrock aquifer within the planning area and is the municipality's principal aquifer. It is a sandstone formation of Cambrian age underlying the planning area's southern section. This unit lies immediately overlying the Precambrian rocks, both north and south of the uplands area. This sandstone layer is recharged indirectly by infiltration through the overlying overburden material, and directly by runoff from the Precambrian upland to the north through the coarse sands and gravels discussed previously. The higher elevation of the Precambrian upland results in a significant hydraulic gradient within the aquifer, with groundwater flow predominantly to the south. Groundwater flows through the sandstone aquifer under a confining layer of clay in the southern part of the planning area, resulting in artesian conditions and flowing wells.

The deep overburden aquifer appears to be, in general, contiguous with the underlying sandstone bedrock aquifer. For all practical purposes, the upper fractured sandstone aquifer unit and the deep overburden aquifer could be considered as one aquifer formation. The municipal wells in the City derive their water from this combined overburden and bedrock aquifer formation.

2.3.2.5 Conceptual Hydrostratigraphic Model

In summary as presented in Table 2.3.3, the overburden materials in the planning area consist of beach sands and gravels, shallow water sand, deep water lacustrine clay/silt, deep water sands and till material, underlain by the sandstone and in turn underlain by the Precambrian granitic rocks.

Table 0.3.3 - Conceptual Hydrostratigraphic Model

Hydrostratigraphic Unit No	Formation Type	Relative Hydraulic Conductivity	Comments
Layer 1 (Top Layer)	Sand and Gravel	High	Extensive along the "recharge area" and absent in the south
Layer 2	Sand/silt	Moderate	Varying thickness, generally thin and/or combined with Layer 3
Layer 3	Clay/Silt	Low	Extensive in the low lands, some times with lenses of sand of moderate conductivity
Layer 4	Sand and Gravel	Moderate to high	Varying thickness but appears to be extensive in the former glacial lake basin. Sand and gravel overlying sandstone was found in a number of wells to the south of St. Marys River in Sault Ste Marie, MI.
Layer 5	Till	Low to moderate	Discontinuous
Layer 6	Sandstone	Moderate	Extends over all of the low lands. As noted from a number of borehole logs from Sault Ste Marie Michigan, sandstone is identified as the principal bedrock formation underlying the sand and gravel deposits.
Layer 7	Granite	Low	

Burnside, 2003

2.3.2.6 Summary of Aquifer Characteristics

The groundwater storage and movement in an aquifer depend on its transmissivity (T) and storativity (S) or storage coefficient. These hydrodynamic parameters are the basis for understanding groundwater flow, and are principal inputs to groundwater modelling. Because the municipal groundwater study (Burnside, 2003) did not involve pumping tests, these aquifer parameters were defined based on previous hydrogeological investigations and pumping test results. The municipal well shutdown tests were analysed to obtain a general idea about the range of transmissivity of the aquifer encountered at Goulais Well and the Steelton Well.

Aquifer parameters associated with the municipal wells and a number of test wells drilled during various exploratory programs in the Sault Ste. Marie planning area are summarized in Table .3.4. A review of the available information on the aquifer characteristics clearly shows that although a large number of exploratory wells were drilled in the West Basin, none of the wells were tested and the actual aquifer conditions in that area are unknown.

The data on the hydrodynamic characteristics of the aquifers in the Central and East Basins indicate variable aquifer conditions. The aquifers transmissivity varied from 0.3 m^2/day (Well 4 and 5 in Central Basin) to over 535 m^2/day (OW3/80, OW4/80, OW6/80) in the Central Basin and ranged from 2.1 m^2/day (at WW3) to over 845 m^2/day (TW3/70) in the East Basin. This variability may be related to the variations in the aquifer formation, well construction and other site/well specific details. These results also indicate that the underlying aquifer in the area is confined to the most part and may be semi-confined at places.

Table 2.3.4 - Summary of Aquifer Characteristics

a) West Basin

Well No.	Aquifer Thickness	Aquifer Formation	Transmissivity (m^2/day)	K (m/s)	Storativity
Deep Well 1	15.0	Beach Sands	n/a	n/a	n/a
Shallow Well 1	7.6	Beach Sands	n/a	n/a	n/a
Deep Well 2	15.0	Beach Sands	n/a	n/a	n/a
Deep Well 3	15.0	Beach Sands	n/a	n/a	n/a
Shallow Well 3	7.6	Beach Sands	n/a	n/a	n/a
Deep Well 4	15.0	Beach Sands	n/a	n/a	n/a
Shallow Well 4	7.6	Beach Sands	n/a	n/a	n/a
Deep Well 5	15.0	Beach Sands	n/a	n/a	n/a
Shallow Well 5	7.6	Beach Sands	n/a	n/a	n/a
Deep Well 6	15.0	Beach Sands	n/a	n/a	n/a
Shallow Well 6	7.6	Beach Sands	n/a	n/a	n/a
Deep Well 7	15.0	Beach Sands	n/a	n/a	n/a
Shallow Well 7	7.6	Beach Sands	n/a	n/a	n/a
Deep Well 8	15.0	Beach Sands	n/a	n/a	n/a
Shallow Well 8	7.6	Beach Sands	n/a	n/a	n/a
Deep Well 9	15.0	Beach Sands	n/a	n/a	n/a
Shallow Well 9	7.6	Beach Sands	n/a	n/a	n/a
Deep Well 10	15.0	Beach Sands	n/a	n/a	n/a
Shallow Well 10	7.6	Beach Sands	n/a	n/a	n/a
Deep Well 11	15.0	Beach Sands	n/a	n/a	n/a
Shallow Well 11	7.6	Beach Sands	n/a	n/a	n/a
Deep Well 12	15.0	Beach Sands	n/a	n/a	n/a
Shallow Well 12	7.6	Beach Sands	n/a	n/a	n/a
Background Well	n/a	n/a	n/a	n/a	n/a
Average	**11.5**				

b) Central Basin

Well No.	Aquifer thickness	Aquifer Formation	Transmissivity (m^2/day)	K (m/s)	Storativity
Well No. 1 (Lot 4)	3.0	Sand	29.8	1.15e-04	0.01
Well No. 2 (Lot 3)	n/a	n/a	n/a	n/a	n/a
Well No. 3 (Lot 10)	4.2	Gravel & Stones	7.5	2.06e-05	0.01
Well No. 4 (Lot 1)	2.1	Boulders &	n/a	n/a	n/a
OW3 / 80	2.7	Red Sandstone with Grey Layers	535.4	2.26e-03	0.003
OW4 / 80	2.1	Red Sandstone with Grey Layers	535.4	2.90e-03	0.003
OW6 / 80	6.1	Red Sandstone with Grey Layers	535.4	1.02e-03	0.003
Well 1	4.6	Course Sand	n/a	n/a	n/a
Well 2	4.6	Course Sand	n/a	n/a	n/a
Well 3	4.9	Course Sand	n/a	n/a	n/a
Well 4	3.0	Course Sand	0.3	1.14e-06	n/a
Well 5	3.4	Gravel Boulders	0.3	1.04e-06	n/a
Well 6	2.7	Gravel Boulders	n/a	n/a	n/a
Average	**3.6**				

c) East Basin

Well No.	Aquifer Thickness	Aquifer Formation	Transmissivity (m^2/day)	K (m/s)
WW1	7.6	Red Sandstone and boulders	335.3	5.09e-04
WW2	12.8	Red & Grey Sandstone	23.0	2.08e-05
WW3	53.3	Sandstone, boulders with sand and clay/ Sandstone Interbedded with clay	2.1	4.50e-07
TW2/70	6.096	Sand fine to coarse	25.4	4.82e-05
TW3/70	7.62	Sand fine to coarse and Gravel	845.6	1.28e-03
TW4/70	12.192	Sand fine Sand fine to medium Sand fine to coarse		0.00e+00
Average	**16.6**			

2.3.3 Surface – Groundwater Interactions

To date, there have not been any base-flow studies completed for SSMRCA watershed.

WC Map 05A: Hydrologic Features
WC Map 05B: Recharge Areas and Discharge Area
WC Map 2C: Quaternary Geology

2.3.4 Climate

Climate data is available from several sources for the Sault Ste. Marie Region Source Protection Area. Environment Canada has had station data located at several sites in the SSM area. The longest continual station site has climate data available from 1945-2003. The oldest recorded data in the area is 1889 – 1933. Below (2.3.5) is a reflection of the Environment climate station history in the Sault. There is an obvious data gap from 1933 -1945.

Table 2.3.5 - Environment Canada Weather Station Recording History (Environment Canada: Canadian Daily Climate Data on CD-ROM - Eastern Canada

Station ID	Station Name	Organization	Years of Data
6057595	Sault Ste. Marie Forestry	Env. Canada	1889-1933
6057597	Sault Ste. Marie Insectary	Env. Canada	1951-1954
6057605	Sault Ste. Marie Shingwauk	Env. Canada	1954-1955
6057589	Sault Ste. Marie	Env. Canada	1949-1959
6057590	Sault Ste. Marie 2	Env. Canada	1957-2002
6057592	Sault Ste. Marie A	Env. Canada	1945-2003

In addition to the Environment Canada weather stations the Ontario Ministry of Natural Resources (OMNR) also has weather stations in the Sault Ste. Marie and surrounding areas for use in the Forest Fire Management program as well as in various types of research. These stations have the capacity to fill in data gaps if any exist. However they were historically reported on weather conditions from May until September of any given year to coincide with the anticipated fire season. That reporting time has, in recent years, been extended until October on those stations still in service. The stations are listed below in Table 2.3.6. There are over 40 years of climate data available. This data includes precipitation, temperature, wind speed and direction and relative humidity,

Table 2.3.6 - OMNR Fire Weather Station Recording History

Station ID	Station Name	Organization	Years of Data
42200	SAULT STE MARIE	OMNR	1963-2004
42201	PANCAKE BAY	OMNR	1963-1983
42250	PANCAKE BAY	OMNR	1984-2004
42202	RANGER LAKE	OMNR	1963-85, 1989-2004

The climate of the Sault Ste. Marie Region Source Protection Area is affected temporally and spatially by seasonal variations and the physical proximity to Lake Superior. The winds are predominantly from the west in the winter season and can also be from the Gulf of Mexico during the summer. The area is subject to warm summers and cold snowy winters. Lake effect snow is a common feature of Sault Ste. Marie winters making it a recognized snow-belt area. Average snowfall for December, January, February and March is 79.7 cm, 83.3 cm, 51.2 cm, and 35.4 cm annually. The snowfall maximums and minimums as illustrated in Table .3.7 demonstrate the immense variability from year to year in this area. Note that the December 1995 maximum of 207.2 cm was preceded by the 1994 record low of 10.9 cm.

Table 2.3.7 - Environment Canada Data from Station 6057592 Sault Ste. Marie A

Month	Average Snowfall (cm)	Maximum Snowfall (cm)	Year of Maximum	Minimum Snowfall (cm)	Year of Minimum
December	79.7	207.2	1995	10.9	1994
January	83.3	146.9	1982	36.5	1981
February	51.2	133.8	1968	9.2	1993
March	35.4	162.8	2002	Trace	1973

2.3.5 Climatic and Meteorological Trends

For the long-term temperature and precipitation trend in the watershed region the time-series of average annual, minimum and maximum daily air temperatures for the 1945 to 2005 period are plotted in Figure 2.3.5 below. The five-year moving average trend line is shown in red on Figure 2.3.5 for the average daily temperature. It suggests that there has been a mild warming trend over the last 20 years (1985 to 2005). Although this warming trend has been noticed in most locations throughout Canada over the same time period, it does not indicate a significant variation from the long-term average for the past 50 years.

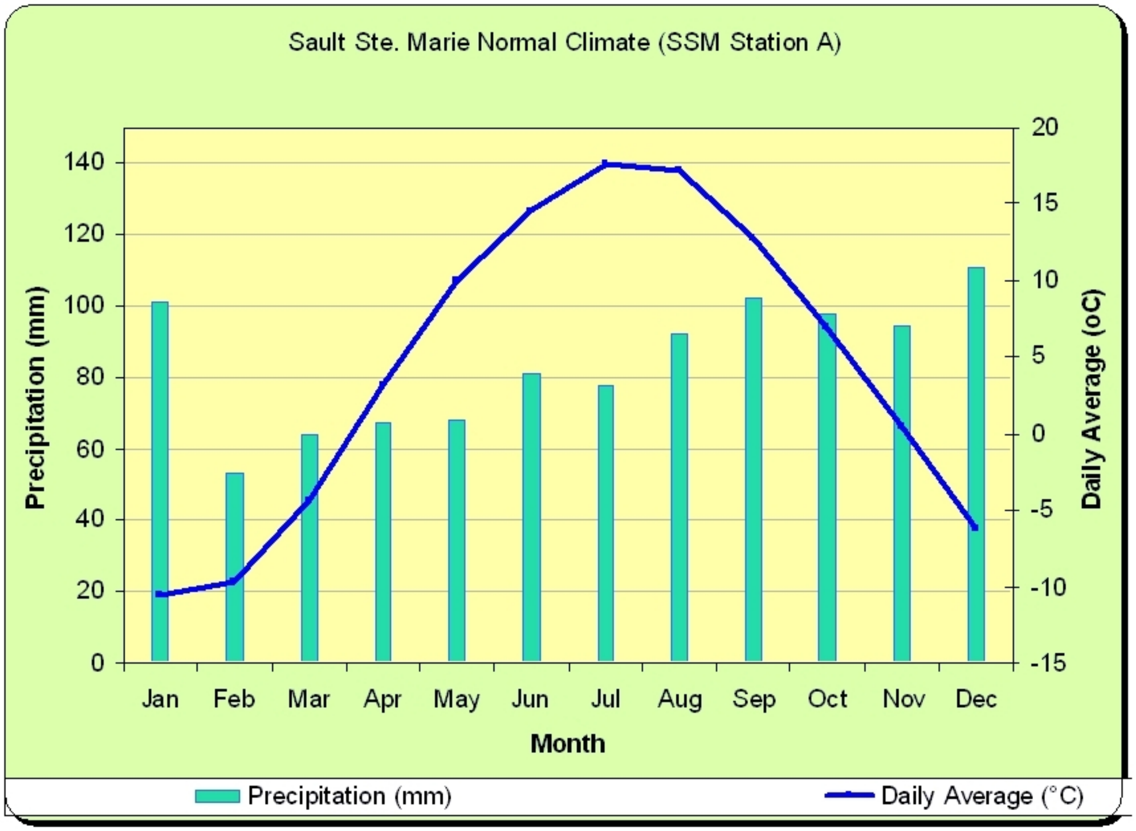


Figure 2.3.4: Climate Normal of Sault Ste. Marie (Monthly Avg. 1970-2001)

The last 60 years of record as shown in Figure 2.3.5, the year with the highest mean daily temperature of 7.5°C occurred in 1961, whereas the year with the lowest mean daily temperature of -3.2°C occurred in 1948. The absolute highest maximum daily temperature of 36.8°C occurred on July 07, 1988, whereas the lowest minimum daily temperature of -38.9°C happened on January 23, 1948.

Figure 2.3.6 illustrates the annual time-series of total precipitation, rainfall and snowfall occurring at Sault Ste. Marie for the last 60 years. Generally speaking, there has been a downward trend in the precipitation totals since the 1960s, primarily due to a lowering of the snowfall totals over the same period. However, rainfall amounts have remained generally steady at between 500 and 700 mm annually. From Figure 2.3.6, it appears that the wettest period in terms of total precipitation occurred between 1966 and 1978 whereas the driest period took place between 1949 and 1962. The highest annual precipitation total of 1790 mm took place in 2005 whereas the lowest total of 377 mm occurred in 1961. In terms of total annual rainfall, the highest total of 1331 mm occurred in 2005 whereas the lowest amount of 244 mm happened in 1961. The highest and lowest total snowfall of 1948 cm and 636 cm occurred in 2005 and 1958 respectively.

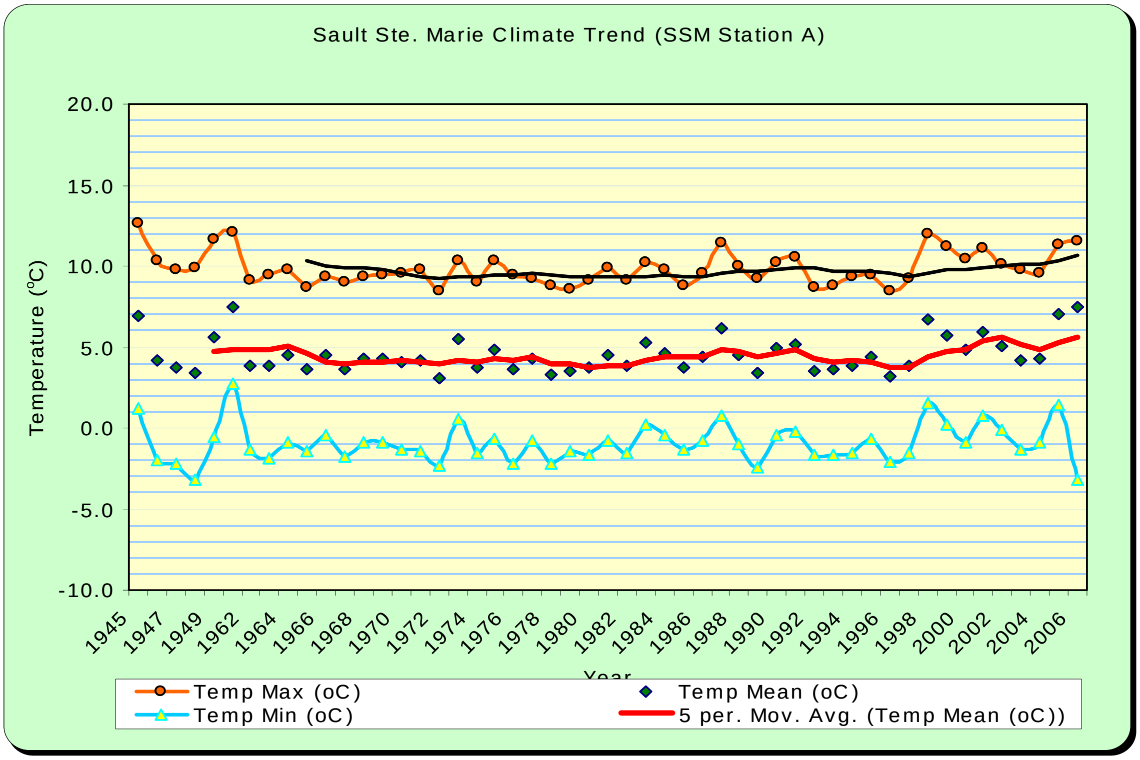


Figure 2.3.5: Time Series Trend in Climate of Sault Ste. Marie (1945-2005)

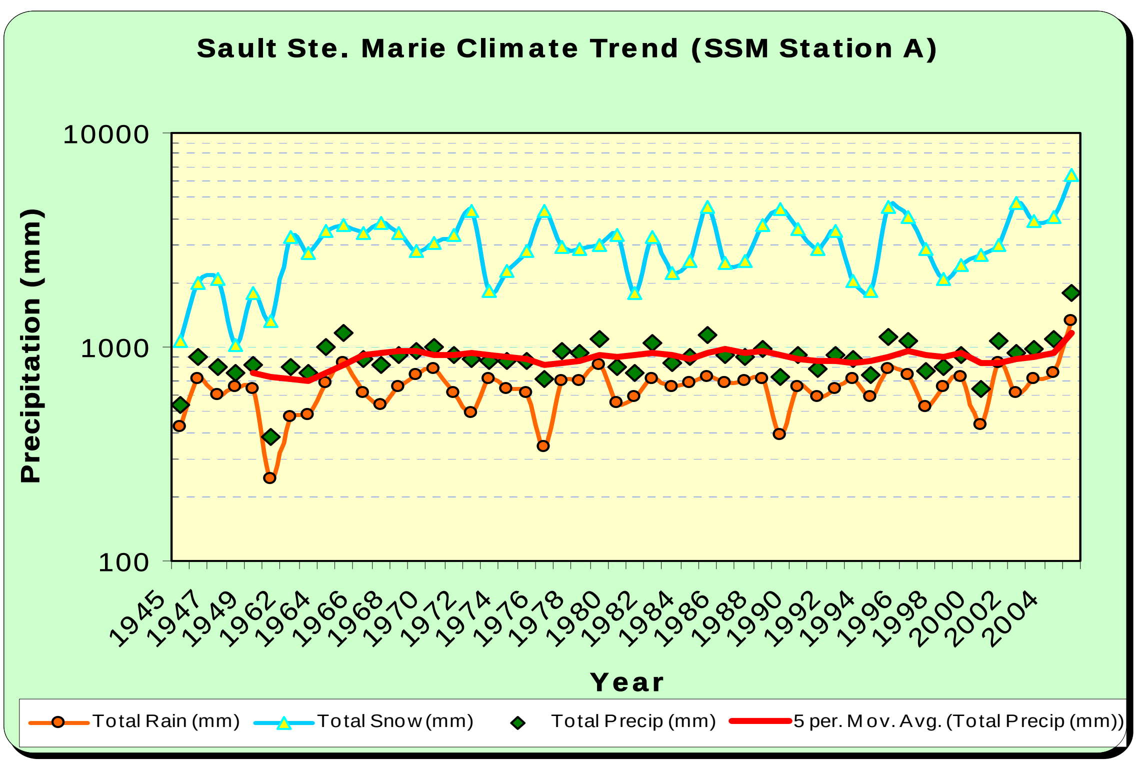


Figure 2.3.6: Time Series Trend in Precipitation of Sault Ste. Marie (1945-2005)

2.4 Naturally Vegetated Areas

Naturally vegetated areas include wetlands, woodlands, and vegetated buffers in riparian areas that are likely to influence quality and quantity of source water. Riparian areas are those which lie within a transition zone between uplands areas, such as, forest, streams, wetlands and lakes.

These areas can protect drinking water sources by trapping sediments and soils, altering or reducing contaminants, nutrients and some pathogens. These areas form part of a water feedback loop as both groundwater and surface water cycle interchange through both the atmosphere and landscape. "Healthy" watersheds have a good mix of naturally vegetated areas that are well distributed across the landscape. More naturally vegetated watersheds are better able to filter soil, nutrients, pathogens and contaminants on the landscape from subsurface and surface waters.

The forest regions of the Sault Ste. Marie watershed predominantly lie within the Great Lakes-St. Lawrence Region and also within the Boreal Shield. This area represents the transitional zone between the forest of Great Lake-St. Lawrence and the predominantly coniferous Boreal Forest. It has mixed wide range of tree and shrub species. These range from eastern white pine, hemlock and white cedar, red pine and balsam fir to sugar maple, white and yellow birches, red oak, basswood , black and white spruce, jack pine, balsam fir, tamarack and eastern white cedar. The differences in the species number and type are the result of terrain, soil and climate variations.

Hard maple, along with lesser amounts of yellow birch, is the most common trees species in the Great Lakes-St. Lawrence Region. Other species in this forest region include soft maple, balsam fir, white spruce, white pine and red oak. The Great Lakes-St. Lawrence Region extends north into the Algoma Forest because of the moderating influence of the Great Lakes. Hard maple, yellow birch and soft maple tend to grow on fine textured till soils with hard maple occupying the drier sites, yellow birch growing on the moister sites and soft maple dominating on the wet sites. Red oak is an uncommon species clinging to the edge of Lake Superior on ridge tops.

2.4.1 Wetlands

Within the planning area, wetlands comprise 6.11 % (32 km^2) of the watershed area (522 km^2). WC Map 06 illustrates the wetlands within the planning area. There are a number of smaller wetland areas in the northern uplands of the planning area which are associated with headwater areas of the rivers and creeks which flow south towards the St. Marys River. Along the shore of the St. Marys, a number of larger wetland areas are found at the outlet of rivers such as the Big and Little Carp and the Root River.

Wetlands within the area can play significant roles in groundwater discharge and recharge. Without measuring hydrogeologic characteristics within a wetland, certain observable features can suggest the presence of groundwater recharge or discharge. Wetlands assessed according to the provincial wetlands evaluation system can provide valuable qualitative data for assessing the groundwater function of wetland areas. The system assigns a value to wetlands depicting their recharge and discharge potential. Points are accrued based on observations which are indicators for discharge and recharge (MNR, 1993)

Recharge through wetlands is typically dependent on the topography, geologic setting and the type of wetland. Headwaters wetlands located high in drainage basins or on heights of land between rivers are common sites of groundwater recharge. Also isolated and palustrine wetlands are also more likely to be associated with recharge than riverine and lacustrine wetlands. Soils which are more permeable are more effective at conveying groundwater in either a discharge or recharge situation. Sand, gravel and loam are considerably more permeable than clays and silty soils (MNR, 1993).

Wetlands contributing to discharge are typically riverine or lacustrine in nature and located at a major break in the relief. Groundwater discharging to a wetland is typically nutrient and mineral rich, therefore swamps, marshes and fens are more indicative of groundwater discharge than nutrient poor bogs (MNR, 1993).

Water deep within an aquifer generally has limited contact with air and bacteria. Under such conditions evaporation, oxygen transfer and bacterial activity are restricted. Once the groundwater is exposed to the surface, evaporation concentrated the dissolved minerals within the water which can cause them to precipitate out of solution. Also once exposed to air, oxygen transfer is increased and oxidation of such compounds as iron will also cause precipitation. Finally, bacterial activity can also enhance precipitation of iron solids out of solution. Evidence of iron precipitates and marl deposits comprised of calcium carbonate are other good indicators of groundwater discharge.

Of the many areas illustrated in WC Map 06, only six of these wetlands have been evaluated using the provincial wetland evaluation system within the past fifteen years. Of these six, only five of the evaluations were located at the MNR Sault Ste. Marie District Office. Table 2.4.1 outlines these wetlands and their evaluation scores.

Table 2.4.1: Sault Ste. Marie District Wetlands

Wet land #	Official Name	Coastal/ Inland	Area (ha)	Year of Evaluation	Total Field Evaluation Score	Wetland Status
1	Bell's Point East	Coastal	35.1	1992	NA	Not PSW
2	Bell's Point West	Coastal	19.5	1992	NA	Not PSW
4	Carp Rivers	Coastal	165.27	1997	620	PSW
14	Mary-Ann Lake	Inland	16.75	1999	550	Not PSW
16	McNabb St.	Inland	NA	1996	372	Not PSW
22	Shore Ridges	Coastal	559.3	1999	675	PSW

PSW - Provincially significant wetland
Data provided by T.Cooke, Ducks Unlimited, Feb. 2006

2.4.1.1 Evaluated Wetlands

The following sections are summary of the characteristics of each of the evaluated wetlands based on the Wetland Data and Scoring Record obtained from the MNR Sault Ste. Marie District Office's data library. Table 2.4.2 represents the summary of wetlands within SSMRCA watershed. Location of these wetlands is shown in WC Map 06, WC Map 06A & WC Map 06B maps.

2.4.1.1.1 Carp River

The Carp River wetland is one of two provincially significant wetlands in the planning area. A close up view of the wetland is presented at WC Map 06B. This riverine wetland encompasses the mouth of both the Big and Little Carp Rivers situated on the shore of the St. Marys River. The lacustrine wetland is characterized by flat/rolling topography with full soil coverage. The area is predominantly swamp (88%) with the remaining 12% of the area being characterized as marsh. The wetland area to upslope catchment area is less than 5%. The soil is highly permeable and comprised of sand with a small degree of clay/loam. The pH was found to be greater than 5.7. These characteristics both suggest that there is potential for groundwater discharge within the wetland (MNR, 1994). The wetland was given a score of 30 points out of 30 for groundwater discharge significance. This high score "indicates that there is a strong potential for the existence of an important discharge function for the wetland" (MNR, 1994). Trees and shrubs are present along shoreline, which provide shoreline erosion control.

2.4.1.1.2 Bell's Point East

This wetland lies at the mouth of the Root River on an outcropping of land along the St. Marys River known as Bell's Point. The Bell's Point East wetland is also comprised of three different site types including riverine at river mouth (30%), lacustrine at river mouth (60%) and lacustrine on enclosed bay, with a barrier beach (10%). The terrain of the wetland is undulating and the pH of the wetland waters were found to be acidic (pH <4.2). The soils within this wetland are thick and permeable; predominantly comprised of sand with about 5% which are humic/mesic. The wetland type was characterized as swamp (38%) and marsh (62%). This wetland was not highlighted as being significant to groundwater recharge based on its riverine and lacustrine nature; it was however given a score of 57 out 100 for its potential as an area of groundwater discharge.

2.4.1.1.3 Bell's Point West

Located on the shore of the St. Marys River west of the mouth of the Root River, this wetland is characterized as swamp (49%) and marsh (48%), similar to its east lying sister. The terrain is flat with a hummock-depression microtopography. The soils are thin and permeable, comprised mainly of sand. The evaluation described this wetland as intact, but that impairment of ecosystem quality was intense in some areas (MNR, 1992). Some iron precipitates were observed which may indicate groundwater discharge. The pH of the wetland was found to be low (pH<4.2). The wetland was rated 10 out of 30 for groundwater recharge potential and scored 27 out of 100 for groundwater discharge potential.

2.4.1.1.4 Shore Ridges

Shore Ridges is the other provincially significant wetland within the planning area. A map of the wetland is presented at WC Map 06A. This wetland was primarily evaluated as swamp (74%) with some fen area (25%) and a very small portion of marsh (1%). The soils are mainly sandy in nature (75%) with an additional component of humic/mesic soils (25%). The soils are thick and permeable. The wetland site is lacustrine with a barrier beach separating it from the St. Marys River. Some seeps and iron precipitates indicate that groundwater is in a discharge state. The wetland scored 30 out of 30 for groundwater discharge potential and was awarded no points for groundwater recharge.

The SSMRCA owns a large portion of this wetland. Recent subdivision development (along the St. Marys River on the barrier beach between the wetland and the riverfront) has introduced a dramatic change in the local landscape. A road has been constructed approximately along the perimeter of the wetland, delineating it from the beach heads which separate it from the shoreline. A number of drainage ditches have been constructed to convey water to the river. The ditches run perpendicular from the road to the shore line. A culvert joins the wetland to one of these drainage ditches. The flow through the culvert is controlled by a stop log structure.

2.4.1.1.5 Mary Ann Lake

This is a small palustrine wetland consisting of 54% swamp, 12% fen and 34% marsh area. The soils consist of 88% sand and 12% fibric soil. It is seasonally flooded. It was assigned a score of 30 out of 30 for groundwater discharge potential, and 27 out of 30 for groundwater recharge potential. It is hydrologically connected to a constructed drainage system surrounding the perimeter of the Sault Ste. Marie airport.

Table 2.4.2: Summary of Wetlands within SSMRCA watershed

Classification	Type of Wetland	%
Evaluated Wetland		1.52 %
	Swamp	1.14 %
	Marsh	0.12 %
	Fen	0.27 %
Unevaluated Wetland		4.59 %

WC Map 06: Wetlands
WC Map 06A: WetlandShoreridge
WC Map 06B: WetlandCarpRivers

2.4.2 Woodlands and Vegetated Riparian Areas

The majority of the planning area is undeveloped land, particularly outside of the Sault Ste. Marie city limits and away from the Highway 17 corridor. According to the Ontario Base Map (OBM) data, 73.15% of the planning area is designated as vegetation, which is analogous to wooded areas. The OBM data has been generated based on interpreted aerial photography captured between 1977 and 1996 (McKinnon & Conservation Ontario, 2006). WC Map 7 outlines the natural features of the planning area including the woodlands areas.

Though a definition of riparian areas is yet to be unanimously accepted by the scientific community, they are typically riparian areas are described as transitional zones between aquatic and terrestrial (upland) environments. They often share characteristics of both ecosystems. They occur as belts along rivers, streams and lakes (Baker, T., 2006). Typically perennial and intermittent streams can support riparian areas, whereas ephemeral streams which flow in response to precipitation do not. Ephemeral streams can't support the water loving vegetation characteristic of a riparian habitat. Riparian vegetation is unique in its high root density which supports stream banks, reduces risk of erosion and acts as a sediment trap. Streamside riparian vegetation also acts as a filter by absorbing excess nutrients and other pollutants before they enter the groundwater and surface water systems. Biochemical processes including nutrient and heavy metal uptake by plants and biodegradation by soil micro-organisms can remove pollutants carried in runoff before it percolates to the groundwater or flows to a streambed.

By maintaining natural vegetation in riparian areas infiltration rates are kept high and the vegetation's cleansing action ensures that water which recharges underlying aquifers has improved quality.

Within the municipal boundary, vegetated riparian areas are secured by provisions in the City of Sault Ste. Marie's zoning by law. The by law, amended in June 2005, introduced an Environment Management Zone which applies to creeks, ravines and wetlands that have been designated as Natural Resource and Constraint Areas in the City's Official Plan. The purpose of the zone is to protect the natural environment. Permitted uses are restricted to conservation uses. Building applications within these zones are reviewed on a site-by-site basis.

The Sault Ste. Marie Region Conservation Authority's Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses (O. Reg. 176/06) restricts development in areas within the SSMRCA jurisdiction along wetlands, shorelines, river and streams as well as valley lands within the jurisdiction of the SSMRCA. This regulation was passed into law in the spring of 2006. Funding to update digital maps of the regulated area is currently being sought. An engineered digital geodatabase model needs to be developed to fulfill the current regulation.

In general terms the regulation restricts development along the shore of Lake Superior, St. Marys River and inland lakes. The regulation protects the area within the 100 year flood level plus an additional allowance for wave uprush. In addition to lake shores, the regulation also establishes a 15 meter buffer zone back from the stable slope on either side of rivers or stream valleys whether they contain water or not. The regulation also restricts development in wetlands and their surrounding area. For provincially significant wetlands and wetlands greater than 2 ha, the buffer zone established is 120 m. For wetlands less than 2 ha, the restricted development zone is 30 m.

WC Map 7: Woodlands
WC Map 7A: Riparian Area (Modelled)

2.5 Aquatic Ecology

Aquatic species are often used as indicator of local water quality. These include fish and macroinvertibrates and their presence or absence often used to determine water temperature, water quality parameters and pollutants. For example, many species of trout are indicative of a cold or cool water stream while certain species of shiners are more indicative of warm water. Fish communities also serve as barometers of human health and well-being.

2.5.1 Fisheries

The Sault Ste. Marie Region Source Protection Area has a variety of watercourses in its jurisdiction including lakes, large rivers, streams, creeks and intermittent streams. Most, if not all of the streams in the Source Protection Area are classified as cold water streams (WC Map 8). Most of the headwaters originate in the recharge area. One of the main aquatic species indicators of water quality is brook trout (*alvelinus fontinalis)*. Brook trout do not tolerate large temperature changes, sediment build up or pollution. They are an indicator of good water quality. In most of our streams brook trout have been observed. Exceptions to this are Fort Creek and Clark Creek. Fort Creek has a build up of sediment and the water temperature appears to have been increasing over time (anecdotal information). Fort Creek has a rehabilitation potential and is being actively investigated by the Department of Fisheries and Oceans Canada. Clark Creek has no fish present; reasons at this point are unknown. Other water courses are listed below by name and the species of fish observed:

- Root River – brook trout, rainbow trout *(Oncorhynchus mykiss)*, and salmon species with fish observed to be moving upstream to tributaries for spawning
- East and West Davignon Creeks – brook trout, rainbow trout and could support salmon
- Bennett Creek – brook trout
- Crystal Creek – brook trout
- St. Marys River – salmon species, Chinook or King (*Oncorhynchus tshawytscha*), coho (*Oncorhynchus kisutch*), pink (*Oncorhynchus gorbuscha*), northern pike (*Esox lucius*), whitefish (*Coregonus clupeaformis*), yellow perch (*Perca flavescens*), small mouth bass (*Micropterus dolomieui*), walleye or pickerel (*Stizostedion vitreum*), sturgeon (A*cipenser fulvescens*), white suckers (*Catostomus commersoni*), carp (*Cyprinus carpio*), burbot (*Lota lota*), America eel (*Anguilla rostrata*), silver lamprey (*Lchthyomyzon unicuspis*).

According to a Ministry of Natural Resources past surveys, there are 26 fish species in the lakes, streams, and river system within the Source Protection Area. Rock bass and lake trout are the most abundant in these water systems and provide the most sport-fishing opportunities. Lakes, located at the upper north and west portion of the watershed are the major form of instream development. These lakes vary in surface area from 0.3 to 240 ha and include Heyden, Prince, Trout, Lower and Upper Island Lakes. When compared to other lakes within the Source Protection Area that have been sampled in the northern portion, Trout Lake is the deepest/biggest of the reservoir lakes.

Lake surveys, fisheries assessments and angler surveys have been conducted on twenty three (23) lakes in the Source Protection Area. These surveys provide information regarding lake morphological, chemical properties, fish populations, estimates of angling pressure and success.

Brook trout, rock bass and perch populations make up significant portions of fish communities in the Root River and Bennett Creek. Trout Lake is a significant fishery in this watershed. Besides brook trout, Trout Lake is dominated by common sucker, lake trout and shinner minnow species. Table 2.5.1 shows that white sucker is only found in Prince Lake. Brook trout, common sucker, lake trout and rock bass are found in all lake. Walleye, yellow perch, northern pike, lake herring, smallmouth bass, salmon, muskellunge, lake sturgeon, sea lamprey, prey fishes are commonly present in St. Marys River.

Organochlorine compounds, PCBs and pesticides, have never been identified in fish tissue in the SSM Watershed Region at levels exceeding the human consumption guidelines as recommended by the Ontario Ministry of Environment. High concentrations of Iron have been reported at some parts of the river systems.

No recent information is available on the evaluation of the fish toxicity and temperature studies in the watershed region. Lake surveys undertaken by the Ministry of Natural Resources reveal that in the Source Protection Area, most of the lakes are in the cool water category.

Cool water fisheries are dominant in the watershed and are scattered evenly throughout, supporting both sport and commercial fishing activities. Cool water species include northern pike, perch, lake trout and sucker. Warm/cool water species (walleye and northern pike) are also present. Cold-water species include various species of trout such as the lake, brook and rainbow trout. Fish species such as lake trout, brook trout, rainbow trout, perch, smallmouth bass, rock bass, splake, common sucker, white sucker, brook stickleback, lake chub, shiners minnows and brown bullhead were found in lakes within the Source Protection Area during MNR surveys.

Table 2.5.1: Fish Species within SSM Source Protection Area

Species	Heyden Lake	Prince Lake	Trout lake	Upper Island lake
Lake Chub			x	
Brook Trout		x	x	
Common Sucker	x		x	
Shinner Minnows	x		x	
Lake Trout			x	x
Northern Pike				
Perch	x			x
Red Fin			x	
Rock Bass	x	x	x	x
Brown Bullhead	x	x		
Smallmouth Bass	x		x	
Smelt				x
White Sucker		x		

In the Source Protection Area, cold-water fisheries are predominant in the Kelly, Lower Island and St. Joe lakes. Cold water fishery is also found in river and creek systems; the Root River, Big Carp River, East and West Davignon, Crystal and Bennett Creek. Most of this cold-water fishery potential is in the form of brook and rainbow trout. The habitat for these species includes streams and small kettle lakes.

Lake trout are only restricted in number since they usually must be relatively deep and large in size in order to maintain a viable population. In the Source Protection Area, lake trout was only observed in Trout Lake and Upper Island Lake. These are the dominant lakes with naturally reproducing populations. Although there are some other lake trout lakes, they are of reduced potential and are dominated by other species. Table 2.5.2 provides the list of cold, cool and warm water lakes, river and streams within the Source Protection Area.

The Watershed Plan Report, SSM Region Conservation Authority (SSMRCA, 1983) discusses various management programs regarding the over-harvest, production and regulation of fisheries in the watershed region. Stream fisheries habitat could be protected through the Authority's support of Ministry recommendations in the plan review process. Habitat protection may also be achieved through enforcement of the Authority's Fill and Alteration to Waterways regulations. Another report, "Sault Ste. Marie District Fisheries Management Plan, 1988-2000" (MNR, 1989) focuses mainly on more fish production, more angling opportunity, the local economy and a higher level of angling satisfaction.

No specific information is available in relations of fisheries management plans with water quality. However, the Fisheries Management Plan does refer to the loss of environmental quality and its impact on the fisheries habitat in the watershed region. Habitat loss and/or degradation result from natural phenomena ranging from mercury, other heavy metals, pollution and physical destruction or alteration of habitat. The loss of wetlands due to filling and dredging is a prime example of habitat loss or degradation.

Inadequate fisheries information makes it difficult to address some fisheries concerns such as the Pacific salmon stocking program, potential yield in the Great Lakes, and rehabilitation of fisheries. There is lack of information on population status and brook trout in many inland lakes, critical spawning and nursery habitat, and baitfish resources.

Table 2.5.2: Lakes, Rivers and Streams within SSMR Source Protection Area

Lakes	Temperature	Area (Km²)		Rivers	Temperature	Area (Km²)
Alexander Lake				Bennett Creek	Cool	22
Allard Lake				Big Carp River	Cool	58
Belleau Lake				Black creek		
Caribou Lake	Cool	0.05		Cannon Creek		
Crystal Lake	Cool	0.25		Central Creek	Cool	3
Finn Lake	Cool	0.28		Clark Creek	Cool	6
Heyden Lake	Cool	0.38		Cold Water Creek	Cool	3
Johnstone's Lake	Cold			Coldwater Creek		
Kelly lake	Cold			Crystal Creek	Cool	21
Lake One	Cold			East & West Davignon Creek	Cool	66
Lower Island Lake	Cold	0.54		Fort Creek	Cool	7
Mabel Lake				Kelly Creek		
Maki Lake	Cool	0.09		Leigh Bay Creek	Cool	7
McIntyre Lake				Little Carp River	Cool	21
Mable Lake	Cool	0.41		Root River	Cool	114
Moss lake				St. Marys River (small portion)	Warm	
Nettelton Lake						
Parts Lake						
Prince Creek						
Prince Lake	Cold	0.47				
Redrock Lake	Cool	0.03				
St. Joe Lake	Cold	0.003				
Syrette Lake						
Thielman Creek						
Trout lake	Cool	2.40				
Upper Island lake	Cold	1.52				
Walls Lakes	Cool					

2.5.2 Aquatic Macroinvertebrates

Aquatic Macroinvertebrates such as dragonflies, mayflies and snails, have been used successfully to assess the quality of rivers, streams and lakes water. Narrow tolerance ranges for specific environmental characteristics make the prevalence of particular species indicative of water quality. At the present time the Ontario Benthos Bio-Monitoring Network is being developed by the Sault Ste. Marie Region Conservation Authority for the Source Protection Area to fill the current data gap.

2.5.3 Species and Habitats at Risk

Knowledge of species at risk of extinction in a watershed area is important to Source Protection Planning. For example, the occurrence of any aquatic species that may be at risk can suggest the presence of unique habitat characteristics that should be taken into account in the Source Protection Plan.

Generally, there are two trends that are believed to occur regarding species and ecosystem complexity. Firstly, as latitude increases or the variety of topographical features decrease, the variety of species and/or ecosystems should decrease. Secondly, landforms and/or landscape become more homogeneous moving from south to north. As the landscape with its landforms become more homogeneous, the variety of adaptations required in this environment decreases, thereby, less species and/or ecosystems are necessary to fill this environmental niche.

As a result, species and/or ecosystem complexity in the Transitional zone of Great Lakes-St. Lawrence Region and Boreal Shield, is perceived to be simple and so consequently species may be increasingly vulnerable to disturbance. However, there is scientific uncertainty regarding the “true” vulnerability of a species. Ecologically rare species may have adapted resilience and/or resistant characteristics, allowing their survival within natural disturbance cycles such as fire, storms, predator/ prey relationships, or unnatural disturbance cycles including fragmentation on river systems due to dams. On the other hand, if a species, whether rare or common, become threatened by a threatening process and is unable to adequately adapt to these environmental changes then the species will likely become vulnerable, threatened and/or endangered

With respect to species vulnerability, the following list of species from the Ministry of natural Resource are of concern or threatened within the Sault Ste. Marie Region Source Protection Area

- Lake Sturgeon (Threatened)
- Peregrine Falcon (Threatened)
- American White Pelican (Threatened)
- Bald Eagle (Special Concern)
- Milksnake (Special Concern)
- Monarch Butterfly (Special Concern)
- Golden-winged Warbler (Special Concern)

2.5.4 Invasive Species

The introduction of certain species to the aquatic environment carries specific implications of water quality. For example the impact of imported species such as common carp (*Cyprinus carpio*) and zebra mussel (*Dreissena polymorpha*) have had on lakes and rivers throughout Southern Ontario.

Invasive/exotic species are a problem in the Great Lakes in general. The Lake Superior ecoregion shares most of the common invaders and the threats they pose for the Great Lakes and the native habitant species. The invaders can displace native organisms by food competition, have exponential growth rates due to lack of natural predators, they take over/destruct habitat which ultimately results in the decline of native species, a lack of diversity, alteration of the native food web and a dwindling balance of the ecosystem. There are a number of exotic species that can vary in their destructive nature to the lakes.

Below is a list of the invasive plant species found within the Source Protection Area:

Alliara petiolata	Garlic Mustard
Phragmites australis	Common Reed
Myriophyllum spicatum	Eurasian Watermilfoil
Lythrum salicaria	Purple loosestrife
Vinca minor	Common periwinkle
Echium vulgare	Blueweed
Polygonum cuspidatum	Japanese knotweed
Phalaris arundinacea	Reed canary grass
Melilotus alba	White sweet clover
Cirsium arvense	Canada Thistle

(Source: Invasive Species Research Institute, Sault Ste. Marie)

2.6 Human Characterization

2.6.1 Population Distribution and Density

The Source Protection Area is comprised of the municipality of Sault Ste. Marie and the Township of Prince and includes portions of the townships of Dennis, Pennefather, Aweres, Jarvis and Duncan as well as areas of the Garden River and Batchewana First Nations. Discrete population data is available for the city of Sault Ste. Marie, the Township of Prince and the Garden River First Nation and is presented in this section. The other areas however, have been included in Statistics Canada's 2001 and 2006 Census Study under the area of "Algoma, Unorganized, North Part", which comprises the northern section of the District of Algoma which stretches north beyond the Source Protection Area. For this reason, this information has not been presented. The majority of the population in the Source Protection Area is within the immediate area of the City of Sault Ste. Marie which consists of over half of the planning area's geographical area, therefore the data presented provides a general description of the population of the Source Protection Area.

Table 2.6.1 below gives a snapshot of the population in 2001 for the City of Sault Ste. Marie, the Township of Prince and the Garden River First Nation as displayed in WC Map 9. According to the Statistics Canada, the population of the City of Sault Ste. Marie in 2001 was 74, 566, which represented a 6.9% decline from the 1996 population of 80, 054. In contrast to this decrease, the population of Prince Township increased from 971 in 1996 to 1010 in 2001. This change represents a 4% increase over the five year period.

Table 2.6.1: Comparative Census Statistics for Sault Ste. Marie, Prince Township and Garden River First Nation.

	Population 1996	Population 2001	% Change	Population 2006	% Change	Area (sq.km)	2006 Population Density (sq.km)
City of Sault Ste. Marie	80,054	74,566	-6.9	74,948	0.5	221.71	338
Prince Township	971	1,010	4.0	971	-3.9	89.81	11
Batchewana First Nation (Rankin 15D)	N/A	N/A	N/A	566	N/A	15.31	37
Garden River First Nation	N/A	859	N/A	985	14.6	166.86	6

The population density for the Algoma District area which includes the Source Protection Area is illustrated in Table 2.6.1. As is to be expected, the highest population density is centered on Sault Ste. Marie and decreases radically out from the city. The population is also moderately concentrated (i.e. 10 to <50 persons/km^2) north of the city along the Trans Canada - Highway 17 North corridor. The area shaded blue-green north of the city on the coast of Lake Superior represents the community of Goulais. The community is concentrated around the mouth and valley of the Goulais River which is the northern neighbouring watershed of the St. Marys River watershed.

Figure 2.6.1, Figure 2.6.2, Figure 2.6.3 and Figure 2.6.4 outline population distributions for Sault Ste. Marie, Prince Township, Garden River First Nation and Batchewana First Nation.

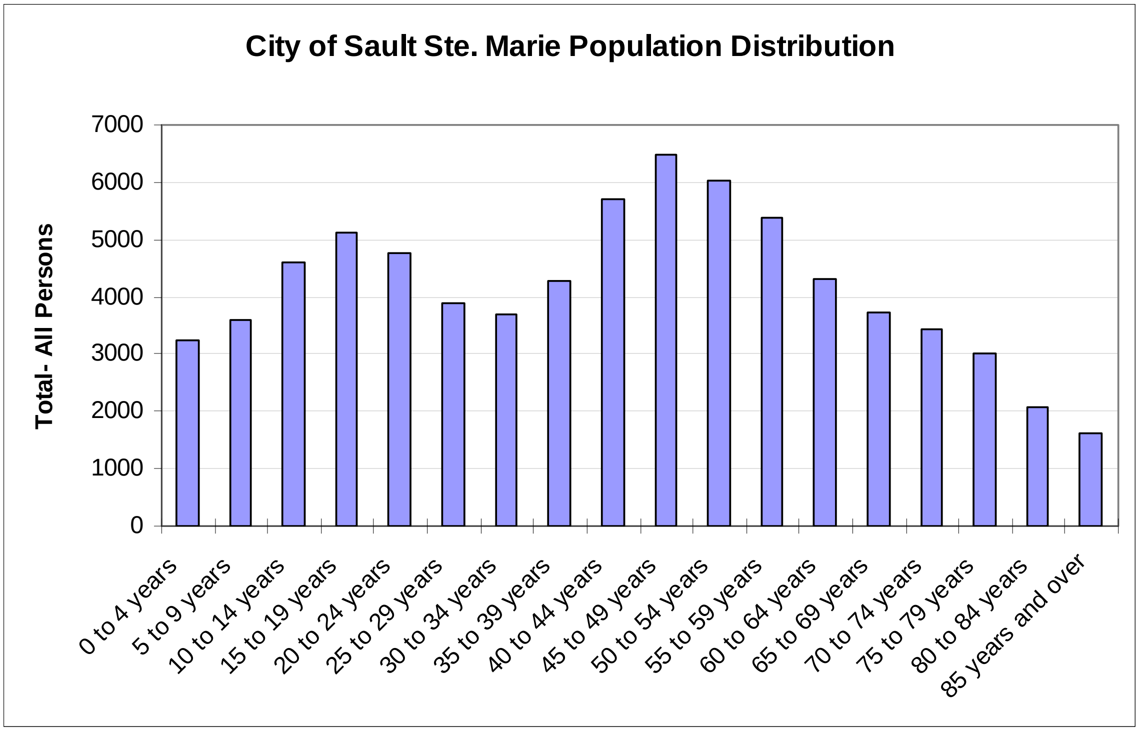


Figure 2.6.1: City of Sault Ste. Marie Population Distribution (2006 Census)

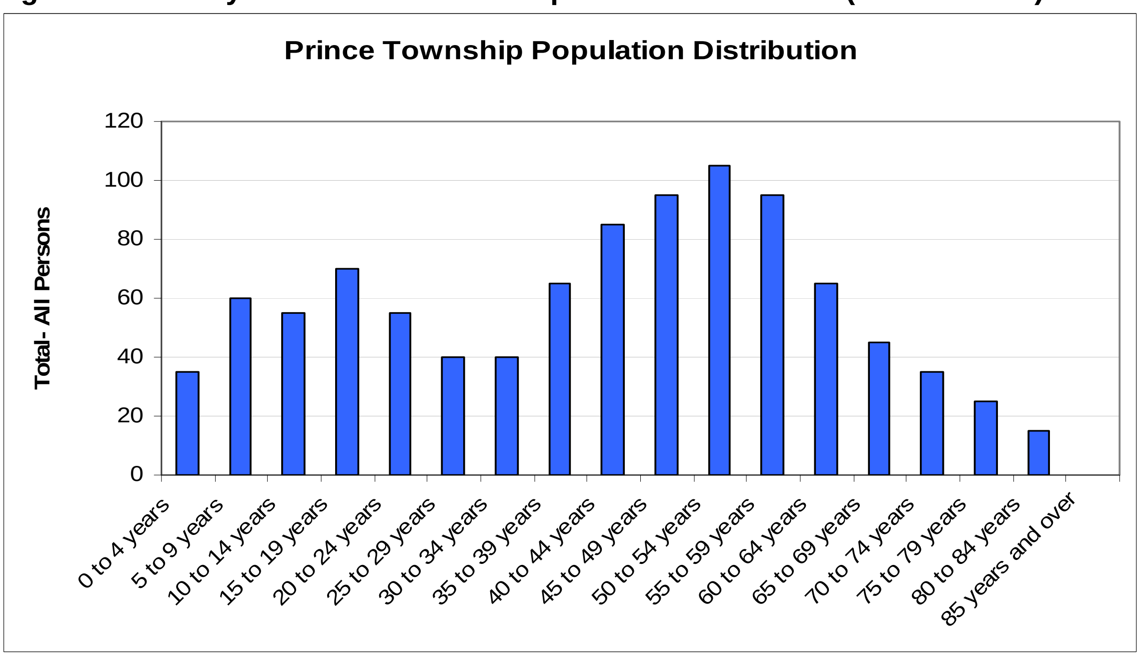


Figure 2.6.2: Township of Prince population distribution (2006 Census)

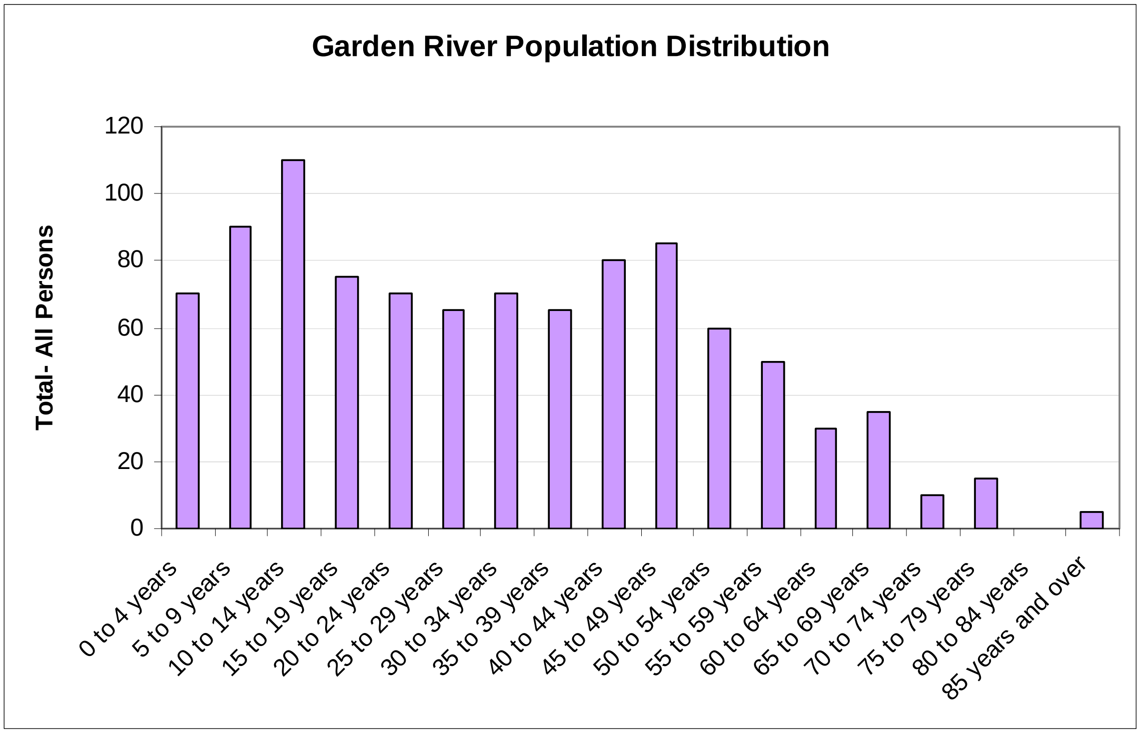


Figure 2.6.3: Garden River First Nation Population Distribution (2006 Census)

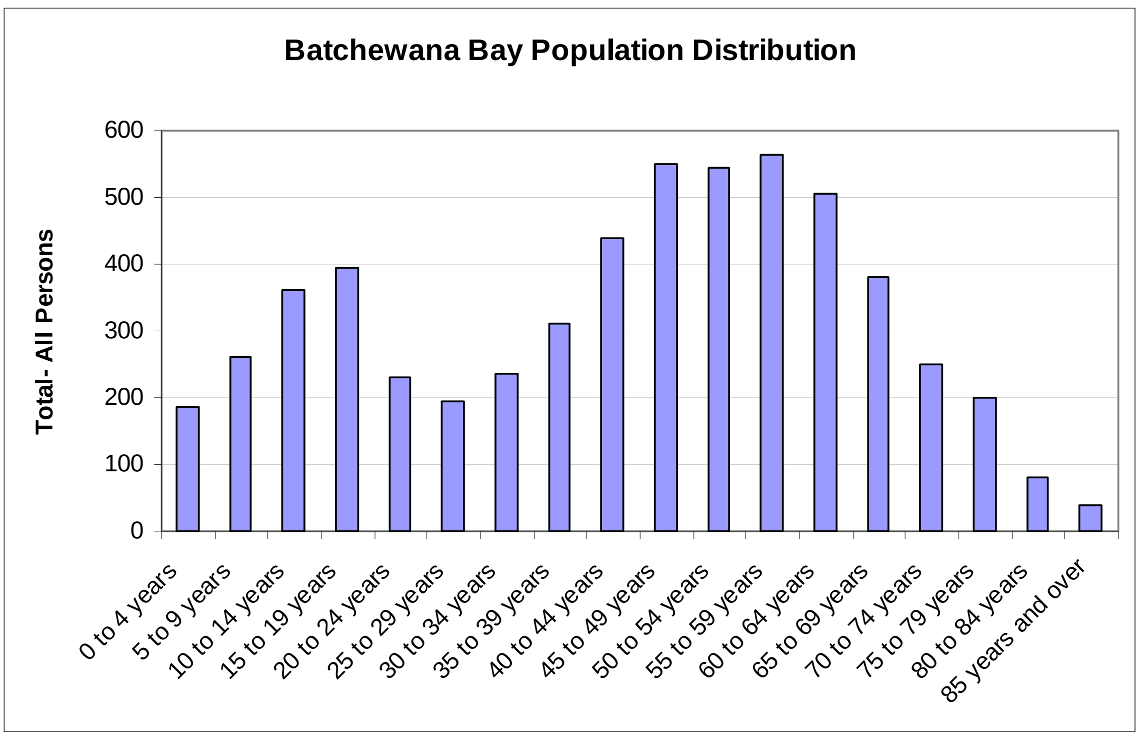


Figure 2.6.4: Batchewana First Nation Population Distribution (2006 Census)

In May 2006, the City of Sault Ste. Marie completed a Population, Household & Labour Force Forecast which was conducted by Hemson Consulting Ltd. The study's population projections from 2001 to 2026 are outlined in Table 2.6.2. The investigation was carried out as a result of the City's wish to expand the urban boundary. The Provincial Policy Statement stipulates that municipalities wishing to expand their urban settlement areas must undergo a comprehensive review.

Table 2.6.2: Sault Ste. Marie population forecast.

Sault Ste. Marie Population Forecast			
Year	**Population**	**Growth**	**Net-Migration**
2001	74 600 (74 566)**		
2006	73 400 (74 948)**	-1 200 (382)**	-800
2011	72 600	-800	-300
2016	72 700	100	700
2021	74 300	1 600	2 200
2026	75 700	1 400	2 200

Source: Statistics Canada & Hemson Consulting Ltd., 2006
*** Census Canada Actual Figures (2001 and march13, 2006)*

The report predicts that the population will continue its slow decline until 2016. By 2026, Hemson expects that the population will again rise to above the 2001 level. The historical population decrease leading up to 2001 has been attributed to the down turn of the economy in the late 1990's. In recent years, there has been resurgence in the economy and the workforce has stabilized. Population decline is expected to taper off leading up to 2016 at which point population growth is predicted. Figure 2.6.5 illustrates the predicted population distribution for 2026 (Hemson, 2006).

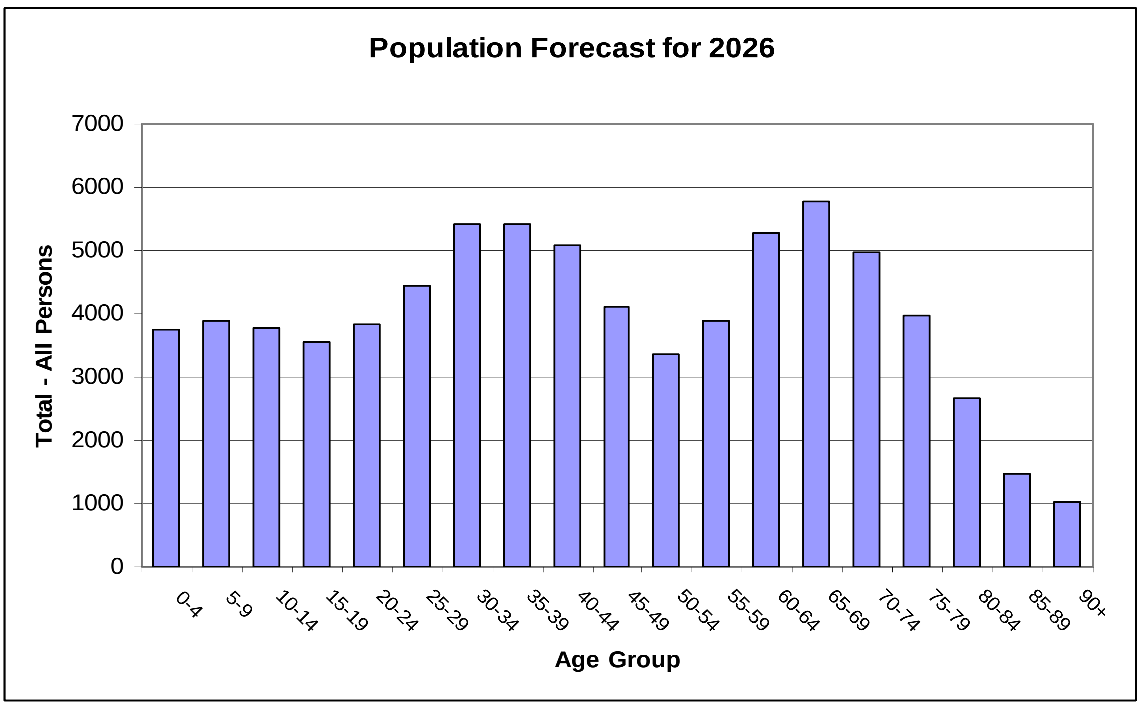


Figure 2.6.5: Sault Ste. Marie population forecast for 2026 (Hemson, 2006).

Despite the expected decrease in population over the next decade, the study predicts a demand for new housing in the near future. This demand is thought to be driven by the population aged 30 and older. The city's strengthening incomes are due to the growing economy combined with an aging population has resulted in more individuals becoming active in the housing market. For example, employment in 2005 reached 37,100, the highest it has been since 1991. Figure 2.6.6: Sault Ste. Marie Unemployment Rate (Hemson, 2006) illustrates the unemployment rate from 1987 through to 2006. In addition to this, the number of building permits issued by the Sault Ste. Marie hit a low in 1999 but has been on the increase since 2001 as illustrated by Figure 2.6.7. The Hemson study also noted that the out-migration from the city tends to be young people under the age of 30 who tend to be less involved in purchasing homes. (Hemson, 2006)

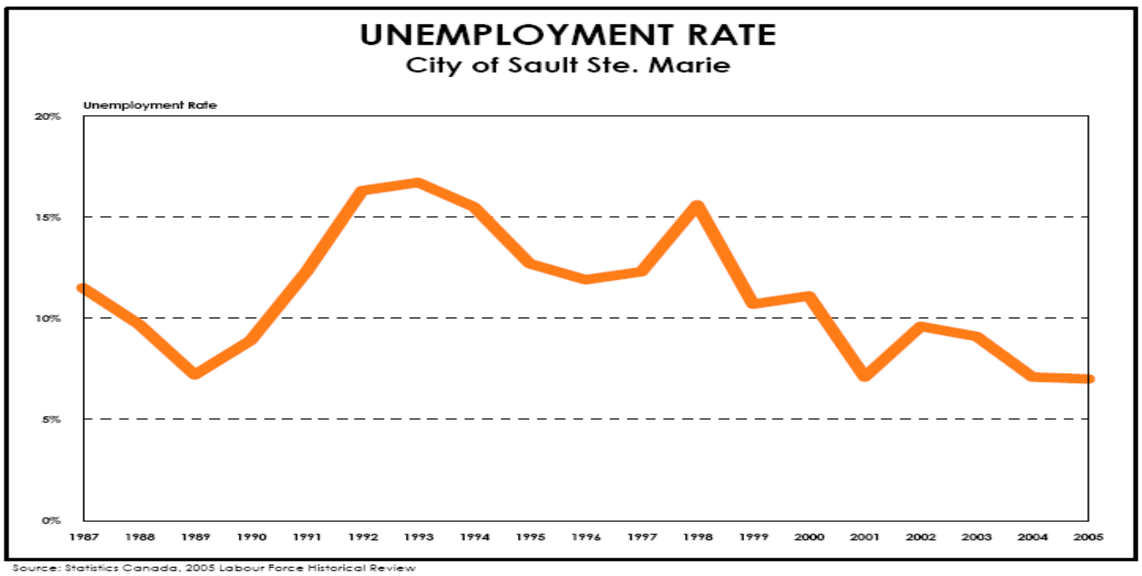


Figure 2.6.6: Sault Ste. Marie unemployment rate (Hemson, 2006).

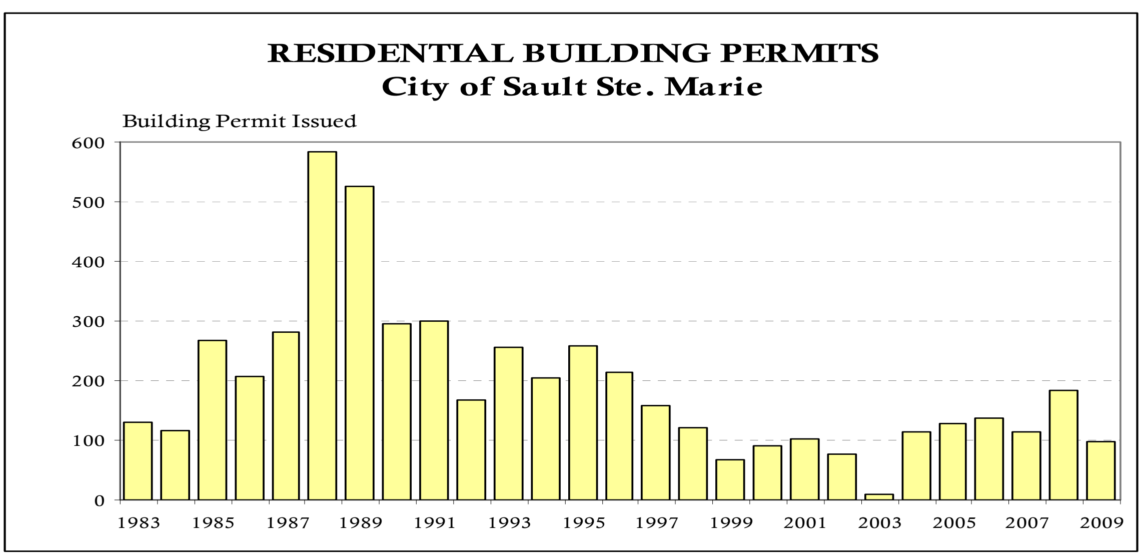


Figure 2.6.7: Building permits issued by the City of Sault Ste. Marie (SSM)

In summary, within the Source Protection Area no significant increase in population is expected over the next ten years. It is more likely that the population will continue to decline, but at a slower rate than the previous ten years. Mild population growth in the region may occur after 2016. The current growth trend in residential dwellings is not expected to impact water use significantly within the planning area.

2.6.2 Land Use

Studying land use within the Source Protection Area plays a significant role in identifying present and future impacts on source water quantity and quality. Being situated on the Great Lakes, the land use and development within the Sault Ste. Marie area has been shaped by the area's physical setting. Within the municipal boundary of Sault Ste. Marie, land use is represented by the City's most current Official Plan which came into effect in 1996 and was revised in 2003. WC Map 10 outlines the land use as prescribed by the zoning by-law which was revised in 2005. The land use (zoning) codes used on WC Map 10 are explained in Table 2.6.3.

Table 2.6.3: City of Sault Ste. Marie Land Use Codes.

Code	Land Use
C	Commercial
CT	Commercial Transitional
EM	Environmental Management
HZ	Highway Zone
I	Institutional
M	Industrial
PR	Parks and Recreation
R	Residential
RA	Rural Area
REX	Rural Aggregate Extraction
RP	Rural Precambrian Uplands

The land use of the Source Protection Area is presented in WC Map 10. Most development and the majority of the population are in the City of Sault Ste. Marie, along the north shore of St. Marys River on the lowlands. Other small communities are found along the northern shore of Lake Superior, on the Precambrian uplands and along the Hwy 17 North corridor. The Census data taken from Statistics Canada shows that the population in Sault Ste. Marie in 1996 decreased in 2001 and increased slightly in 2006; the stability in population suggests that future changes to the present land use will be limited. It is estimated that the urbanized area accounts for approximately 9.8% of the overall planning area. This includes residential, industrial, commercial and institutional uses. The remainder of the area is mainly composed of rural, sparsely wooded, or scrub.

The boundary of the Source Protection Area extends out to the international border along its entire width. The land-based area of the planning area is 522 km^2. The City of Sault Ste. Marie and the rural residences outlying the city limits located north of the shore of

St. Marys River on the lowlands is the main urban area. The urbanized area accounts for approximately 9.8% of the overall planning area.

Land cover for the Source Protection Area is shown in WC Map 10. The remainder of the Source Protection Area is comprised of a combination of water bodies, vegetation in the form of woodlands and scrub and land suitable for agricultural (Land Use – Canada Land Inventory, 1966). The estimated area of woodland was 71.5% (productive woodland), the area for scrub was 6% (non productive woodland) and the area suitable for agriculture was 9% of the overall planning area.

WC Map 10: Land Use

2.6.3 Settlement Areas

Settlement areas are the built-up areas of urban and rural municipalities and the lands that have been designated for future development in an official plan. The City of Sault Ste. Marie is located in a river valley setting, with its most prominent physical feature being the Lake Superior and St. Marys River shorelines. The river originally provided food resources for a permanent First Nation settlement approximately 4000 years ago. The river became part of the French Canadian "voyageur" route in the 1600's, aiding European exploration of this part of the North American continent and development of the fur trade. Today, the TransCanada Highway (locally Hwy 17) passes through Sault Ste. Marie and forms a major transportation corridor for forest products and minerals from the West and North to other parts of Canada and for exports to the United States.

The Original "City Plan" was surveyed for the north side of the St. Marys River in 1846, marking the beginning of urban development on individual land holdings. The settlement reached the status of a "town" in 1887, having a population of 1 600 people. The Canadian Pacific Railway had also reached the Sault by this time, with a link across the river to the American railways.

The industrial era of F.H. Clergue began in 1894, by which time the pulp and steel mills were established. The first hydroelectric stations and the Canadian Locks on the St. Marys River were also built about this time. Essar Steel Algoma Inc. had become Canada's second largest steel plant by the end of the Second World War, and the City's population had reached 40 500 in 1951 (Source: Stats Canada). The increasing demand for steel and mineral products after the war led to a rapid increase in population to 65 560 by 1961. This resulted in much of the downtown waterfront being used as an industrial transfer point for coal, oil, lumber, and passenger traffic. Numerous large bulk fuel storage facilities existed along the waterfront to support the harbour traffic.

Gravel extraction activities have also been conducted throughout the development of the City. The majority of these were small operations, occurring whenever sufficient gravel resources were located, with a total of 88 pits being identified. These areas included the southern margin of the Precambrian uplands, as well as along the Hwy. 17 and ACR corridors north of the City as shown in WC Map 10A. In 1985, there were 22 licensed properties, all located on the southern margin of the uplands; currently six major operations continue production. Production was approximately 800 000 tones around 1980, dependent on the level of construction activity. In addition, sand and gravel have been extracted from the St. Marys River since the 1940's using a dragline (Aggregate Resources Inventory of the Sault Ste. Marie Area, Algoma District; MNR 1985).

In addition to quarry operations, logging has been a major industry of the Sault Ste. Marie area since settlement of the area began. The town is a major transfer point of pulp logs for regional paper mills.

The community underwent a major restructuring in the 1960’s and 1970’s. During this period, the Townships of Korah and Tarentorus were amalgamated into the Corporation of Sault Ste. Marie, transportation links were improved with the Trans Canada Highway and Federal airport being constructed, and access to the markets in the U.S. was improved with construction of the International Bridge in 1962. The construction of this bridge and retirement of the passenger vessel M.S. Norgoma in 1963 completed the shift from water based to land based transportation for the community.

The population of the City reached 80 000 by 1980, with Algoma Steel employing 11 500 workers or one third of the City’s work force. However, long-term economic growth came to a halt in 1982, when changes in the global economy resulted in large layoffs at the steel mill. Based on the declining employment base, the population peaked at 83 270 in 1983 (Municipal Handbook, page 52) and then began to decline. Current population of the City is 74 960.

Settlement patterns indicate that population growth has become concentrated in conjunction with the larger service centers as well as linearly along the major transportation links. Although, there is a certain percentage of the population that is scattered throughout the watershed living on farms, in logging camps and various remote sites, the trend in recent years has been for these people to centralize and relocate within the City’s limits. However, this trend has been offset by an expansion of the population into rural areas where year-round cottages and country residences are increasing in numbers.

2.6.3.1 Designated Growth Areas

Economic activity within the Sault Ste. Marie (SSM) watershed will dictate the type and extent of future land use. Projections show further increases in basic employment, namely in the primary industries of manufacturing and non-basic employment, in the commercial and service sectors.

With the population of SSM expected to grow, increased pressure will be put on residential and commercial development both within the present urban core as well as the urban fringe. At present, the majority of the plans of subdivision, several of which have already been filed and approved, are slated for the West and East fringe of the City. Further increases in commercial space will be accommodated within the downtown core as well as along the major traffic corridors, especially Highway 17 East and North. This space will also be supplemented by industrial parks.

Expansion in the agricultural sector is expected to be limited. Future demand can be accommodated on west side of Sault Ste. Marie and private lands adjacent to existing farming areas in west and east of Hwy 17. Projected increases in population and leisure time activities will place greater demands on outdoor recreation opportunities. Camping, fishing, hunting and skiing will contribute to a more extensive use of wilderness areas, while picnicking, swimming and hiking will focus on the urban and near-urban resources.

With the continued expansion of the primary industrial base of the region, demand on natural resources will increase. Aggregate production near the urban centers will see a greater use of the sand and gravel deposits areas. These pressures will be felt especially within those areas presently in production such as on the northerly portions of the watershed in SSMRCA.

2.6.3.2 Rural Areas

Since it is anticipated that there will be little or no growth in rural areas, there should not be much of an increase in the future water needs for this portion of the watershed. As well, there is little potential for converting farmland to non-agricultural uses.

2.6.3.3 Urban Residential Development

Characteristic of the urban structure of the City of Sault Ste. Marie is the concentration of residential, commercial and industrial land uses within the city boundaries. The result is a mixture of urban land use within a relatively restricted area. Residential areas have also expanded into the urban fringe areas, intermixed with the more rural type land uses. Throughout the watershed are smaller urban communities directly associated with the railways, aggregate extraction or farming.

2.6.3.4 Rural Residential

The 2001 Census shows that 5.50 % (4 342) of the Source Protection Area population lives in rural areas. It is anticipated that there will be little or no growth in these rural areas. As has been noted, there is very little potential for converting farmland to non-agricultural uses. As such, there should not be much of an increase in the future water needs for rural areas.

2.6.3.5 Cottage and Camp Development

In the Source Protection Area, the population does not increase significantly seasonally. There are 8 Cottage Associations and Tourist Outfitters in the Source Protection Area. A very small percentage of the watershed area has been allocated to accommodate cottage development. There are 3 sites allocated within SSMRCA for cottage and camp development, which are a) around Prince Lake, b) Pointe des Chênes and c) Red Rock. The percentage of cottage development within the Source Protection Area is low.

2.6.3.6 Industrial / Commercial Sectors Distribution

There are some commercial land use activities that continue to be dominant in the downtown core, north, west and east of the City along the Hwy 17 Corridor. Most of the expansion is currently occurring along the main transportation corridors (Hwy 17). On the other hand the industrial activity, consisting mainly of manufacturing and Essar Steel Algoma Inc., which are generally confined to the urban fringe.

2.6.3.7 Managed Lands

Managed Land means land to which agricultural source material, commercial fertilizer or non-agricultural source material is applied. (Technical Rules: Assessment Report, Clean Water Act, 2006 Part I.1).

The percent managed land was calculated based on the zoning that the City of Sault Ste. Marie had in place including rural area, parks and recreation, environmentally managed, aggregate extraction, residential, commercial, industrial, institutional, highway zone, Precambrian and miscellaneous. In the case of the Township of Prince the categories of Summer Cottage, Hamlet and Rural Residential were grouped as residential, Shield was defined as Precambrian and Commercial as commercial.

From the resultant zoning layer the rural area (potential farm land) and parks and recreation would be calculated on a land base of 80% of the total. The resultant layer would then have the percentages applied using the example within the Technical Bulletin: Managed Lands and Livestock Density, December 2009. For example the rural area (remaining portion is likely to be vacant land) to be applied at 5%, environmental managed at 0%, aggregate extraction at 0%, residential at 20%, reflective of a City of Sault Ste. Marie pesticide/herbicide prohibition bylaw, commercial at 20%, industrial at 20%, highway zone at 20%, institutional at 20%, Precambrian at 0% and miscellaneous at 30%.

Table 2.6.4 displays the Rural Area, Parks and Recreation, Residential and Other for the Total Managed Lands and the Percentage of the Vulnerable Area.

The Other column includes the zoned areas of environmentally managed, aggregate extraction, Precambrian, commercial, industrial, highway zone, institutional and miscellaneous. Managed Lands are illustrated in WC Map 21Ba and WC Map 21Bb.

Table 2.6.4: Managed Lands within Sault Ste. Marie

Vulnerable Area	Rural Area (km²)	Parks and Recreation (km²)	Residential (km²)	Other (km²)	Total Managed Lands (km²)	%age
SGRA	2.453496	5.941559	0.296268	0.531591	9.222914	22.85
HVA	2.18371	5.11426	0.600543	3.130248	11.028761	7.17
WHPA A	0	0	0.017421	0.006354	0.023775	18.73
WHPA B	0.020088	0.110143	0.2053	0.044154	0.379685	13.7
WHPA C	0.150956	0.0027	0.159066	0.139026	0.451748	11.7
WHPA D	0.155144	0.841093	0.305062	1.191504	2.492803	26.76
IPZ 1	0.000351	0	0.005808	0.001047	0.007206	6.65
IPZ 2	0.004006	0	0.04996	0.001033	0.054999	4.85

2.6.4 Brownfields

Brownfields are defined as those sites where industrial and commercial activities have occurred historically in the past and must be rehabilitated before they can be redeveloped. In the City, brownfields are associated with Essar Steel Algoma Inc. The largest brownfield in the area is the tailing or private dump of the Essar Steel Algoma Inc. on the western portion of the Essar Steel Algoma Inc. property.

2.6.5 Landfills

The sites consider for solid waste disposal are known as landfills. In 1998, the Ministry of the Environment released standards, which apply to all new and expanding landfill sites, to regulate the size, location and operation of these facilities. The nature of these facilities naturally makes them a potential threat to surface and groundwater quality if managed maintained or designed incorrectly.

2.6.5.1 Existing

Solid waste disposal in the City is restricted to sanitary landfill sites. Site selection, development and use are carried out under Ministry of the Environment guidelines so as to ensure minimal contamination of surface and subsurface water resources.

The Ministry of the Environment maintains a database of all known active and closed landfill sites in Ontario. This includes information on transfer stations and processing locations. Based on the database, there is one municipal landfill site and one private landfill on file in the City. The municipal landfill is located in the former Township of Tarentorus, Algoma District. A private landfill and a sludge disposal area are located on the property of Essar Steel Algoma Inc. The MOE database also identifies nine transfer stations. Based on the discussions with the City staff, there are a few closed (unlicensed) dumpsites in the study area. The actual location of these dump sites is not documented. The currently operating landfill site is shown in WC Map 10.

The city landfill was privately operated from the early 1950's to the early 1980's. The Municipality of Sault Ste. Marie has operated the landfill since the early 1980's, with both solid waste and sewage sludge from the City's water pollution control plant land filled at the site. The City's waste management program includes refuse collection, recycling programs, and sanitary landfill management. It is reported that the recycling, coupled with the municipal composting initiative, have quantifiably reduced the volume of material coming to the Municipal Landfill Site, potentially extending the life of the site.

In recent years, hazardous materials such as used batteries and refrigerators are collected and disposed of in a safe manner. Used tires and gas cylinders are collected and sold as scrap. Wood waste is collected and reused as fuel and bi-products. Leaves are collected and deposited at a licensed composting facility at the landfill.

2.6.5.2 Proposed

In order to ensure adequate disposal capacity for the community, the City of Sault Ste. Marie has initiated a Waste Management Environmental Assessment. All options for waste disposal are being considered including landfill expansion and mining waste to energy, increasing recycling and transport of waste to other facilities

2.6.5.3 Abandoned

Landfill facilities that have reached their capacity are formally closed and decommissioned using the guidelines provided by the Ministry of the Environment. These closed sites are designated as abandoned landfill facilities and are recorded by the Municipality.

Two such facilities in the City of Sault Ste. Marie have previously been closed. There is one inactive landfill west of the presently active landfill site. At present, there is no information available about its cleanup and/or closure process. There was an abandoned incinerator site in the Huntington Park area in the east end of the City. No information is available regarding dump sites located within Prince Township.

2.6.6 Mining and Aggregate Extraction

There is a Provincial Policy Statement that requires the City to protect mineral resources. The major mineral aggregate resource in Sault Ste. Marie is sand and gravel. Aggregate resources are used in almost all construction projects. Aggregates are a non-renewable resource that must be protected for future generations. Care must be taken to ensure that the environmental and social impact of mineral resource extraction is minimized. To this end, extractive operations must maintain good operating standards as well as have a viable rehabilitation plan.

At present, there are a number of gravel extraction pits along the sand and gravel resources area (or the recharge area) to the north of the City of Sault Ste Marie. Also, the Municipal Landfill is located within this area. A part of the area is zoned as residential and some industries are also located within the recharge area. This may include portable asphalt plants together with other uses associated with a sand and gravel extraction operation.

2.6.7 Oil and Gas

There are no oil or gas reserves within the SSMR Source Protection Area.

2.6.8 Forestry

Forest resources and their proper management also contribute to the enhancement of the watershed's wildlife and recreational potential. To date, forest management is implemented under a number of acts of legislation, including the Crown Timber Act administered through the Ministry of Natural Resources. Although a large proportion of the land area located within the watershed is Crown Land and managed by the Province, most urban and near urban land resources are under private tenure, set aside for urban, industrial and agricultural purposes.

The forest resources of the Source Protection Area form an integral part of the watershed's physical and biological environment. They also play an important role in the economic and social stability of the City of Sault Ste. Marie and the outlying communities surrounding it. The forestry industry contributes significantly to the local economy. A well-managed forest resource will ensure the economic viability and growth of the region. Employment statistics and economic profiles reflect the importance of forest products as a regional export and the industry as a large employer of the local work force.

Forest Management Plans (FMP's) are in place for the northern portion of the Source Protection Area. The FMP's summarize the future strategies, targets and objectives of the forest company. The FMP's outline the forest company management activities for operations, harvestings and silvicultural systems that are to ensure the sustainability of the forest resource.

The major forest company in the Sault Ste. Marie area is Clergue Forest Management Inc. Currently, there are a number of forest industries and no forest operations existing within the boundaries of Source Protection Area.

2.6.9 Transportation

The major highways located within the Source Protection Area are Highway 17, Highway 550 and Highway 556. These highways connect the region to the Trans Canada Highway, namely Highway 17 to the north and Highway 17 to the East. Locally serviced roads provide access to residential and recreational areas outside of the urban area of Sault Ste. Marie. There are numerous forest access roads throughout the region that provide access to the area's many rivers and lakes.

The Huron Central Railway (formerly CP Railway) passes through Sault Ste. Marie, crossing the southern portion of the watershed region from Sault Ste. Marie to Sudbury. The Huron Central rail line is located within the Wellhead Protection Area B (WHPA-B) of the Shannon well field and within the WHPA-C of the Lorna well field. The Algoma Central Railway (CN Railway) connects Sault Ste Marie to the U.S. and north to Hearst.

The City of Sault Ste. Marie is serviced by the Sault Ste. Marie Airport Authority. The airport is located in the western portion of City.

2.6.10 Wastewater Treatment

Two wastewater treatment facilities are located in the Source Protection Area. One of these is located in the east side of the City of Sault Ste. Marie and one in the west end of the City. These facilities have Certificates of Approval from the Ministry of the Environment. These C of A's provide the application number, the certificate granted date, ownership, location and capacity of the treatment facilities. The Certificate details the frequency, timing and water quality parameters for the discharge of treated water into the adjacent surface water. The Certificate also includes a number of conditions that must be complied with.

Currently, data and reports are not available from Essar Steel Algoma Inc. and St. Marys Paper Ltd. about their effluent discharged into water bodies.

2.6.10.1 East End Wastewater Treatment

The Sault Ste. Marie East End Water Pollution Control Plant (WPCP) is located at 2221 Queen Street East. It is a secondary treatment facility that discharges treated effluent to the St. Marys River.

The International Joint Commission's Great Lakes Water Quality Board Identifies the St. Marys River as an Area of Concern and a Remedial Action Plan (RAP) is in place. There has been previously two studies (Wm. R Walker Engineering Inc, 2002 and Earth Tech Canada Inc et al, 2003) undertaken to upgrade this WPCP. The plant was upgraded in 2006 from primary treatment to secondary treatment and is the first large sewage treatment plant in Ontario utilizing the Biological Nutrient Removal process.

The outfall sewer is 1 600 mm diameter constructed from high density polyethylene (HDPE) pipe, extending from the plant site approximately 100 m into the St. Marys River channel to a water depth of 5.3 m to 8.3 m, terminating in a staged diffuser arrangement. The plant is designed to handle up to 171 ML/d maximum inflows which are treated through primary clarifiers, secondary treatment, UV disinfection and finally discharge through the outfall.

2.6.10.2 West End Wastewater Treatment

The west end plant is designed to provide conventional activated sludge treatment for a design capacity of 20 ML/d (20 000 m^3/d). Domestic waste from the city flows to three main lift stations, located at 291 John St. Station, 800 Young St. and 55 Allen Side Rd. (Main station), which directs the flow into plant. The wastewater flow is measured and recorded prior to screening and degritting. The screened flow is mixed with wastewater activated sludge from the secondary clarifiers and directed into the primary clarifiers for co-sedimentation.

Settled sludge from the primary clarifiers is transferred to holding tanks for dewatering before being transferred to the landfill. Next, the primary effluent is introduced into the aeration tanks with return activated sludge for biological processing. The aeration tank effluent is dosed with alum to aid in phosphorous removal and is sent to secondary clarifiers. The clarifier effluent is chlorinated from May 1st until October 31st (As described in the Certificate of Approval) and discharged to the St. Marys River. Table 2.6.4 reflects the total annual flow discharged into water bodies (St. Marys River)

Table 2.6.5: Effluent Discharged into the St. Marys River

Waste Water Treatment Plant	2001	2002	2003	2004	2005	2006	Mean annual (m^3/year)
East End WPCP			5,359,040[1]	10,042,470	9,525,510	9,663,439	9,743,806[2]
West End WPCP	3,390,860	3,060,688	1,491,534* +2,412,542 =3,904,080	4,742,124	3,907,677	4,763,187	4,763,187[2]

*(1st quarter report), PUC Services took over the wastewater operation in July of 2003.
[1] Partial data for the year.
[2] Mean annual based on the data from 2004 to 2006.

WC Map 10: Land Use
WC Map 10A: Aggregates
WC Map 11: Municipal Service
WC Map 12: Municipal/Communal Wastewater Treatment Facilities
WC Map 21Ba: Managed Lands Nutrient Application
WC Map 21Bb: Managed Lands Non-Agricultural

2.6.10.3 Serviced Versus Non-serviced Areas

The serviced area in the Source Protection Area is defined by the Urban Service Line. The area outside of this boundary but within Source Protection Area as shown in WC Map 11 is non-serviced municipal area and their waste waters are discharged into private septic systems. The area within the Urban Service Line discharges their sewage into the municipal wastewater facilities. The residents living in the Township of Prince have their own well and septic system and are a non-serviced municipal area.

2.6.10.4 Septic Systems and Wastewater Treatment Facilities

Trailer parks located within the jurisdiction of Source Protection Area operate either a communal septic system, individual septic systems or if within the urban service line are connected to the municipal service. The residents living in Prince Township have their own septic systems. The Garden River First Nation residents have their own septic systems. Most of the cottages in the watershed area are on septic systems.

2.6.10.5 Stormwater Management

Storm water is that portion of runoff that flows across impervious surfaces such as roads, sidewalks, driveways and enters surface water sources as untreated. During its overland travel it often comes in contact with contaminants such as sediment, fertilizers, animal waste, oil and grease. In order to mitigate the potentially harmful effects of storm water to our water sources, management plans need to be implemented to minimize this contamination. These plans or strategies include the construction of detention/retention ponds, pre-treating runoff, and the installation of designed vegetative strips for infiltration. The City of Sault Ste. Marie owns a sanitary sewer overflow tank located at Bellevue Park that provides additional storage within the sewage collection system. This diverts flow from the downstream Clark Creek Pumping Station and the East End Wastewater Treatment Plant

A Storm Water Management Investigative Study is currently being undertaken by the City of Sault Ste. Marie. The outcome of the assessment is “to develop a Storm Water Master Plan Strategy to address storm water quality and quantity concerns”.

2.6.11 Agricultural Resources

Within the Source Protection Area, agriculture is of limited regional significance with little or no anticipated expansion. The expansion of operations in size or number occurred in the past decades. Present patterns of agricultural activity reflect the limited suitability and capability of both the land and the local market area to sustain a large integrated and economically viable farming community.

At present, agricultural activity is centered on the east and west of the City of Sault Ste. Marie with most of the land in production supporting mixed, beef or horse type of operation. There are some agriculture activities existing in Prince Township. Present trends reflect a relatively stable rate of activity. The area suitable for agriculture is only 9% of the overall planning area (WC Map10).

2.6.11.1 Agricultural Sector Distribution

By Looking into the agricultural capability in the Source Protection Area, according to the Canada Land Inventory (CLI) system (WC Map 4A: Land Use CLI Data), land can be “designated" according to its potential to support agriculture. Although the physical properties of soil are of primary importance in determining capability, factors such as topography and climate are also considered. With the CLI system, soils are classified according to their capability on a class scale of 1 to 7 with Class 1 being the most productive. Those soils greater than Class 4 are generally regarded as unproductive unless artificially improved.

There is small portion of the watershed area on the west side comes under CLI class 3 having some capabilities for agriculture and majority of the areas fall under class 4 to 7. There is only small portion comes under CLI class 2, moderate limitation for agriculture production.

The Source Protection Area contains a wide range of soil classes with the highest being a Class 3, described as gently undulating silts and clays located in the west and some portion in the east of the watershed. The next major class, Class 4, consists of wet clay soils found mainly to the north of the City. These soils have an inherent wetness and must be artificially drained before being put into agricultural production. The dominant soil type to the north of the watershed is associated with CLI class 7.

In the main agricultural area of the watershed on the west side, the dominant limitations other than low fertility are the cold climate and poorly drained soils. These factors in turn affect the choice of crops, planting, harvesting and timing and use of tillage. According to CLI mapping, some portions in the Prince Township, which appear to have the highest capability for agriculture.

2.6.11.2 Trends in Agriculture

Regionally, the number of farms and the amount of land area put into production has been declining since 1961 mainly as a result of the increased economic constraints being put on farming operations. Throughout the Province, the trend towards farm consolidation has seen farms managed more intensively as fewer and fewer operations cultivate larger tracts of land. Increased size allows flexibility and diversity in the overall operation.

Based on statistics of Agriculture Census of Canada, agricultural activity in the Algoma Region is limited with only 1 215 hectares of land improved and under production. This land base supported 45 commercial farms. No further information is available on the number of dairies; poultry farms swine operations, vegetable farms, grain producers and beef operations. The total farm operations includes under crops, under tame or seeded pasture and under natural land for pasture. All other land use (including Christmas tree farming) is unknown. There are a total of 780 person involved in the agriculture production.

Table 2.6.6 provides a list and description of the various soil types and their agricultural limitations. This information was derived from Canada Land Inventory Level Space Digital Data. A map has been produced for the soils limitations in the Watershed Region, WC Map 4. It should be noted that there is a data gap for a small area on the western boundary of the watershed.

Table 2.6.6: Canada Land Inventory Level Space Digital Data Classifications

Soil Class	Description	Comments
2	Moderate Limitations	Moderate Conservation Practices Required
3	Moderately Severe Limitations	Range of Crops, Restricted or Special Conservation Practices Required
4	Severe Limitations	
5	Forage Crops	Improvement Practice Feasible
6	Forage Crops	Improvement Practices Not Feasible
7	No Capability for Arable Culture or Permanent Pasture	
?	Unmapped Area	
O	Organic Soils	
U	Urban Area	

2.6.11.3 Livestock Density

Livestock density within the entire Sault Ste. Marie Region Source Protection Area is <0.5 nutrient units per acre as illustrated in Table 2.6.7 and **WC Map 21A**. This area does not have any industrial agricultural operation that requires a Nutrient Management Plan.

Table 2.6.7: Livestock Density in Nutrient Units per Acre

Livestock Density	Lorna Well	Shannon Well	Steelton Well	Goulais Well
WHPA – A	0.0	0.0	0.0	0.0
WHPA – B	0.0	0.0	0.0	0.0

The data derived from Stats Canada – Census Consolidated Subdivision information which is the only data available for the Source Protection Area and does not provide location information. Methodology for these calculations were approved as per the Directors letter for alternate method dated May 6, 2010.

2.6.11.4 Impervious Surfaces

Impervious surfaces are defined as "the percentage of impervious surface area where road salt can be applied per square kilometre in the vulnerable area" (Technical Rules). The percentage of impervious surfaces within each of the vulnerable areas is illustrated on **WC Map 21C** .

WC Map 4 : Soils
WC Map 4A : Land Use CLI Data
WC Map 21A : Managed Lands Nutrient Application
WC Map 21B : Managed Lands Non-Agricultural
WC Map 21C : Impervious Surface

2.6.12 Recreation

Intensive use of the land for recreation is generally confined to the City of Sault Ste. Marie where a number of municipal parks are maintained. These parks are supplemented by several Conservation Areas, a National Park as well as municipal and privately operated park facilities located throughout the watershed. In contrast to these site-specific facilities, extensive use is made of the vast tracts of Crown land surrounding the municipality for camping, hiking, hunting etc. Water based recreation within the Source Protection Area varies in complexity and mode from kayaking and motor boating on Lake Superior and St. Marys River to swimming and canoeing on the inland lakes that connect to the major rivers of the watershed.

The following is a short list of some of the larger recreational facilities found within the Source Protection Area:

- Hiawatha Highlands Conservation Area and trail system
- Fort Creek Conservation Area and trail system
- Shoreridges Conservation Area – Provincially Significant Wetland, site of a Dynamic Beach and trail system
- Marks Bay Conservation Area with waterfront, boat launch and trail system
- Kinsmen Park and trail system
- Parks Canada – Sault Ste. Marie Canal National Historic Site of Canada with connection to riverfront boardwalk
- Pointe des Chênes Park with extensive beach area on St. Marys River
- Strathclair Sports Complex with Sinclair Yards for soccer and baseball
- Bellevue Park with playground and marina
- Queen Elizabeth Park with John Rhodes Community Centre
- Bondar Park and Marina with pavilion and connection to riverfront boardwalk
- Steelback Centre

2.6.13 Protected Areas

Within the jurisdiction of SSMRCA, specific areas are protected from development changes that could alter the natural character. This is designated through the federal government (national parks), the provincial government (provincial parks, Crown lands), and local initiatives (municipal zoning, parks and Conservation Areas). “Protected” areas (WC Map 12A) are not likely to alter by the passage of time; this designation refers to an area that should encounter minimal human disturbance. The following is a list of protected areas within the SSMRCA jurisdiction:

- Greenways, greenbelts and neighbourhood parks (through subdivision and development agreements)
- Environmental Management zoning (EM) within the city of Sault Ste. Marie
- Conservation Areas and Property belonging to SSMRCA which include:
    - Provincially Significant Wetland
    - Dynamic Beaches
    - Headwaters

2.6.14 Other Land Use Related Issues

Land tenure within the Source Protection Area is predominantly Crown. The majority of the private land is located in the central-southern portion of the watershed around the urban core of the City of Sault Ste. Marie and along the Highway 17 corridor. In addition, there are two First Nations, Batchewana and Garden River, on the eastern boundary of the watershed. In the northern portion of the watershed there are several large parcels of land to which the surface rights are leased for aggregate and agriculture purposes.

Resource management program development and implementation is often restricted by land tenure. Whereas Crown land designation provides government agencies the opportunity to regulate land use directly, private lands are controlled through various forms of legislation. As such, Conservation Authorities often have to rely on outright purchase or easement over private lands in order to implement conservation, engineering or recreational projects.

2.7 Water Use

Water use in the City of Sault Ste Marie and surrounding area can be grouped into the following four main categories:

- Individual/Domestic,
- Municipal/Public,
- Commercial/Industrial, and
- Agricultural.

Present uses within the above four categories are discussed in terms of the amount and adequacy of water. In order to ensure sustainable growth, the rate of groundwater extraction in any area should be related to the groundwater recharge and allowable groundwater withdrawal, based on maintaining satisfactory base flow in the local streams. If groundwater use is more than the groundwater recharge, a groundwater overdraft (or “mining”) will occur which would result in the depletion of groundwater, a reduction of the total available groundwater resource, and impact to streams. The assessment of total water use and the groundwater budget presented in this report will therefore assist to develop appropriate management strategies.

The data sources for the assessment of the amount of water used by residents and businesses within the study area included: PUC Inc. (formerly Sault Ste Marie Public Utilities Commission) pumping records, Ministry of the Environment water well records, permits to take water, and typical water consumption estimates based on type of use. Table 2.7.1 provides a summary of water users in the City of Sault Ste Marie and surrounding area.

2.7.1 Drinking Water Sources

The Drinking Water Systems Regulation (Ontario Regulation 170/03) of the Safe Drinking Water Act (SDWA) regulates municipal and private water systems that provide water to year-round residential developments and designated facilities that serve vulnerable populations such as children and the elderly. Designated facilities include children's camps, child and youth care facilities, health care and social care facilities, schools and learning institutions.

The City of Sault Ste Marie municipal water supply is a large municipal residential system under O. Reg. 170/03, servicing 25,618 households and draws approximately equal quantities of groundwater from its municipal wells and surface water intake. The watershed of the intake is shown on WC Map 18.

Table 2.7.1: Summary of Water Users

Water Users	Service Type	Population	Source
City of Sault Ste Marie	Municipal	77 000	1
Prince Township	Domestic	980	2
Batchewana First Nation	Domestic	150	3
Other rural population (north of the City)	Domestic	8 300	4
Total Number of Water Users		85 000	

Source:
[1] Environment Canada Water Use Study, 2000
[2] Ontario Municipal Directory, 2002
[3] RJB, 2002
[4] Sault Ste Marie Planning Department communications

Table 2.7.2: Water Use Summary

Water Use Area/Category	Total Annual Volume (1000 m^3/annum)	Comments	Source
Prince Township	128	Based on a population of 977 and 350 L/c/d	1
Batchewana First Nation	19	Based on a population of 150 and 350 L/c/d	1
Sparse rural population	1 060	Based on a population of 8,299 and 350 L/c/d	1
City of Sault Ste Marie - Municipal / Public	7 100	Based on PUC annual pumpage summary	2
City of Sault Ste Marie - Commercial / Industrial	160	Based on PTTW maximum daily water taking	3
City of Sault Ste Marie - Permits to Take Water (groundwater)	880	Based on PTTW maximum daily water taking	3
Total Volume of Groundwater Taking	**9 347**		

1. Best Management Practices, *Irrigation Management*, Agriculture and Agri-Food Canada, Ontario Ministry of Agriculture, Food and Rural Affairs, 1995.
2. Sault Ste Marie Public Utilities Commission, Annual Pumpage Summary, 2000.
3. Ministry of Environment Permits to Take Water (PTTW).

2.7.1.1 Municipal Wells

The Municipal/Public supply system accounts for the largest water-consuming category within the study area, and is located completely within the Urban Service Line area of the City of Sault Ste Marie. The system is comprised of groundwater and surface water, each contributing approximately equal portions to the municipal/public system. Based on MOE records, six municipal wells provide the groundwater component, and the surface water component is now provided by Lake Superior.

By 1979, five municipal wells were developed within the City, with two in the East Basin (13 ML/d or 3.4 Mgpd) from the Dacey Road #1/Shannon and Queen St. #3/Lorna wells) and three in the Central Basin (18 ML/d or 4.8 Mgpd from the Goulais #1 and #2 well, and the Steelton well). The Shannon well came on line in 1973 and the Lorna well was commissioned in 1979. A second well at the Lorna site was constructed and brought on line in 1982, with a pumping capacity of 4,5504.6 ML/d (1.2 Mgpd), thus doubling the capacity at this well field.

The Steelton and Goulais wells were placed in production prior to 1976. The Steelton well pumped on an average approximately 250 ML/month until March 1993, when pumping rates were reduced considerably. The Goulais well pumped approximately 300 ML/month from 1976 until 1994, with half that amount pumped from 1986 to 1993. The Lorna wells were pumped at 200 ML/month until 1983. This pumping rate was increased to 250 ML/month from 1983 to 1985, but has been reduced to 150 ML/month since 1986. The pumping rate for the Shannon well has varied from 200 ML/month (1976 to 1984) to 50 ML/month (1986 to 1994) to 150 ML/month since 1994. The decreases in the pumping rates observed in 1985 and 1986 correspond to the commissioning of the surface water treatment facility for the City.

Current permitted pumping rates for the municipal water sources, as obtained from the Engineers' Report for Water Works under Drinking Water Protection Regulation O. Reg. 459/00; (Delcan, May 31, 2002) are:

Source	m^3/d	MGD
Gros Cap (Lake Superior source)	75 000	17
Two Goulais wells	10 000	2.2
One Shannon well	7 000	1.5
Two Lorna wells	14 000	3.1
One Steelton well	8 200	1.8

The first is a surface water source and the latter four are groundwater sources from four well fields. The current water taking from both groundwater and surface water sources is schematically presented in Appendix E. As seen from this data, the groundwater sources account for approximately 50% of the total municipal water supply in the City.

Updated Certificate of Approvals pumping rate data will be considered in a future updated Assessment Report.

2.7.1.2 Sault Ste. Marie Wells and Water Treatment Plant

The Sault Ste. Marie water treatment plant is a direct filtration plant, treating water taken directly from Lake Superior (DWSP Annual Report 1987). Treatment consists of coagulation, flocculation, filtration and disinfection. The plant has a design capacity of 40 ML/d (40,000 m^3/d) with the distribution system serving 85 000 people (1987).

Currently, groundwater is pumped into the City distribution system from four well fields: the Lorna and Shannon wells supplying water from the East Basin and the Steelton and Goulais wells, supplying water from the Central Basin. The only treatment of the groundwater is the addition of ammonia/chlorine (for disinfection) prior to it entering the distribution system. Analyses of the water indicated that the water supply is of good quality throughout the distribution system (PUC, 2008).

According to the Sault Ste Marie Public Utilities Commission 1999 data, approximately 15 GL (15 000 000 m^3) of water was delivered to the municipal/public water supply system (for a population base of 75 500), with groundwater and surface water accounting for 47 % and 53 % respectively. Total water delivered to the distribution system in 2008 was 12.79 million cubic meters compared to 13.09 in 2007. The maximum day production in the year was 44.0 thousand cubic meters, which occurred August 20, 2008. Annual consumption has fluctuated around 14 million cubic meters over the past four decades. There is evidence of a decline in the amount of water consumed annually over the past ten years (PUC, 2008).

2.7.1.3 Private Groundwater Supplies

Areas outside of the City of Sault Ste Marie's urban area are primarily serviced by individual domestic wells. Water demands of such areas are estimated based on 350 litres per capita per day (L/c/d). There are also a number of Permits to Take Water (PTTW) that have been issued for private systems using more than 50 m^3 per day.

The majority of the City of Sault Ste Marie is serviced by a public supply of water, with individual/domestic systems located primarily outside the Urban Service Line of the City, in Prince Township, Batchewana First Nation, Garden River First Nation and in Sault North planning area within the study limits. A number of private wells exist within the City of Sault Ste Marie; however, it is assumed that the primary source of potable water is the municipal supply. For areas outside of the City of Sault Ste Marie, it is assumed that all identified residential lots have a well. Based on the assumption that each resident uses 350 L/day (Best Management Practices Water Wells, 1997), for a domestic well user population of 9,426 (see Table 2.7.1, above), the individual/domestic water demand within the study area is estimated as approximately 1.2 GL (1 204 170 m^3) per annum.

WC Map 13: Wells Municipal/Communal Treatment Facilities

2.7.1.4 Surface Water Intakes

There is only one surface water Intake to supply the City's drinking water demands. The water is drawn from Lake Superior at Gros Cap. The raw water intake is a buried pipe with a 1.2 m diameter and is 830 m long with a capacity of 150 ML/d (150 000 m^3/d). It is located off Gros Cap, together with a circular fibreglass intake structure located at 15 m below the water surface.

Raw water from the intake at Gros Cap is pumped to the water treatment plant where a process of filtration and chlorination prepares the water for consumption. Water from the deep wells is chlorinated prior to being pumped to the distribution system. The maximum permitted water takings allowed under the MOE Permit to Take Water from Lake Superior at Gros Cap is 75 Ml/d (75 000 m3/day).

WC Map 14: Surface Water Intakes and Treatment Facilities

2.7.2 Recreational Water Use

In the Sault Ste Marie Watershed Region there are a large number of interdependent, multiple use recreational stakeholders.

The rivers and lakes in the area are used for but not restricted to the following “recreational” purposes:

- Boating
- Canoeing
- Cottages
- Fishing and hunting
- Kayaking
- Swimming
- Tourist outfitters
- International Cruise Lines
- White Water rafting

In addition, these same rivers and lakes are used for:

- Tourism
- Agriculture
- Hydro-electric generation
- Industry
- Municipal water supply
- Storage/flood control
- Wildlife management/trapping

These uses contribute immensely to local prosperity by creating jobs, income revenue and property/business taxes and are extremely dependent on each other.

The rivers and lakes are managed, often at opposing/conflicting requirements, to protect fish spawning areas; wildlife habitat; maintain water levels for recreation; supply water for electricity production, industry, agriculture and drinking water and to minimize the effects of flooding.

For example, stakeholders on one lake require the lake maintained at a certain level for recreation while downstream stakeholders require that water be taken out of the lake, thus lowering the lake level, for hydro-electric generation, to protect a fish spawn or to ensure an adequate water supply for the municipal water intake.

There are no active permits for recreational water use in the watershed region.

2.7.3 Ecological Water Use

The extensive rivers and creeks present in the study area are habitat for a multitude of fish species that depend on up-wellings for spawning and sustained health throughout the seasons. Similarly, within the planning area, wetlands are habitat for numerous amphibians, flora and fauna. The wetlands comprise 3.9 % of the study area. There are a number of smaller wetland areas in the northern uplands of the planning area associated with headwater areas of the rivers and creeks, which flow south towards the St. Marys River. Along the shore of the St. Marys River, a number of larger wetland areas are found at the outlet of rivers such as the Big and Little Carp and the Root River.

As a part of this report, the water used by these features will be discussed qualitatively since monitoring data is not available at this stage to provide quantitative estimates. The objective of including these features in the assessment is to ensure that they are considered as a part of the system and that necessary flow to support natural function of these features is not altered or affected severely as a result of an imbalance of the water.

2.7.4 Agricultural Water Use

The study area does not generally support any large agricultural (irrigation and livestock) operations. As a result, groundwater demand for such uses is negligible. It should be noted, however, that three current PTTW exist for agricultural purposes. Water takings for these purposes are obtained directly from surface water resources, and are not considered in the average annual groundwater taking analysis.

2.7.5 Industrial Water Use

Based on the MOE record of PTTW, there are eight active water-taking permits for commercial/industrial purposes in the watershed region. The permits were issued in 1974 to 2005 and will expire 2006 to 2028. The commercial water use in the watershed region is from surface water sources for different purposes (golf course, aquaculture, hydro-electric, cooling, pulp and paper).

The commercial/industrial system is primarily serviced through the municipal network. Approximately 3.2 GL (3 200 000 m^3)/annum are accounted for in the municipal category. Based on MOE Permit to Take Water records, five additional wells are used for commercial/industrial purposes that are not accounted for in the municipal system. The total permitted volume of annual water taking for these purposes is approximately 160 ML (160 000 m^3).

3.0 WATER QUALITY

This section provides a general assessment of surface and groundwater quality conditions and trends by use of the existing available data from different sources. Trend graphs, box plots and maps presented in this section illustrate the prevailing trends of water quality. The overall objectives are:

a) To describe the current state of the surface and groundwater quality and

b) To identify long-term trends to see if water quality is improving, deteriorating or staying the same within the source protection watershed area.

The quality of the water resources of a watershed is a true reflection of how well humans have been actively integrating their activities with the natural environment. Whether these activities or uses are passive (recreational or aesthetic) or active (power generation or irrigation) they affect or are affected by the quality of the water supply.

Although water resources are put to intensive use in the urban environment, one must consider the watershed as a whole and the impact that extensive activities such as logging and mining have on the overall quality of water. Furthermore, with over 775 km^2 of land and water within its boundaries, the Source Protection Area is susceptible to external impacts as well, including acid rain and other forms of particulate fallout.

The quality of fresh water is important to both human and ecosystem health. Humans depend on surface and groundwater sources for drinking water, to generate energy, to grow crops, for washing and cleaning, industrial uses and recreational purposes. Water is also important as a habitat for a variety of plants and animals.

In Canada, the responsibility for ensuring drinking water supplies are safe is shared between the provincial, territorial, federal and municipal governments. The responsibility of providing safe drinking water to the public generally rests with the provinces and territories, while municipalities usually oversee the day to day operations of the water treatment facilities (WC Map 12). All of the provinces and territories in Canada have developed guidelines for drinking water quality. These guidelines set out the maximum acceptable concentrations of various substances in drinking water.

In Ontario, drinking water supplies are regulated under the Ontario Drinking Water Quality Standards (O.Reg. 169/03). This regulation defines the *Ontario Drinking Water Standards, Objectives and Guidelines (ODWS)*, which are administered and enforced by the Ontario Ministry of the Environment (MOE) under the Ontario's *Safe Drinking Water Act, 2002* and its regulations. The ODW standards deal with microbiological, chemical and radiological contaminants. They also address concerns with the physical characteristics of water, such as taste and odour. The most immediate risk to people's health from drinking water comes from microscopic organisms such as disease-causing bacteria, protozoa and viruses. The standards that relate to these microorganisms are stringent because the associated health effects can be quite severe.

Standards for chemical and radiological substances which may be found in some drinking water supplies are generally developed based on the possible health effects from their long term exposure.

Aesthetic quality guidelines address parameters which may affect consumer acceptance of drinking water, such as taste, odour and colour. Operational guidelines are set for parameters that may affect processes at a treatment plant or in the drinking water distribution system.

Guidelines have also been developed to help protect aquatic life and recreation, and to provide guidelines for the management of the province's water resources. In Ontario, these guidelines, the Provincial Water Quality Objectives (PWQO), are also administered and enforced by the MOE.

For the purposes of assessing the water quality in the Source Protection Area, selected parameter concentrations were compared to the MOE Ontario Drinking Water Standards, Objectives and Guidelines (ODWS; July 2003) and the Provincial Water Quality Objectives (PWQO; July 1994). According to the MOE, the primary purpose of the ODWS is to "*provide information for the protection of public health through the provision of safe drinking water. Water intended for human consumption should not contain disease-causing organisms or unsafe concentrations of toxic chemicals or radioactive substances. Water should also be aesthetically acceptable and palatable".* According to the MOE, the purpose of the PWQO guidelines is to provide direction of how to manage the quality and quantity of both surface water and groundwater in the province of Ontario. The goal of the PWQO's regarding surface water is to ensure that the water quality is satisfactory for aquatic life and recreational purposes.

Much of the data and information relating to water quality and supply that is available for the Source Protection Area is collected and correlated by the MOE through their Technical Support Program. Besides general monitoring of the watershed's resources, specific studies are undertaken to address unique problems or issues. Although the Ministry of Natural Resources (MNR) has an extensive lake and river survey program in place, the emphasis of their study is on determining the quality of the fish habitat and not the wider ranging pollution parameters presently under study by the MOE.

This section will outline various aspects of quality and supply, source of pollution, what studies have been undertaken, how the resources are being monitored and what can be expected in the future.

3.1 Selecting Indicator Parameters

It is not feasible to monitor all water quality contaminants (chemicals and pathogens) at all locations all of the time. Indicator parameters should be selected that function as a surrogate for ecosystem and human health.

The primary sources of contamination for Sault Ste. Marie surface water is identified as storm water drainage, land use activities and mineralogy of the area.

Sodium and chloride concentrations are used to evaluate the impact of road salting on the surrounding surface water and groundwater quality. Chloride is often one of the most useful indicator parameters for road salt impact as well as municipal landfill leachate impact, as it is a common constituent of municipal landfill leachate and road de-icing agents. In addition, chloride ions are relatively mobile in the groundwater flow system. Chloride ions do not significantly enter into oxidation or reduction reactions. As a result they do not form important solute complexes with other ions unless the chloride concentration is very high, nor do the ions form salts of low solubility and they are not significantly adsorbed on mineral surfaces. The ions play few vital biochemical roles (Hem, 1989). Since chloride ions tend to remain in solution once dissolved, nearly all Chloride added to environment will eventually migrate to surface or groundwater. As such, the mobility of the chloride ions in the subsurface is not appreciably retarded with respect to the rate of groundwater flow. Therefore, in areas characterized by naturally low chloride concentration; this parameter becomes a useful indicator with respect to the extent of road salt and/or landfill leachate impact on groundwater and surface water. It produces a detectable salty taste at the aesthetic objective level of 250 mg/L. Chloride is widely distributed in nature, generally as the sodium (NaCl), potassium (KCl) and calcium ($CaCl_2$) salts.

The aesthetic objective for sodium in drinking water is 200 mg/L at which it can be detected by a salty taste. Sodium is not toxic. Consumption of sodium in excess of 10 grams per day by normal adults does not result in any apparent adverse health effects. In addition, the average intake of sodium from water is only a small fraction of that consumed in a normal diet. A maximum acceptable concentration for sodium in drinking water has, therefore, not been specified. Persons suffering from hypertension or congestive heart disease may require a sodium-restricted diet, in which case, the intake of sodium from drinking water could be a contributing health factor. It is therefore recommended that the measurement of sodium levels be included in routine monitoring programs of water supplies. As per O. Reg. 170/03, the water plant operator/authority must inform the local Medical Officer of Health when the sodium concentration exceeds 20 mg/L, so that this information may be passed on to local physicians.

Softening using a domestic water softener increases the sodium level in drinking water and may contribute a significant percentage to the daily sodium intake for a consumer on a sodium restricted diet.

Indicator parameters that are used to evaluate nutrient loadings from sources such as lawn fertilizers, detergents, domestic sewage or treated wastewater contamination decay of plant or animal material and urban runoff include phosphates, nitrite, nitrate and ammonia.

Nutrients, such as nitrogen and phosphorus, are necessary for growth of plants and animals and support a healthy aquatic ecosystem. In excess, however, nutrients can contribute to fish disease, brown tide, algae blooms and low dissolved oxygen. Excessive nutrients in lakes, rivers and streams stimulate the growth of algae, which in turn can result in eutrophication. The algae prevent sunlight from penetrating through the water column. Once deprived of sunlight, underwater plants cannot survive. Animals that depend on these plants for food or shelter leave the area or die. As the algae decay, they rob the water of oxygen. Fish and shellfish are in turn deprived of oxygen. Excessive algae may also cause taste and odour problems and decreased aesthetic value. It also may affect water treatment processes.

The maximum acceptable concentration of nitrates in drinking water is 10 mg/L as nitrogen. Nitrates are present in water (particularly ground water) as a result of decay of plant or animal material, the use of agricultural fertilizers, domestic sewage or treated wastewater contamination, or geological formations containing soluble nitrogen compounds. There is a risk that babies and small children may suffer blood related problems (methaemoglobinaemia) with excess nitrate intake. The nitrate ion is not directly responsible for this condition, but must first be reduced to the nitrite ion by intestinal bacteria. The nitrite reacts with the iron of haemoglobin in red blood cells which are then prevented from carrying oxygen to the body tissues. Nitrate poisoning, in terms of methaemoglobinaemia, from drinking water appears to be restricted to susceptible infants. Older children and adults drinking the same water are unaffected. Most water-related cases of methaemoglobinaemia have been associated with the use of water containing more than 10 mg/L nitrate as nitrogen. In Canada, no cases of the condition have been reported where the nitrate concentration was consistently less than the maximum acceptable concentration. Where both nitrate and nitrite are present, the total nitrate plus nitrite-nitrogen concentration should not exceed 10 mg/L. In areas where the nitrate content of water is known to exceed the maximum acceptable concentration the public should be informed by the appropriate health authority of the potential dangers of using the water for infants.

The aesthetic objective for sulfate in drinking water is 500 mg/L. At levels above this concentration, sulfate can have a laxative effect, however, regular users adapt to high levels of sulfate in drinking water and problems are usually only experienced by visitors and new consumers. The presence of sulfate in drinking water above 150 mg/L may result in noticeable taste. The taste threshold concentration, however, depends on the associated metals present in the water. High levels of sulfate may be associated with calcium, which is a major component of scale in boilers and heat exchangers. In addition, sulfate can be converted into sulfide by some anaerobic bacteria creating odor problems and potentially greatly accelerating corrosion.

The mineralogy of the bedrock geology in the area results in naturally elevated concentrations of various metals in the groundwater and soil in some locations. Metal concentrations in the surface water and groundwater are evaluated as part of this scope of work through the following indicator parameters, wherever possible: arsenic, cobalt, copper, iron, nickel and zinc.

3.2 Surface Water Quality Data Analysis and Reporting

3.2.1 Source of Water Quality Data

Various existing sources of water quality data were investigated and analyzed to provide a general assessment of current water quality in the area as well as to evaluate water quality trends over time. Water quality data was obtained from the PUC Inc. and the MOE. A summary of each data source, the years for which data is available and the usefulness of the data are summarized below and presented in **Table 3.1** in **Appendix 3A**.

3.2.1.1 MOE Provincial Water Quality Monitoring Network

According to the MOE, Ontario's Provincial Water Quality Monitoring Network (PWQMN) collects surface water quality information from streams, rivers and lakes across Ontario. The network has 390 monitoring stations operated in partnership with Ontario's 36 Conservation Authorities.

In Northern Ontario the MOE is currently undertaking the sampling at the monitoring locations. The standard set of water quality indicators monitored at each PWQMN station generally includes chloride, nutrients, suspended solids, trace metals and other general chemistry parameters. Other substances such as pesticides and other contaminants are monitored in detailed water quality surveys in priority watersheds.

PWQMN information is used to assess source water quality, determine the location and causes of water quality problems and measure the effectiveness of pollution control and water management programs. PWQMN information is one of the main sources of surface water information required in source protection planning. Information is also used by the MOE to evaluate applications for certificates of approval and permits to take water and to develop water quality standards.

A total of thirteen (13) stations out of thirty (30) stations have historically been monitored within the Source Protection Area, along the Big Carp River, Fort Creek, Root River and St. Marys River. Of these thirty stations, only two stations are currently being monitored and active. Both of these stations are located along the Root River. One station (13001100102) is located at the Root River, along Highway 17, East of Sault Ste. Marie. The second station (13001100202) is located on Root River along Highway 17, North of Sault Ste. Marie. The data from these locations was used for both water quality trends over time as well as current water quality of the watershed. A summary of the PWQMN stations is presented in **Table 3.2 in Appendix 3A**.

The remaining seventeen (17) stations were sampled anywhere from 1 to 9 years in between 1968 to 1995. These stations were located within the Source Protection Area and are located on Root River, St. Marys and Little Carp River. For the purpose of this study, the data was used to assess the water quality trends over time. A trend graph and a Box and Whisker Plot with summary statistics were prepared for nine (9) stations for selected water quality parameters are presented in **Appendix 3B & 3C**. The remaining 21 stations were sampled with less frequency and discontinued after 1995, therefore these do not reflect current water quality situation with in the planning area.

3.2.1.2 Municipal Water Supply

Drinking water quality information in the source protection planning area is obtained from the Ontario Drinking Water Surveillance Program (ODWSP). Municipal water in the City of Sault Ste. Marie is obtained from a combination of surface water and groundwater. As mentioned earlier, about 50% of potable water is obtained from the Lake Superior at Gros Cap and 50% is obtained from four (4) groundwater well fields located on two aquifers within the watershed region (WC Map 13). The raw water quality data from Lake

Superior at Gros Cap, at the Sault Ste Marie Water Filtration Plant (WC Map 14) and the raw water quality data from all six (6) groundwater wells was supplied by the ODWSP. Yearly Averages for the Raw/Treated water quality data from Lake Superior Intake and Water Treat Plant (WTP) is available from 1990 to 2005. The data is analysed for selected water quality parameters and microbiological quality. Raw/Treated groundwater quality data for all six (6) wells is available on yearly averages bases and analysed.

The control room operator through the use of the Supervisory Control and Data Acquisition (SCADA) system continuously monitors, records and trends all operational parameters from the plant on a 24/7 basis. All non-compliant conditions from within the WTP result in both an audible alarm and a visual display until such time that they are acknowledged and addressed by the Control Room Operator.

The operator tests and monitors hourly for all operational parameters, including pH, filtered water turbidity, finished (system) water turbidity, colour, free chlorine residual, and chemical dosage settings (i.e. hydrated lime, aluminum sulphate, flocculent, chlorine and ammonia).

The operator tests daily for temperature, aluminum residuals and alkalinity. On a daily basis, water quality tests for free chlorine residual are taken at a point which reflects the maximum residence time in the distribution system.

Weekly samples of the Raw Water supply, Treated Water within the process, and Finished Water at both the point of entry to the distribution system and points reflecting the maximum residence time in the distribution system are collected and analyzed for chlorine residual, turbidity, total coliform, E-Coli, general bacterial population and heterotrophic plate count. The Water Quality Analyst obtains seven (7) samples reflecting the maximum residence time in the distribution system and one sample from the raw water supply and finished water on a weekly basis as per Ontario Regulation.

Quarterly samples reflecting the maximum residence time in the distribution system are collected and analyzed for all microbiological parameters and those conditions listed in Schedule 23 (Inorganics), and Schedule 24 (Organics) as outlined within Ontario Regulation 170/03. In addition to the noted sampling requirements, the analysis of Iron, Lead, Sodium, Cyanide, Aluminum, Fluoride, Silica, Asbestos, Pyrene, Formaldehyde, Phenols, Dioxin, Furan, Nitriloacetic Acid and Nitrosodimethylamine have been included in the quarterly samples.

Raw and treated water at the plant, from four wells and at two locations in the distribution system were sampled for the presence of approximately 190 bacteriological, inorganic, organic and radiological parameters from 1993 to 1995. A total of 5,312 tests were performed in 14 sample events from the Sault Ste. Marie WTP and 5,452 tests were performed in 23 sample events from the Sault Ste. Marie well supply.

For the 1996 and 1997 sampling period only water from the WTP and the distribution system were sampled. Raw and treated water at the plant and water at two locations in the distribution system were sampled for the presence of approximately 200 bacteriological, inorganic, organic and radiological parameters. For 1996 and 1997, a total of 1,540 tests were performed in four (4) sample events from the Sault Ste. Marie WTP and distribution.

Raw and treated water for the years 1998 and 1999 at the plant along with raw water from four wells and treated water from three wells and at two locations in the distribution system were sampled. A total of 2,939 tests on up to 200 inorganic, organic and radiological parameters were performed.

Raw and treated water for the years 2000 to 2002 at the plant along with raw water from four wells and treated water from four wells and at two locations in the distribution system were sampled. A total of 1,919 tests on up to 200 inorganic, organic and radiological parameters were performed.

Raw and Treated water for the years 2003 to 2006 at the plant along with raw water from four wells and treated water from four wells at two locations in the distribution system were sampled. It is noted that when compared with all of the above criteria, there were no known health related guidelines exceeded.

3.2.2 Surface Water Quality

All water contains many naturally occurring substances, mainly bicarbonates, sulphates, sodium, chlorides, calcium, magnesium, and potassium (total dissolved solids). They reach the surface and groundwater from:

- Soil, geologic formations and terrain in the catchment area (river basin);
- Surrounding vegetation and wildlife;
- Precipitation and runoff from adjacent land;
- Biological, physical and chemical processes in the water; and
- Human activities in the region.

Many human activities and the by-products have the potential to pollute water, including large and small industrial enterprises, the water industry, the urban infrastructure, agriculture, horticulture, recreation and transport. Pollutants from these and many other activities may enter surface or groundwater directly, may move slowly within the groundwater to emerge eventually in surface water, may run off the land, or may be deposited from the atmosphere.

The analytical methods used to determine water quality have improved significantly over the past several decades, consequently reducing method detection limits. As such, during the evaluation of water quality trends over time, in particular for the PWQMN stations, this information must be considered. It is possible that some of the potential decreases in water quality over time may be attributed to improvements in analytical method detection limits. Water quality trends over time are presented graphically in **Appendix 3B**, while Box and Whisker Plots are presented in **Appendix 3C**.

3.2.2.1 Root River Water Quality

Water quality data for the Root River is available for seven (7) locations along the river within watershed from the PWQMN. There are two that have been historically monitored and are active. The rest of four (4) sites were monitored 3 to 5 years in the period from 1986 to 1991.

The Root River is encompasses a major portion of the surface water in the Sault Ste. Marie region watershed. There are some potential sources of contamination located in the Root River watershed. Runoff from the urban and agricultural land use may have some impact on the surface quality of the river.

Much of the Root River's pollution is likely in the form of iron and phosphorous loadings. Mineralogy of the area and some non-point sources has impact on the water quality of the river. There is increasing trend of these two pollutants observed from upstream to downstream which reflects that some non-point source pollution exist in between two locations (13001100402 and 13001100202).

From upstream to downstream, the surface water quality data available for the Root River includes monitoring at the six (6) sites. Historical PWQMN stations (see Table 3.1 in Appendix 3A). Summary tables for each of the active stations are presented below, from upstream to downstream. The tables include the number of samples for which data is available, the maximum, minimum, average and the 75th percentile concentrations for selected parameters. In addition, the respective PWQO and ODWS for each parameter, if applicable are shown. Water quality vs. flow plots are presented in Appendix 3D, while the Box and Whisker Plots are presented in Appendix 3C

Table 3.1: Surface Water Quality of Root River (13001100202)

Station Location:	**Root River, Hwy 17, N of Sault Ste. Marie (13001100202)**		
UTM Co-ordinate:	**Easting: 705277**	**Northing:**	**5161133**
Sampling Period	**1972-2005**	**ACTIVE**	

	No. of Samples	Max.	Min.	Avg.	25th Perc.	75th Perc.	PWQO (mg/L)	ODWS (mg/L)
Arsenic							0.1	0.025(AO)
Chloride	134	194	1	19	8	20	n/a	250(AO)
Cobalt	14	**0.0011**	0.0001	0.0004	0.0002	0.0005	0.0009	n/a
Copper	99	**0.072**	0.0001	0.0027	0.001	0.002	0.005	1(AO)
Cyanide	2	0.001	0.001	0.001	0.001	0.001	0.005	0.2
Iron	112	**4.35**	0.058	**0.404**	0.23	**0.456**	0.3	0.3(AO)
Nickel	95	0.02	0.00001	0.00214	0.001	0.002	0.025	n/a
Nitrogen TKJDL	99	**25**	0.23	1.45	0.43	1.05	10	10
Phosphorous	134	**0.64**	0.001	0.015	0.005	0.012	0.010-0.030	n/a
Sodium	21	32.2	0.94	10.06	5.26	14.4	n/a	200
Sulphate	7	9.5	7	8.07	7.75	8.25	n/a	500(AO)
Zinc	99	0.11	0.0007	0.0083	0.003	0.008	0.03	5(AO)

Table 3.2: Surface Water Quality of Root River (13001100102)

Station Location: **Root River, Hwy 17, E of Sault Ste. Marie (13001100102)**
UTM Co-ordinate: **Easting:** **Northing: 5158496**
Sampling Period **1968-2005** **ACTIVE**

	No. of Samples	Max.	Min.	Avg.	25th Perc.	75th Perc.	PWQO (mg/L)	ODWS (mg/L)
Arsenic	5	0.01	0.01	0.01	0.01	0.01	0.1	0.025(AO)
Chloride	214	78	1	12	6	14	n/a	250(AO)
Cobalt							0.0009	n/a
Copper	114	0.1	0.001	0.006	0.001	0.003	0.005	1(AO)
Cyanide	11	0.01	0.001	0.005	0.001	0.01	0.005	0.2
Iron	149	**2.1**	0.05	**0.658**	**0.45**	**0.73**	0.3	0.3(AO)
Nickel	113	**0.083**	0	**0.005**	0.001	0.002	0.025	n/a
Nitrogen TKJDL	189	5.7	0.09	0.422	0.3	0.44	10	10
Phosphorous	215	**0.71**	0.003	**0.031**	0.014	0.029	0.010-0.030	n/a
Sodium	36	17.4	1	6.347	3.325	8.205	n/a	200
Sulphate	21	15	5	8.833	8	9	n/a	500(AO)
Zinc	114	0.067	0.001	0.011	0.003	0.011	0.03	5(AO)

Note max, min and percentiles all are expressed in mg/L
Exceedances are shown in bold

Table 3.3: Surface Water Quality of Root River (13001100402)

Station Location: **Root River, 0.70 km N of 5th Ln Sault Ste. Marie (13001100402)**
UTM Co-ordinate: **Easting: 705800 Northing 5162700**
Sampling Period **1986-1991** **INACTIVE**

	No. of Samples	Max.	Min.	Avg.	25th Perc.	75th Perc.	PWQO (mg/L)	ODWS (mg/L)
Arsenic							0.1	0.025(AO)
Chloride	44	95.0	3.400	26.456	14.825	30.550	n/a	250(AO)
Cobalt							0.0009	n/a
Copper	42	0.02	0.001	0.002	0.001	0.001	0.005	1(AO)
Cyanide	1	0.00	0.001	0.001	0.001	0.001	0.005	0.2
Iron	42	1.8	0.130	0.275	0.190	0.290	0.3	0.3(AO)
Nickel	42	0.010	0.001	0.002	0.001	0.002	0.025	n/a
Nitrogen TKJDL	35	0.89	0.200	0.366	0.275	0.375	10	10
Phosphorous	44	0.08	0.001	0.009	0.004	0.008	0.010-0.030	n/a
Sodium							n/a	200
Sulphate							n/a	500(AO)
Zinc	42	0.047	0.001	0.006	0.003	0.006	0.03	5(AO)

Note max, min and percentiles all are expressed in mg/L
Exceedances are shown in bold

In general, available water quality data appears to be similar from upstream to downstream water quality stations along the Root River except for the Iron, Phosphorous and Nitrogen concentrations. This would indicate a little impact to the River as a result of potential contaminant sources and urbanization from upstream to downstream locations.

A slight increase in chloride concentrations is noted at the downstream location (13001100102) (average chloride of 19.6 mg/L) to stations 13001100104 (average 26.5 mg/L). This may be a result of road salting. Very slight increases in iron and copper were also noted.

3.2.2.2 Fort Creek

Fort Creek originates at the northern limit of the Algonquin Terrace and flows through the heart of the urban district, located on the Nipissing Terrace. The Fort Creek dam was constructed in the 1970's upstream of the Second Line creek crossing to alleviate flood damage to the urban core. The upper two third of the watershed (i.e. upstream of the dam) is steeply sloped and has a number of steep sided ravines. Downstream of the dam at Second Line, the topography gently slopes south towards the St. Marys River. Below the dam, Fort Creek is conveyed by a concrete aqueduct from Hudson Street to Wellington and John Street. At John Street it again enters a concrete aqueduct to Queen Street. Below this point, Fort Creek flows along an open channel to the St. Marys River.

Water quality data for the Fort Creek is available from the PWQMN from 1972 to 1995. Comprehensive water quality parameters were analyzed to assess the water quality of this creek. The overall water quality analysis indicate that Chloride levels were below ODWS from 1972 to 1982 and after this period, there is noticeable increase in the concentration of Chloride (640 to 2 175 mg/L against the 250 mg/L of ODWS). This reflects the increasing impact of untreated storm water, urbanization and road salt activities within the catchments area. Cobalt is only measured once in the sampling period indicates concentration levels above the PWQS (0.002 mg/L against 0.0009 mg/L) attributes to increasing development. Elevated Iron concentrations (0.42 to 17 mg/L) are due to the mineralogy of the area. Nickel and Phosphorous levels were also elevated above the ODWS, which indicates the impact of surface runoff into the creek.

Water quality information is available for the Fort Creek at one monitoring location (PWQMN stations ID # 13000900102). The available data has been analyzed on water quality trends over time and presented in Appendix 3B. However, it is noted that the Fort Creek system is not used as a source of supply for municipal drinking water. It is also noted that there is no fish habitat, which might be due to elevated level of some pollutant as discussed above. The summary of water quality analysis for the Fort Creek is presented below:

Table 3.4: Surface Water Quality of Fort Creek (13000900102)

Station Location: **Fort Creek at Mouth Sault Ste. Marie (13000900102)**
UTM Co-ordinate: **Easting: 703769** **Northing: 5154684**
Sampling Period **1972-1995** **INACTIVE**

	No. of Samples	Max.	Min.	Avg.	25th Perc.	75th Perc.	PWQO (mg/L)	ODWS (mg/L)
Arsenic	5	0.01	0.01	0.01	0.01	0.01	0.1	0.025
Chloride	168	**2175**	5	165	66	177	n/a	250
Cobalt	1	**0.0022**	**0.0022**	**0.0022**	**0.0022**	**0.0022**	0.0009	n/a
Copper	94	0.1400	0.0005	0.0122	0.0040	0.0110	0.005	1
Cyanide	6	0.0100	0.0020	0.0087	0.0100	0.0100	0.005	0.2
Iron	118	**17.00**	**0.420**	**1.798**	**0.823**	**2.175**	0.3	0.3
Nickel	92	**0.070**	0.001	0.006	0.002	0.005	0.025	n/a
Nitrogen T	86	2.90	0.10	0.65	0.45	0.73	10.0	10.0
Phosphor	173	**1.40**	0.00	0.11	**0.04**	0.10	0.01-0.03	n/a
Sodium	15	108.0	23.0	56.1	40.0	59.0	n/a	200
Sulphate	16	28.0	14.0	21.6	18.3	25.6	n/a	500
Zinc	94	0.140	0.001	0.029	0.012	0.036	0.03	5

Note max, min and percentiles all are expressed in mg/L
Exceedances are shown in bold

3.2.2.3 Big Carp River

Surrounding the mouth of both the Big Carp and the Little Carp Rivers is a provincially significant wetland area known as the Carp River wetland. The wetland extends along approximately three (3) km of the St. Marys shore (Cooke, 2005). This wetland area is subject to flooding in times of elevated water on the St. Marys River and also in times of increased surface runoff.

Water quality information for the Big Carp River is available from the PWQMN from 1973 to 1999. Only one location (PWQMN – 1300300102) on this river is sampled for many of the water quality parameters includes Chloride, Iron, Nitrogen, Nickel and Phosphorous. Several water quality parameters were measured well below the aesthetic levels of ODWS except for Iron and Phosphorous.

The overall elevated trend of Iron concentrations for the period of 1973 to 1990 indicates the impact of surface runoff and mineralogy of the area. The Iron concentrations observed from 0.25 to 21.0 mg/L against the 0.3 mg/L of ODWS throughout the 17 year monitoring period.

An increasing trend in the Phosphorous levels of river water is observed. The average value is 0.032 to maximum of 0.53 mg/L is observed against the provincial water quality objectives (PWQOs), which might be due to surface runoff impact.

Table 3.5: Surface Water Quality of Big Carp River (13000300102)

Station Location: **Big Carp River Herkimer St, Sault St. Marie (13000300102)**
UTM Co-ordinate: **Easting: 695650** **Northing: 5177756**
Sampling Period **1973-1990** **INACTIVE**

	No. of Samples	Max.	Min.	Avg.	25th Perc.	75th Perc.	PWQO (mg/L)	ODWS (mg/L)
Arsenic	5	0.01	0.010	0.010	0.010	0.010	0.1	0.025
Chloride	155	68.0	1.670	6.310	3.390	6.900	n/a	250
Cobalt							0.0009	n/a
Copper	99	0.120	0.001	0.006	0.001	0.004	0.005	1
Cyanide	7	0.01	0.001	0.008	0.006	0.010	0.005	0.2
Iron	113	**21.0**	0.250	**1.184**	**0.670**	**1.150**	0.3	0.3
Nickel	92	0.070	0.001	0.006	0.001	0.002	0.025	n/a
Nitrogen T	78	1.10	0.200	0.471	0.350	0.588	10.0	10.0
Phosphor	156	**0.53**	0.001	**0.032**	0.014	**0.031**	0.01-0.03	n/a
Sodium	21	7.8	1.900	3.562	2.700	3.800	n/a	200
Sulphate	23	15.0	8.500	11.426	10.500	12.000	n/a	500
Zinc	99	0.070	0.001	0.013	0.004	0.014	0.03	5

Note max, min and percentiles all are expressed in mg/L
Exceedances are shown in bold

3.2.2.4 Little Carp

Water quality monitoring information for the Little Carp River is available from the PWQMN from 1983 to 1985. Only one location (PWQMN – 13000001002) on this river is sampled for many of the water quality parameters includes Chloride, Iron, Nitrogen, Nickel and Phosphorous. Several water quality parameters were measured well below the Aesthetic levels of ODWS except for Iron, Nickel and Phosphorous.

The overall elevated trend of Iron concentrations for the period of 1983 to 1985 indicates the impact of surface runoff and mineralogy of the area. The Iron concentrations observed from 0.47 to 4.7 mg/L against the 0.3 mg/L of ODWS throughout the three (3) years of monitoring period.

An increasing trend in the Phosphorous levels of river water is observed for the period of 1983 to 1984. The average value is 0.026 to maximum of 0.08 mg/L is observed against the provincial water quality objectives (PWQOs) of 0.03 mg/L, which might be due to surface runoff impact. The summary of water quality analysis is presented below.

Table 3.6: Surface Water Quality of Little Carp River (13000001002)

Station Location: **Little Carp River Leigh Bay Sault Ste. Marie (13000001002)**
UTM Co-ordinate: **Easting: 694950 Northing: 5156350**
Sampling Period **1983-1985 INACTIVE**

	No. of Samples	Max.	Min.	Avg.	25th Perc.	75th Perc.	PWQO (mg/L)	ODWS (mg/L)
Arsenic							0.1	0.025
Chloride	17	6	0.8	2.3	1.4	2.7	n/a	250
Cobalt							0.0009	n/a
Copper	18	0.0400	0.0010	0.0038	0.0010	0.0020	0.005	1.0
Cyanide							0.005	0.2
Iron	17	**2.5**	**0.475**	**0.958**	**0.655**	**1.175**	0.3	0.3
Nickel	18	**0.003**	0.001	0.002	0.002	0.002	0.025	n/a
Nitrogen TKJDL							10.0	10.0
Phosphorous	16	**0.076**	0.006	0.026	0.011	0.028	0.01-0.03	n/a
Sodium							n/a	200
Sulphate							n/a	500
Zinc	18	0.023	0.001	0.008	0.004	0.011	0.03	5

Note max, min and percentiles all are expressed in mg/L
Exceedances are shown in bold

3.2.2.5 East Davignon

The East Davignon head waters are located north of the city limits high within the Precambrian Shield. Nettleton Lake is a small lake (12 ha) located along the main branch of the creek at Fifth Line. The East Davignon flows south through a steep ravine to Rossmore Road. South of Rossmore Road, the urban development is very close to the creek. South of Second Line, the creek is channeled into a continuous concrete aqueduct which carries the creek across Wallace Terrace and then southwesterly through the Essar Steel Algoma Inc. property to the St. Marys River. Along this channel, discharges from Tenaris Algoma Tubes and Essar Steel Algoma Inc. contribute to the creek flow as well as the aqueduct carrying Central Creek.

Water quality monitoring information for the East Davignon is available from the PWQMN from 1972 to 1995 (23 years of data). One PWQMN site (13000800102) was monitored from 1972 to 1995 and the other PWQMN (13000800202) site was monitored from 1982 to 1983 on this river for many of the water quality parameters includes Chloride, Iron, Nitrogen, Nickel and Phosphorous. Several water quality parameters were measured well below the Aesthetic levels of ODWS except for Cobalt, Iron, Nickel and Phosphorous levels.

The overall elevated trend of Cobalt levels indicates the impact of surface runoff and mineralogy of the area. Cobalt and Iron concentrations observed from 0.005 to 0.15 mg/L and 0.001 to 11.0 mg/L against the 0.0009 mg/L and 0.3 mg/L respectively of ODWS throughout the monitoring period.

An elevated trend in Phosphorous levels of river water is observed for the period of 1972 to 1987. The average value is 0.04 to maximum of 0.45 mg/L is observed against the provincial water quality objectives (PWQOs) of 0.03 mg/L, which might be due to surface runoff from untreated storm sewage. The summary of water quality analysis is presented below.

Table 3.7: Surface Water Quality of East Davignon Creek (13000800102)

Station Location: **East Davignon near Mouth of Goulais Ave. (13000800102)**
UTM Co-ordinate: **Easting: 700890 Northing: 5155400**
Sampling Period **1972-1995 INACTIVE**

	No. of Samples	Max.	Min.	Avg.	25th Perc.	75th Perc.	PWQO (mg/L)	ODWS (mg/L)
Arsenic	23	0.0100	0.0010	0.0044	0.0020	0.0055	0.1	0.025
Chloride	164	78	1.8	15.4	8.2	17.6	n/a	250
Cobalt	12	**0.1500**	0.0005	**0.0262**	**0.0155**	**0.0200**	0.0009	n/a
Copper	129	0.0500	0.0005	0.0072	0.0022	0.0070	0.005	1.0
Cyanide	106	0.1760	0.0010	0.0074	0.0010	0.0100	0.005	0.2
Iron	155	**11.00**	0.001	**1.928**	0.295	**2.988**	0.3	0.3
Nickel	100	**0.180**	0.001	0.009	0.002	0.006	0.025	n/a
Nitrogen T	198	5.50	0.11	0.70	0.29	0.83	10.0	10.0
Phosphor	199	**0.45**	0.01	**0.04**	0.02	**0.05**	0.01-0.03	n/a
Sodium	17	9.5	2.5	4.8	3.5	5.5	n/a	200
Sulphate	39	47.0	4.5	10.4	7.0	11.3	n/a	500
Zinc	129	0.094	0.001	0.013	0.004	0.017	0.03	5

Note max, min and percentiles all are expressed in mg/L
Exceedances are shown in bold

3.2.2.6 Clark Creek

Clark Creek is an engineered drainage channel which conveys storm water run-off from the east end of the city to the St. Marys River. The creek discharges into the St. Marys River south of the Drake Street and Queen Street East intersection. From the Drake/Queen Street intersection to the discharge point on the St. Marys, the creek flows through a concrete box culvert. Upstream of this culvert, the creek is an open channel which extends northeast for approximately 750 m through the Gravelle Subdivision and the Sault Ste. Marie Golf Club and then north for approximately 900 m to the southwest corner of Bennett Boulevard and Boundary Road (Walker, 1998).

Water quality monitoring information for the Clark Creek is available from PWQMN for 1986 to 1995 (9 years of data). One PWQMN site (13001000102) was monitored for many of the water quality parameters includes Cobalt, Copper, Iron, Nitrogen, Nickel and Phosphorous. Several water quality parameters were measured well below the Aesthetic levels of ODWS except for Cobalt, Iron, Nickel and Phosphorous levels.

The overall elevated trend of Cobalt levels indicates the impact of surface runoff. Cobalt concentrations were observed to be 0.0014 mg/L and Iron concentrations were 0.2 to 17.0 mg/L against the 0.0009 mg/L and 0.3 mg/L of ODWS respectively throughout the monitoring period.

An elevated trend in Phosphorous levels of water is observed through out the monitoring period. The average value is 0.06 to maximum of 0.28 mg/L is observed against the provincial water quality objectives (PWQOs) of 0.03 mg/L, which might be due to surface runoff from untreated storm sewage. The summary of water quality analysis is presented below.

Table 3.8: Surface Water Quality of Clark Creek (13001000102)

Station Location:	**Clark Creek 100 m upstrm Queen St. (13001000102)**	
UTM Co-ordinate:	**Easting: 708790**	**Northing: 5152958**
Sampling Period	**1986-1995**	**INACTIVE**

	No. of Samples	Max.	Min.	Avg.	25th Perc.	75th Perc.	PWQO (mg/L)	ODWS (mg/L)
Arsenic							0.1	0.025
Chloride							n/a	250
Cobalt	1	**0.0014**	**0.0014**	**0.0014**	**0.0014**	**0.0014**	0.0009	n/a
Copper	64	0.0220	0.0010	0.0086	0.0026	0.0062	0.005	1
Cyanide	53	0.0030	0.0010	0.0011	0.0010	0.0010	0.005	0.2
Iron	64	**17.00**	0.210	**3.036**	**2.000**	**3.300**	0.3	0.3
Nickel	1	**0.003**	**0.003**	**0.003**	**0.003**	**0.003**	0.025	n/a
Nitrogen TKJDL	64	2.15	0.17	0.72	0.55	0.87	10.0	10.0
Phosphorous	64	**0.28**	0.01	**0.06**	0.03	**0.06**	0.01-0.03	n/a
Sodium							n/a	200
Sulphate							n/a	500
Zinc	64	0.240	0.001	0.030	0.009	0.036	0.03	5

Note max, min and percentiles all are expressed in mg/L
Exceedances are shown in bold

3.2.2.7 Lake Superior Gros Cap Intake

Municipal water in the City of Sault Ste. Marie is obtained from a combination of surface water and groundwater. About 50% of potable water is obtained from the Lake Superior at Gros Cap (WC Map 18). Water quality information from provincial sources for surface and groundwater supplies in the watershed region is available. Drinking water quality information in the source protection planning area is obtained from the Ontario Drinking Water Surveillance Program (ODWSP). Yearly averages for the raw/treated water quality data from Lake Superior Intake and Water Treatment Plant (WTP) are available from 1990 to 2005. The data is analyzed for selected chemical water quality parameters and microbiological quality.

The water quality analysis for the available data of raw water shows that there is no any water quality parameter exceeded the PWQO and drinking water standards (ODWS). As seen from the Box and Whisker Plots from Appendix 3C, only Cobalt levels were elevated (max of 1.10 mg/L) during the year of 1991. Iron concentrations ranged from 1 to 240 µg/l and observed elevated in 1993 but were below the ODWS. Zinc concentrations were close to ODWS in 2000 (5 mg/L). Summary plots of analysis are presented in **Appendix 3E**.

Table 3.9: Surface Water Quality of Raw Water at Lake Superior Gros Cap

Station Location:	**Lake Superior Gros Cap Raw Water**	
UTM Co-ordinate:	**Easting:**	**Northing:**
Sampling Period	**1999-2005**	**ACTIVE**

	No. of Samples	Max.	Min.	Avg.	25th Perc.	75th Perc.	PWQO (mg/L)	ODWS (mg/L)
Arsenic	44	0.7	0.1	0.5	0.3	0.6	100	25
Chloride	46	4.0	0.8	1.4	1.1	2.7	n/a	250 mg/l
Cobalt	46	**1.10**	0.00	0.06	0.03	0.58	0.9	n/a
Copper	46	6.8	1.6	3.3	2.4	5.0	5.0	1000
Iron, µg/L	46	240	1	11	6	125	300	300
Nickel	46	3.9	0.0	0.3	0.1	2.1	25	n/a
Nitrates	47	0.4	0.3	0.3	0.3	0.4	10 mg/l	10 mg/l
Nitrite	47	0.008	0.001	0.003	0.002	0.005	1 mg/l	1 mg/l
Phosphorous	47	0.020	0.002	0.005	0.003	0.012	0.03 mg/l	n/a
Sodium	46	2.8	1.2	1.4	1.3	2.1	n/a	200 mg/l
Sulphate	47	5.0	2.0	3.6	2.8	4.3	n/a	500 mg/l
Zinc	46	**5.0**	0.2	1.5	0.9	3.3	0.03	5 mg/l

Note max, min and percentiles all are expressed in mg/L
Exceedances are shown in bold

There is not any detailed information available at this point for the treated water supply. Only yearly summaries are available from ODWSP, which have already been discussed in this chapter under section 3.2.2. Summary plots of raw water quality at Water Treatment Plant are presented in **Appendix 3F**.

3.3 Groundwater Quality Data Analysis and Reporting

Characterizing a watershed from a groundwater quality perspective requires that the groundwater be understood in conjunction with all of the factors affecting it. In order to achieve such an understanding the groundwater quality information needs to be assembled with geospatial information in a manner that allows for the development of three-dimensional conceptual model. Such features as physiography, geology, groundwater flow patterns and land use would all be included. The final model can then be used to evaluate the significance of risks and the need for risk management measures to protect the groundwater resource throughout the Sault Ste. Marie Watershed Region.

3.3.1 Sources of Groundwater Quality Data

3.3.1.1 Municipal Groundwater Wells of Sault Ste. Marie

The Municipal/Public supply system accounts for the largest water-consuming category within the study area, and is located completely within the Urban Service Line area of the City of Sault Ste Marie. The system is comprised of groundwater and surface water, each contributing approximately equal portions to the municipal/public system. Based on MOE records, six municipal wells provide the groundwater component, and the surface water component is now provided by Lake Superior. The regional groundwater quality is assessed from previous water quality investigation reports (International Water Consultant Ltd., 1995).

3.3.1.2 Provincial Groundwater Monitoring Network

The Ministry of the Environment, to address the need for baseline groundwater data initiated the Provincial Groundwater Monitoring Network (PGMN) in partnership with Ontario's 36 Conservation Authorities in 2000. This Network consists of approximately 400 monitoring wells. The goal of this network is to determine where, how, and why the groundwater resources is changing.

As part of the provincial network, the Sault Ste. Marie Region Conservation Authority and the PUC Services in partnership with the Ministry of the Environment maintain thirteen (13) monitoring wells in the watershed area. These wells record water levels with automated water level monitoring equipment on a daily basis, providing valuable information. In 2005, water samples were collected and analysed for water chemistry parameters.

3.3.1.3 City of Sault Ste. Marie Landfill Site

The City of Sault Ste. Marie landfill site is located in the north of Fifth Line East, north of the City. The site is located to the northwest of Root River. A leachate collection system was installed south of the landfill during the summer of 1992 and has been operating without interruption since November 1992. Prior to 1998, the collected leachate was re-circulated (pumped up to the northern end where it was discharged back into the landfill). In 1998, the leachate collection system was connected to the sanitary sewer system of Sault Ste. Marie (Dillon, 2009) and is treated at the west end wastewater treatment plant. A review of the landfill monitoring reports including 2009 has been completed to understand the water quality issues related to this waste disposal facility.

The purpose of the landfill-monitoring program is:

- Monitor surface and groundwater quality in the vicinity of the site;
- Provide sufficient chemical information to evaluate the impact of the landfill site on groundwater quality;
- Assess the ability of the natural environment to attenuate contamination from the landfill;
- Compare target chemical concentrations in the surface and groundwater to boundary criteria established by the MOE;
- Predict future movement of contaminants and thus predict future compliance with MOE criteria.

Since 1998, several monitoring wells have been installed west of the landfill to investigate off-site groundwater quality. In November 2002, four additional monitoring wells were installed to delineate the extent of groundwater impacts to the southwest of the landfill. Additional monitoring wells were installed in 2004 and 2005. In 2005 indicator parameters in monitoring wells at the western boundary generally increased causing the speculation that the purge well system was not performing as expected or was at its limit of effectiveness. This led to the establishment of the Contaminant Attenuation Zone (CAZ) which extended the western compliance boundary. Additional monitoring wells were also installed at or near the proposed western Contaminant Attenuation Zone (CAZ). These wells were installed to better define the plume and assist with the design and location of potential purge wells in this area.

A total of 38 ground water monitoring wells was sampled in 2008. Groundwater samples were collected in May, August, October and November in 2008. Groundwater elevations were measured at the time of sampling. The surface water monitoring program involved collection of water and benthic invertebrate samples at five locations along Canon Creek and the Root River, with five sampling events conducted in 2008 (Dillon, 2009).

Based on the latest 2008 sampling program, Dillon's report concludes:

Ground Water Quality

- Natural attenuation process and dilution by infiltration of precipitation are maintaining, reducing or keeping the plume stationary along the eastern and southern property boundaries.
- Monitoring wells that are down gradient of the leachate collection system show decreased groundwater levels and indicate improved ground water quality to the point where there is no significant impact south, down gradient of the leachate collection system, in the meander area, or to the east of the landfill.
- Prior to 2001, results along the western boundary had exceedances for several parameters in both on-site and off-site monitoring wells. Concentration of key indicator parameters particularly chloride, declined in 1997 and 1998. Chloride concentration between 2001 and 2002 fluctuated significantly. The 2003 and 2004 data indicated an improvement in water quality along the western site boundary as well as off site.
- The 2005 monitoring data along the western boundary indicated that the decreasing trends in 2003 and 2004 had leveled off. In 2006 and 2007, water quality generally along the western boundary improved significantly. At that time the western contaminated plume had a pronounced separation. In 2007 and 2008, the chloride concentrations at well # 56-I decreased further.
- In 2008, five new wells were installed west of the landfill to assess the water quality. The analytical results are generally consistent with background water quality. These wells have very low chloride concentrations (all less than 5 mg/L). This indicates that the groundwater quality at these new wells has not been impacted by leachate.
- Based on several years of monitoring results, contaminant plumes were delineated and mitigative measures including the installation of purge wells and leachate collection system were established in order to restrict migration of contaminants offsite.

Surface Water Quality

- In 2008, surface water quality at a station on the Root River met almost all effluent criteria established in the Provincial Certificate of Approval. The only exceedance of effluent criteria at this station was for zinc. This is not considered to be an effect of the landfill because two stations upstream of landfill also experienced elevated concentrations. The reduced impact of leachate on the realigned Canon Creek is visually evident from the absence of iron staining on the rocks. Investigation into the source of ammonia impacts will be undertaken if monitoring reveals continuing exceedance of the un-ionized ammonia criteria.

- Since 1992, benthic invertebrate community has been used as a biological indicator of water quality in Canon Creek and the Root River. The water quality in Canon Creek in 2008 was slightly improved over 2007 for most water quality parameters. A significant improvement has been noted in aquatic habitat along the realigned reach of creek. The water quality in the Root River has improved during the two years since Canon Creek was realigned, the improvements have been marginal.

Methane Gas

For the first time, methane gas concentration in the explosive range has been measured at a methane gas monitor. This is an indication of increased landfill gas migration in the subsurface away from the landfill in a southwesterly direction. As the landfill continues to develop in a westerly direction, elevated methane concentrations are expected at the same location.

Leachate

Leachate continues to comply with the MOE model sewer use by-law, with the exception of manganese in 2008. Manganese was slightly over the by-law limit (5.44 mg/L versus 5.0 mg/L). As in past years, the leachate is toxic to fish and must be diluted by a factor of 5 or 6 to achieve a reasonable concentration. Continued fish toxicity testing of leachate was considered not to be useful.

3.3.1.4 City of Sault Ste Marie Groundwater Supplies

Fifty percent (50%) of the municipal water in the City of Sault Ste. Marie is obtained from groundwater, via six wells, located on Central and Eastern Basins of Watershed. The water is disinfected with sodium hypochlorite and ammonia is added to provide chloramine for secondary disinfection prior to being pumped into the distribution system. Only data from 2003 to 2006 per 3 monthly averages for some water quality parameters is available from ODWSP.

3.3.2 Groundwater Quality

Groundwater quality data for the watershed is limited. Only summaries from the previous conducted studies (IWS, 1995 and Burnside, 2003) is available for the ground water quality assessment. A detail water quality analysis of the PGMN network is available for only the year 2005. No detailed long term data is available for the municipal groundwater well (raw and treated at each well for monthly basis). Only yearly averages data is analyzed due to its availability.

3.3.2.1 Municipal Supplies

The water quality both from surface and ground of the City of Sault Ste. Marie is good and there have been no exceedances from PWQOs and ODWS observed. The 1995 study by the IWC focused on the impact of road salts and land uses on the municipal well. A summary of the conclusion is presented in Burnside Groundwater study (Burnside, 2003). The conclusion of this study is summarized as following:

- Chloride concentrations in the Goulais and Steelton wells gradually increased from about 10 mg/L in 1985 to 40 – 60 mg/L in 1994.

- Chloride concentrations in the Shannon Well remained at about the same level, while at the Lorna Wells, the Chloride levels increased from 20 mg/L in 1965 to 65 mg/L in 1994.

- Based on relative concentrations of chloride, sodium and calcium, and ratio of chloride /calcium and boron/strontium, IWS concluded that there are three chemically different sources of water that are being tapped by municipal wells. Goulais and Steelton wells were identified to be tapping from one source, while Shannon and Lorna wells are tapping two other chemically different groundwater sources.

The water quality analysis for the municipal wells as presented in the Engineer's report for waterworks under taken by Delcan (May 31, 2001) show the following results of chloride concentrations in the raw water samples.

Table 3.10: Summary of Chloride Study of SSM Groundwater Supply

Waterworks	Chloride (mg/L)	Sampling Date
Goulais Well	51	Jul-2000
Steelton Well	20	Mar-2000
Shannon Well	37	Mar-2000
Water Treatment Plant	1.4	Sep-2000

The above results in Table 3.10 indicate that the chloride levels slightly decreased and show no increase in sodium concentration in the groundwater during the 6 years since sampling in 1994.

Only yearly basis summery is available from the ODWSP from 1993 to 2006. The summary indicates that there were no health related ODWOs exceeded. No other detailed water quality data for each well is available to further explore the water quality trends over time.

The overall results of the raw groundwater quality are summarized below in Table 3.11 and it is noted that only cobalt concentrations (max. 2.30ug/L) were observed in 1993.

Table 3.11: Summary of Raw Groundwater Quality (ODWSP)

Station Location: **Raw Groundwater Quality**
UTM Co-ordinate: **Easting:** **Northing:**
Sampling Period **1990-2005**

	No. of Samples	Max.	Min.	Avg.	25th Perc.	75th Perc.	PWQO (μg/L)	ODWS (μg/L)
Arsenic	86	3.6	0.1	1.4	0.8	2.5	100	25
Chloride	85	76	16.4	43.6	30.0	59.5	n/a	250 mg/l
Cobalt	167	**2.30**	0.01	0.10	0.06	1.20	0.9	n/a
Copper	86	14.8	0.2	3.0	1.6	8.9	5.0	1000
Iron	86	30.0	0.0	5.2	2.6	17.6	300	300
Nickel	157	8.50	0.08	0.48	0.28	4.49	25	n/a
Nitrogen TKJDL	87	0.43	0.02	0.09	0.06	0.26	10 mg/l	10 mg/l
Phosphorous	87	0.03	0.00	0.01	0.00	0.02	0.03 mg/l	n/a
Sodium	87	31.6	3.4	18.0	10.7	24.8	n/a	200 mg/l
Sulphate	87	15.0	0.5	11.7	6.1	13.4	n/a	500 mg/l
Zinc	86	7.60	0.20	1.56	0.88	4.58	0.03	5000

The available Treated water data for the four groundwater wells have been analyzed for selected water quality parameters and presented below. The treated water met all health-related ODWS. The concentrations of Sodium chloride, nitrite and nitrate at these wells are well below the aesthetic level of ODWS.

Table 3.12: Treated Groundwater Quality of Municipal Wells

Treated Groundwater Municipal Well Water Supply Quality
Monitoring Period : 2003 to 2006 every 3 month frequency

Groundwater V	Arsenic (ug/L)	Nitrate (mg/L)	Nitrite (mg/L)	Sodium (mg/L)
GOULAIS	1.00	0.714	0.032	11
LORNA	2.33	0.030	0.051	31
SHANNON	2.75	0.092	0.023	24
STEELTON	1.00	0.778	0.038	9
PWQOs	100	10	1.000	n/a
ODWS	25	10	1.000	200

3.3.2.2 Domestic Wells

A regional groundwater study was under taken by Burnside in 2003. During this study, residential surveys were also undertaken. One hundred and thirty-five (135) domestic wells spread out over the study area were sampled and analysed for general chemistry parameters. The results of the analysis are summarized below:

Table 3.13: Summary of Domestic Well Quality in SSM Watershed

	Chloride (mg/L	Nitrate (mg/L)	Iron (mg/L)
ODWS	250	10	0.3
Max.	302	9.1	11.5
Min.	0.25	0.1	0.003
Avg.	20.77	0.66	0.277
St. Dev.	43.33	1.2	1.12

Analytical data for Chloride, Iron, Nitrate and Total Dissolved solids (TDS) were evaluated to assess the general quality of groundwater in the study area. Frequency plot of these parameters are presented in **Appendix 3I.** The plots show that these parameters are typically well below Ontario Drinking Water Standards (ODWS) in the majority of wells tested. Nitrate is the only health-related parameter reviewed, and all samples are less than the ODWS of 10.0 mg/L, with the majority of samples showing concentrations less than 1.0 mg/L.

The groundwater quality characteristics are assessed from the piper plot of all the domestic well water quality results. The water quality in most of the water wells can be characterized as calcium carbonate water, and a number of them exhibited mixed water quality. Based on the regional geochemistry, the groundwater quality is expected to be predominantly calcium carbonate waters consistent with the observed water quality in a number of wells. However, local variations in the subsurface stratigraphy and local land use activities may result in mixed waters.

In order to assess spatial variation of the water quality, concentrations of three parameters, chloride, nitrate and iron are plotted as bubble diagrams in **Appendix 3J** respectively. These plots illustrate the following trends:

- **Chloride**: Elevated chloride values are concentrated in the southwestern part of the study area, with a few in the vicinity of the Hwy 17 corridor to the south of the Landfill. Locally, slightly elevated chloride concentrations are also seen near Heyden and on the northwest part of the study area. The majority of samples north of the City are close to 10.0 mg/L, with only scattered analyses above 50 mg/L. These values are below the ODWS aesthetic objective of 250 mg/L. These chloride concentrations are indicative of possible impacts from road salt usage along Hwy 17 and in the area of the City. Another area of elevated chloride concentrations occurs in Pointe des Chênes Park, west of the City. This is a wetland area and thus an area of groundwater discharge. The chloride concentrations may reflect the local land use in this area. Both of these areas of higher chloride concentration also have slightly elevated TDS concentrations.

- **Nitrate**: The majority of nitrate values are below 3.0 mg/L. An area of elevated nitrate values (to 9 mg/L) is centred at 5160000m north, from 695000m to 700000m east (between the Third and Fourth Lines in Korah). This area is near the contact of the overburden sediments and the Precambrian uplands, and is underlain by coarse-grained deposits of the main groundwater recharge zone. This coarser material allows rapid infiltration of surface water to the water table, resulting in less time being available for the natural attenuation of nitrates from septic systems, and elevated nitrate concentrations locally.

- **Iron**: The majority of iron analyses from the groundwater samples returned concentrations less than 0.1 mg/L, which is below the ODWS aesthetic objective of 0.3 mg/L. The highest iron concentrations noted in the study area are less than 2.0 mg/L, and are located in the area of Heyden Lake, on Hwy. 17 north of Sault Ste. Marie. This area is in the centre of the Precambrian uplands, and the iron is likely associated with isolated occurrences of iron-rich rocks within the Precambrian.

3.3.2.3 Provincial Groundwater Monitoring Network (PGMN)

Water quality analysis for the selected parameters for the 1st round of sampling is carried out. The result are summarized below in Table 3.14 and graphs are presented in **Appendix 3G**

It is noted that elevated chloride levels for well # W0000451 observed but were below the ODWS. Elevated Iron above ODWS observed for the well # W0000413, W0000450, W0000448, and W0000415, which indicates the existence of iron in the mineralogy of the area.

Table 3.14: Summary of Provincial Groundwater Monitoring Network (PGMN)

Station Location: **Provincial Groundwater Monitoring Network (PGMN)**

Sampling Period **2005**

	No. of Samples	Max.	Min.	Avg.	25th Perc.	75th Perc.	PWQO (µg/L)	ODWS (µg/L)
Arsenic	12	3.9	0.1	1.4	0.4	2.2	100	25
Chloride	14	224	0.2	45.3	1.8	92.8	n/a	250 mg/l
Cobalt							0.9	n/a
Copper	14	24.6	0.1	3.8	0.5	3.3	5.0	1000
Iron	14	11800	6	2060	61	1084	300	300
Nickel	14	2.50	0.10	1.09	0.58	1.58	25	n/a
Nitrogen T	14	0.34	0.05	0.10	0.05	0.05	10 mg/l	10 mg/l
Phosphorous							0.03 mg/l	n/a
Sodium	14	88.0	1.4	34.5	7.9	64.2	n/a	200 mg/l
Sulphate							n/a	500 mg/l
Zinc	14	28.10	0.50	4.93	1.20	3.85	0.03	5000

3.4 Raw Water Characterization for Drinking Water Intakes

Municipal drinking water in the area is obtained from a combination of surface water and groundwater sources. As discussed in previous sections, the raw water quality at the Sault Ste. Marie WTP and the six groundwater wells is good, with parameters generally meeting drinking water quality standards. The only exception is the sodium and chloride concentrations at the groundwater wells, indicating small increasing trend due to the road salt impact. Available chloride concentrations at the Goulais and Shannon well (2000) are 51.0 mg/L and 37.0 mg/L, respectively, indicating possible road salt impact but the levels remain below the ODWS.

3.5 Microbial Source Water Characterization

Bacteriological water quality data was obtained from several sources (PWQMN and ODWSP). The raw water at the drinking water intake is analyzed for bacteriological quality, as are the PWQMN sites. At the PWQMN sites, the most commonly analyzed microbial indicator is Fecal Coliform. *E. Coli* counts at the various surface water stations along the St. Marys River (13000000302) and Root River (13001100102 and 13001100202) for which available data is highly variable, with occasionally very elevated results, in excess of 1 000 counts/100 mL. Box and Whisker Plot for this analysis is presented in **Appendix 3H.**

Monthly data analysis of surface raw water from Lake Superior showed *E.Coli* counts from 0 to 2 per 100 ml and 0 to 18 counts of Total Coliform per 100 ml for the available data (2005 and 2006). As expected, no *E.Coli* or Total Coliform were observed from the raw water data from all six groundwater wells from the available data (weekly data for 2006 from ODWS and 2001 to 2002 from Burnside, 2003).

3.6 Great Lakes Considerations

The western portion of the St. Marys River watershed drains in to Lake Superior above the St. Marys River and the central and eastern portions of the watershed drain directly in to the St. Marys River.

The *Clean Water Act, 2006* requires that Source Protection Areas that flow in to the Great Lakes, connecting channels or the St. Lawrence River must consider the following documents: Great Lakes Water Quality Agreement, the Canada-Ontario Agreement Respecting the Great Lakes Ecosystem, the Great Lakes Charter and any other agreements to which the government of Ontario or Canada is a party. The Great Lakes Water Quality Agreement (GLWQA) is the prescribed document that has specific influence on the preparation of the Assessment Report

The Great Lakes Water Quality Agreement (GLWQA) identified 43 polluted areas on the Great Lakes as Areas of Concern (AOC). Under the GLWQA a Remedial Action Plan (RAP) for the St. Marys River was developed to address 5 AOCs.

Major environmental issues of concern in the area included:

- Restrictions on fish and wildlife consumption
- Unhealthy fish and wildlife populations
- Fish tumours and other deformities
- Unhealthy populations of bottom-dwelling organisms
- Restrictions on dredging
- Undesirable algae due to excess nutrients in the water
- Beach closures
- Poor aesthetics

- Loss of fish and wildlife habitat

There were three stages identified for the RAP.

Stage 1: Identify environmental problems and sources of pollution.
In May 1992, "The St. Marys River Area of Concern Environmental Conditions and Problem Definitions Stage 1" document was prepared to summarize environmental conditions and problem definitions.

Stage 2: Evaluate and carry out actions to restore the area.
In March of 1999, the Delisting Criteria for the St. Marys River Stage 2 RAP document was completed by members of BPAC, concerned citizens, and representatives of RAP affiliated organizations. The Stage 2 document entitled "The St. Marys River Area of Concern Remedial Strategies for Ecosystem Restoration" was released in 2002.

Stage 3: Confirm that these actions have been effective and that the environment has been restored.
Currently there is an ongoing monitoring process in the St. Marys River Area of Concern. This process also documents evidence that uses have been restored.

The St. Marys River Bi-National Public Advisory Council (BPAC) was created on November 13, 1988. It is a stakeholder's group, and members include citizens, property owners, tribes, elected officials, health units, municipal staff, and university staff from both Canada and the United States. BPAC was formed to assist government agencies that are responsible for preparing a Remedial Action Plan (RAP) for the St. Marys River Area of Concern (AOC). BPAC has been consulted through the preparation of the Assessment Report.

The Remedial Action Plan for the St. Marys River was considered through the development of the Assessment Report it was concluded that the current AOCs do not have any known impacts on the water quality within the Intake Protection Zones for the Gros Cap intake (WC Map 18A).

To date, there have been no “Great Lakes Targets” assigned to the Sault Ste. Marie Region Source Protection Area by the Ontario Minister of the Environment. If and when targets are set, required research and policy development protocols will need to be established to achieve the targets.

4.0 WATER QUANTITY

4.1 Water Use

Understanding the anthropogenic uses of water, especially permitted water takings, is important in a water budget because of the often significant loss of water from the watershed.

Water use in the SSMR Source Protection Area can be grouped into the following categories:

- Agricultural
- Commercial
- Construction
- Dewatering
- Drinking water supply
- Industrial
- Recreational
- Remediation

Present uses include both surface water and groundwater extractions. The information regarding the water consumption/anthropogenic use of water in the SSM Watershed Region was obtained from the Ministry of the Environment Permit To Take Water (PTTW) database.

Based on the limited available information, there are nine (9) and fourteen (14) active water-taking permits inventoried in surface and groundwater category (WC Map 15). Table 4.1.1 and 4.1.2 are shown below, provides the summary of water use and users in the watershed region (WC Map 16). The water use is based on the maximum daily taking and maximum permitted rate per year.

4.1.1 Drinking water Supply

The largest surface water user in the study area is the municipal supply system that is primarily located within the Urban Service Line of the City of Sault Ste. Marie. The system also supplies potable water to an area of the Rankin First Nations Reserve. The source comprises of surface and groundwater with each contributing an approximately equal portion to the municipal system. This system is used to meet the needs of both the public and the commercial and industrial sectors.

The only source of surface water is from the Gros Cap intake located southwest of the Lake Superior shoreline. The other half of the water needs is contributed from groundwater sources. The current permitted pumping rate for the Gros Cap Intake is 7.5 ML/d (75 000 m^3/d).

4.1.2 Industrial

The main use for surface water taking includes hydroelectric power generation. The permitted rate is approximately 85 GL/d (85 076 300 m^3/d). Other uses include irrigation, process water and cooling. Permitted pumping rate for a few of the permits was not provided in the information available. However, based on available information the estimated total permitted volume of annual water taking for commercial and industrial purposes (not including hydroelectric power or municipal supply) is approximately 34 GL (34 320 000 m^3)/annum.

Areas of the city outside of the urban service line, Prince Township and the Sault North planning area are primarily serviced by individual domestic wells. Shallow dug wells are common where groundwater is present but limited to the shallow surficial sand and gravel lenses. Water demands of such areas are estimated based on 350 litres per capita per day (L/c.d) (Best Management Practices Water Wells, 1997). There are also a number of Permits to Take Water (PTTW) that have been issued for small communal systems, both public and private, using more than 50 m^3/d. Based on the assumption that the population of Prince Township is 9 400, the individual/domestic water demand within the study area is estimated at approximately 12 GL/a (1 204 170 m^3/annum).

The residents from the City of Sault Ste. Marie are serviced by six municipal wells that obtain water from the Jacobsville Formation and overlying units of the east and central basins. There are two (2) wells at the Lorna Well Site and one (1) well at the Shannon Well Site within the east basin. The total permitted rate in this basin is 21 ML/d (21 000 m^3/day) or 7.7 GL/a (7 665 000 m^3/annum). There are two (2) wells at the Goulais Well Site and one (1) well at the Steelton Well Site located in the central basin. The total permitted rate in this basin is 18 ML/d (18 188 m^3/day) or 6.6 GL/a (6 639 000 m^3/annum). According to PUC Services Inc., the amount of water pumped from the wells averaged approximately 17 ML/d (17 000 m^3/day) in 2004 and 15 ML/d (15 000 m^3/day) in 2005, which was well below the permitted limit.

The commercial and industrial system is primarily serviced through the municipal network. Approximately 3.2 GL/a (3 200 000 m^3/annum) are accounted for in the municipal category. Based on current available data, there are no existing PTTW records for groundwater taking; however, as indicated previously, there are a few surface water PTTWs identified for commercial and industrial purposes. Other than municipal water supply, the only other major groundwater taking is associated with remediation programs, one of which is owned by the SSM Municipal Landfill.

There is no major groundwater takings associated with agriculture.

As a part of water balance, the water used by ecosystem and recreational features is not known since no monitoring data are available at this stage to provide quantitative estimates.

Permits to Take Water (PTTWs) are issued for water supply wells that draw more than 50 m^3/d (50 000 L/d). The type of use of each of the PTTW is also shown in Table 4.1.1 and Table 4.1.2. PTTWs on file at the MOE for the City of Sault Ste Marie include permits for groundwater remediation, and communal water supply. In total, the maximum permitted volume of annual water taking for these purposes is approximately 0.54 GL/a (540 200 m^3/annum). This accounts for approximately 4% of the permitted municipal takings.

Table 4.1.1: Surface Water Permits to Take Water

Permit No.	Source Name	General Purpose		Expiry Date	Issued Date	Municipality	Maximum Permitted Rate (m^3/d)	Maximum Permitted Rate (m^3/year)
74-P-5000	St. Marys River	Commercial	Golf Course	8/31/2009	4/29/1974	City of Sault Ste. Marie	1 527	557 355
0225-68PS83	Thayer Spring	Commercial	Aquaculture	3/31/2014	9/24/1984	City of Sault Ste. Marie	-	-
96-P-6005	Clergue Generating Station Tailrace	Commercial	Aquaculture	5/6/2006	6/5/1996	City of Sault Ste. Marie	1 384	505 160
92-P-5035	St. Marys River Power Canal	Industrial	Hydro-Electric	3/30/2008	12/22/1992	City of Sault Ste. Marie	128 000	4 672 000
78-P-5110	St. Marys River	Industrial	Hydro-Electric	3/31/2028	5/26/1978	City of Sault Ste. Marie	84 948 300	31 006 129 500
97-P-6009	St. Marys River	Industrial	Cooling Water	3/31/2017	3/14/1997	City of Sault Ste. Marie	3 318	1 211 070
2153-6DMMXM	Upper St. Marys River	Industrial	Pulp and Paper	6/30/2015	6/24/2005	District of Algoma	-	-
0641-6CQJBP	Upper St. Marys River	Industrial	Cooling Water	6/1/2015	6/14/2005	District of Algoma	-	-
92-P-5951	Gros Cap/Lake Superior	Water Supply	Municipal	7/24/2007	4/23/1992	Township of Prince	75 000	27 375 000
00-P-6058	Holding Pond/East Gavignon Creek	Commercial	Golf Course	31-Oct-05	13-Feb-01	City of Sault Ste. Marie	1555	279900

Table 4.1.2: Groundwater Permits to Take Water

Permit No.	Source Name	General Purpose		Expiry Date	Issued Date	Municipality	Maximum Permitted Rate (m^3/day)	Maximum Permitted Rate (m^3/year)
01-P-6022	Sault Ste. Marie Municipal Landfill	Remediation	Groundwater	6/27/2011	6/27/2001	City of Sault Ste. Marie	720	262 800
01-P-6022	Purge Wells	Remediation	Groundwater	6/27/2011	6/27/2001	City of Sault Ste. Marie	650	237 250
02-P-6005	MOE well #11-937	Water Supply	Campgrounds	5/30/2012	5/31/2002	Parke	-	-
02-P-6005	MOE well # 11-940	Water Supply	Campgrounds	5/30/2012	5/31/2002	Parke	-	-
02-P-5039	Drilled Well	Water Supply	Communal	3/31/2013	5/5/2003	City of Sault Ste. Marie	-	-
98-P-6059	Well	Water Supply	Communal	12/31/2008	7/6/1998	District of Algoma	38	13 870
02-P-5045	Upper Well	Water Supply	Communal	6/23/2013	6/24/2003	City of Sault Ste. Marie	-	-
02-P-5045	Lower Well	Water Supply	Communal	6/23/2013	6/24/2003	City of Sault Ste. Marie	-	-
02-P-5033	Steelton Well	Water Supply	Municipal	8/11/2012	8/13/2002	City of Sault Ste. Marie	8 200	2 993 000
02-P-5052	Goulais Well #1 and # 2	Water Supply	Municipal	8/11/2012	12/31/2002	City of Sault Ste. Marie	10 001	3 650 365
78-P-5115	Shannon Well, River Range	Water Supply	Municipal	4/30/2018	3/23/1998	City of Sault Ste. Marie	7 000	2 555 000
92-P-5034	Well #1, Section 20	Water Supply	Municipal	3/31/2013	12/18/1992	District of Algoma	50	18 250
92-P-5034	Well #2, Section 18	Water Supply	Municipal	3/31/2013	12/18/1992	District of Algoma	22	8 030
78-P-5116	Lorna Well #1 and #2	Water Supply	Municipal	8/11/2012	6/16/1978	City of Sault Ste. Marie	13 638	4 977 870
00-P-6042	PW-1	Commercial	Golf Course	31-Oct-05	31-Oct-00	City of Sault Ste. Marie	231	55 670
00-P-6058	Well near East Davignon Creek	Commercial	Golf Course	31-Oct-05	13-Feb-01	City of Sault Ste. Marie	1 310	235 800
94-P-6015	addition Lots 26, 59, 60 (both sw & gw)	Commercial	Golf Course	31-Mar-04	06-Jun-94	City of Sault Ste. Marie	205	8 200

The data sources for the assessment of the amount of water used by residents and businesses within the study area included: Sault Ste Marie Public Utilities Commission pumping records, Ministry of the Environment water well records, permits to take water, and typical water consumption estimates based on type of use. Table 4.1.3 provides a summary of groundwater users in the City of Sault Ste Marie and surrounding area.

Table 4.1.3: Groundwater Use Summary

Water Use Area/Category	Total Annual Volume (m^3/annum)	Comments	Source
Prince Township	128 000	Based on a population of 977 and 350 L/c/d	1
Batchewana First Nation	19 000	Based on a population of 150 and 350 L/c/d	1
Sparse rural population	1 060 197	Based on a population of 8,299 and 350 L/c/d	1
Sault Ste Marie PUC - Municipal Supply (groundwater)	7 850 000	Based on PUC annual pumpage summary	2
Sault Ste Marie PTTW (groundwater)	540 200	Based on PTTW maximum daily water taking	3
Total Volume of Taking	9 597 397		

Taken from MacViro Water Budget Study for SSM Watershed
1 Best Management Practices, *Irrigation Management*, Agriculture and Agri-Food Canada, Ontario Ministry of Agriculture, Food and Rural Affairs, 1995.
2 Sault Ste Marie Public Utilities Commission, Annual Pumpage Summary, 2000.
3 Ministry of Environment, Permits to Take Water (PTTW).

WC Map 15: Water Taking Volume (PTTW)
WC Map 16: Water Taking Use (PTTW)

5.0 DESCRIPTION OF VULNERABLE AREAS

Since 1997, municipalities and Conservation Authorities have undertaken numerous groundwater management studies that have been aimed at assessing the vulnerability of aquifers to contamination, delineating wellhead protection Areas (WHPAs) and completing an inventory of potential source of contamination within WHPAs. Groundwater sources of the St. Marys River watershed have been previously studied with respect to hydrogeologic characterization, aquifer vulnerability, groundwater management and delineation of WHPAs (Burnside 2003 & 2005).

5.1 Identification of Source Protection Area

A common broad goal of the Drinking Water Source Protection Program is to minimize the degradation to the quality of groundwater resources. In order to achieve this broad goal, land use quantities of hazardous materials, best management practices for containment, etc. are seen as means by which land uses can be directed or managed, to reduce the likelihood of groundwater contamination.

In the Sault Ste. Marie Region Source Protection Area, there are nine (9) areas that have been identified as vulnerable areas. Six of these are groundwater protection areas containing six (6) municipal groundwater supply wells. These areas have been studied for groundwater management. The seventh area is the Intake Protection Zone (IPZ) for the Sault Ste. Marie surface water supply. The municipality draws 50% of its water supply from the Gros Cap, Lake Superior. The eighth source protection area is the significant groundwater recharge zones at the base of Precambrian uplands within the watershed. The ninth source protection area that may have potential future groundwater supply source is located in the Western basin and has not been studied.

5.2 Groundwater Wellhead Protection Areas (WHPA's)

The wellhead protection area (WHPA) is simply the area (both on the surface and subsurface) that contributes groundwater to a water supply well. In other words, WHPA is the volume of soil/geologic material that contributes groundwater to a water supply well. The WHPA is typically based on a time of travel (TOT) assessment, which identifies the area supplying groundwater to the well over a given time frame, 2 years, 5 years and 25 years. Identifying such time-based areas provides a reasonable length of time to respond to identified threats within the well head protection areas.

The WHPAs have been delineated based on TOT capture zone for the City of Sault Ste. Marie wells by using the 3 dimension groundwater model (MODFLOW). The 100-m, 50-day, 5-year, 10-year, and 25-year TOT capture zones were delineated in previous groundwater studies (Burnside, 2003 & 2005).

WC Map 17 represents the TOT zones that were delineated for the municipal wells (Goulais Avenue Well, Steelton Well, Shannon Well and Lorna Wells). The capture zones associated with the City municipal wells elongate and exist roughly within the East and Central basins where the wells are located. The TOT zones for the Goulais Avenue and Steelton wells are oriented northeast while those for the Shannon and Lorna wells are oriented in a northwest direction. All TOT zones terminate in the significant recharge area that occurs at the foot of the Precambrian highlands. This indicates that the Precambrian high land area is a very important recharge zones for all wells in the City of Sault Ste. Marie.

- 100 m, 0-2 year TOT zone:

  A 0-2 year TOT was delineated which correspond to the 2-year zone in the groundwater study. A 100 m prohibition area was delineated around the wells and the 50-day TOT zone was eliminated accordingly to MOE TOR (Burnside, 2005). This 2-year TOT zone represents the bacteriological/pathogenic protection zone. The 100 m prohibition area is defined based simply on a fixed radius from the well.

- 5-year TOT zone:

The 5-year TOT capture zone was delineated to represent the zone for protection from Dense Non-Aqueous Phase Liquids (DNAPL). The 5-year TOT zone served as the focus for the assessment of contaminant risk from the fuel storage.

- 25-year TOT zone:

  The 25-year TOT zone was also delineated to reflect a secondary wellhead protection area (WHPA). A similar assessment of contamination risk was performed in this zone, although the assessment criteria were relaxed.

WC Map 17 : Well Head Protection Areas

5.3 Surface Water Intake Protection Zones (IPZs)

5.3.1 Great Lakes and Interconnecting Large River System

Within SSMR Source Protection Area's jurisdiction, the municipality obtains 50% of its water supply from Gros Cap, Lake Superior. The Gros Cap intake itself is approximately 820 m from the shoreline and is at a depth of approximately 15 m below the surface and approximately 4.5 m above the lake bottom. The PUC operates a water treatment plant. Through Source Protection legislation, the Great Lakes drinking water intakes are to be managed through establishment of a 1 km and 3-hr time-of-travel (TOT); Intake Protection Zone 1 and 2 (IPZ1&2) as per Technical Rules (Dec 2008).

WC Map 18: Watershed of Intake
WC Map 18A: Surface Water Intake Protection Zones

5.3.2 Other Vulnerable Areas: Highly Vulnerable Aquifer

5.3.2.1 Intrinsic Susceptibility Index (ISI)

The potential vulnerability of an aquifer to groundwater contamination is a function of the susceptibility of its recharge area to infiltration. The intrinsic susceptibility (IS) to contamination can be estimated by assigning numerical scores related to hydraulic conductivity (K) of the material in each layer overlying the water table or upper most aquifer multiplied by the thickness of that layer.

Intrinsic Susceptibility Index (ISI) is worked out according to the MOE guidelines. Based on this analysis, the higher the ISI, the less sensitive the aquifer. Areas with ISI>80 are considered as the least sensitive and areas having an ISI less than 80 but greater than 30 (30<ISI<80) are classed as medium sensitivity and all areas with ISI<30 value are highly sensitive areas (MOE, 2006).

As indicated from the intrinsic susceptibility mapping of the Sault Ste. Marie watershed aquifer, most of the area covered by the Precambrian uplands has been assigned a high vulnerable class of ISI<20. Aerial photography data and the DEM data interpretation shows the high vulnerable class area lies over most parts of the Precambrian shield, with the exception of parts of Hwy 17 corridor where relatively thick overburden materials have been mapped. Along a few parts of the Hwy 17 corridor in the north, moderate vulnerable areas have been identified. Most of the area over low lands covered by the thick clay and silt deposits has been identified as having low vulnerability. Also, artesian conditions exist in the deep aquifer over parts of the "Central Basin" and the "East Basin" that are effectively protecting the deeper aquifer (Burnside, 2003).

5.3.2.2 Aquifer Recharge/Discharge Areas

Areas where infiltration occurs can be defined as recharge areas. However, recharge areas are more realistically defined zones having significant downward groundwater gradients (where the groundwater flow is predominantly vertical). The best recharge areas are thus topographically elevated areas having permeable formations exposed at surface.

Groundwater discharge occurs where the water table or the piezometric surface intercepts the ground surface. In general, if the hydraulic head in the aquifer is higher than the ground surface or higher than the water table aquifer, groundwater said to be in discharge conditions.

The recharge/discharge zones within the study area are illustrated in WC Map 19. This map was based on net hydraulic head as obtained by subtracting the piezometric surface from the water table surface. All areas with negative values have been identified as discharge areas and those areas with positive values are designated as recharge areas. As can be seen from the map, a majority of the study area is identified as a regional recharge zone. This indicates that some recharge occurs through the thin or fine-grained surficial material that covers the majority of the area.

One significant recharge zone is located within the Precambrian uplands. This zone is a bedrock valley filled with sand and gravel, corresponding to the valley hosting the ACR railway and Hwy 17 North corridor. Discharge zones within the uplands occur along surface watercourses, as well as the area of sand and gravel located along the northern contact of the uplands.

Two groundwater recharge areas occur within the City limits; one in the area of Gros Cap along the shore of Lake Superior in the west (approximately 312 ha), and a major area at the bedrock/overburden contact along the southern contact of the Precambrian uplands to the north of the City (approximately 3,750 ha). This larger zone of high groundwater recharge is associated with the gravel-rich glaciolacustrine beaches deposits adjacent to the uplands and covers an area approximately 20 km long and 2 to 3 km wide. This is recognized as the main recharge zone within the study area, providing recharge to both confined and unconfined aquifers in the vicinity of the City. Groundwater recharge through these beach deposits occur by direct infiltration of precipitation, and recharge from surface streams and wetlands flowing south from the bedrocks highs in the north. Groundwater recharge through this area has been estimated to be in the order of 15 to 20 GL/a (15 -20 000 000 m^3/annum) (IWC, 1997 and Burnside, 2003).

Three large areas of groundwater discharge located near the City are also identified. These discharge zones are associated with areas of glaciolacustrine sand, particularly in the south, adjacent to the St. Marys River. These main areas of groundwater discharge are located near the Pointe des Chênes Park in the west, in the area of the Central bedrock valley. This indicates that the bedrock valley influence the groundwater flow and nature of the surficial deposits, focusing the areas of groundwater discharge. Smaller areas of groundwater discharge occur along the southern limits of the glaciolacustrine deposits near the uplands, and form the headwaters of numerous streams there.

5.3.2.3 Potential Future Drinking Water Sources

There was no future drinking water exploration study conducted for the Sault Ste. Marie Area. The PUC only identifies one area for the potential groundwater supply source. The PUC Inc. owns property at 845 Second Line West, which is located on the municipal distribution system and may be reserved for a future potential municipal well site. The proposed well site is located in the Central Basin, which is a practical source for additional groundwater. The West Basin is significantly beyond the extent of the Sault Ste. Marie water distribution system, and the East Basin is already rated at its recharge capacity (Kresin, MacViro, 2006). Although it would be possible to draw additional water from Lake Superior, the associated treatment plant would require extensive modification to provide more than the rated 40,000 m^3/day (Hallett, 2006).

WC Map 19: Highly Vulnerable Aquifers
WC Map 20: Potential Drinking Water

6.0 SUMMARY

The Source Protection Authority (SPA) has developed a watershed characterization by accumulating all of the available information about the area. It includes information compiled on the area physical, sociological and economic makeup. Also included are facts and figures on population distribution, land use and on the natural characteristics of the local watershed specifically related to storage and movement of water. Maps have also been produced to provide a visualization of the watershed.

The water quality section describes the water quality conditions and trends in the watershed region. Simple statistical analysis was carried out and maps and graphs were generated to illustrate these trends. Box and Whisker Plots were also developed to display and compare the water quality data. The analysis of surface water, groundwater, domestic water, groundwater well, provincial groundwater monitoring network well, raw/treated water data of the Gros Cap Intake and available data from all six (6) groundwater supply wells has been carried out. Water quality conditions and trends within the watershed are also discussed. The water quality analysis for the raw water data of Gros Cap Intake shows that no water quality parameters exceeded the PWQO and ODWS standards. The treated water from all six groundwater wells met all health-related ODWS. The concentrations of sodium chloride, nitrite and nitrate at the wells are well below the aesthetic level of ODWS. There is a slight increasing trend in the sodium and chloride concentrations at the groundwater wells which are below the aesthetic standards. Available chloride concentrations at the Lorna and Shannon wells (2000) are 51.0 mg/L and 37.0 mg/L, respectively, which may indicate possible road salt impacts.

An inventory of water use in the watershed region was prepared from the Ministry of the Environment's (MOE) Permit To Take Water (PTTW) database. It shows the current draw on the water, as well as historical takings. Population growth was also estimated for the watershed area to determine if there may be any significant impact on future water demands. Total water delivered to the distribution system in 2008 was 12.79 million cubic meters compared to 13.09 in 2007. The maximum daily production in the year was 44.0 thousand cubic meters, which occurred August 20, 2008. Annual consumption has averaged about 14 million cubic meters over the past four decades. There is evidence of a decline in the amount of water consumed annually over the past ten years (PUC, 2008).

7.0 REFERENCES

Baird, 2008. Gros Cap Intake Protection Zone Study. W.F. Baird & Associates Coastal Engineers Ltd.

Bennett, G, Hillier, R.D. Nentwich, F, Depuis, C.P. and Pucovsky, M. 1975. Jarvis Lake –Garden River Area, District of Algoma; Ontario Division of Mines, Prelim. Map P. 1064, Geol. Ser., scale 1 inch to ¼ mile or 1:15,840. Geology 1974.

Bennett, G. 1978. Huronian volcanism, districts of Algoma and Sudbury; *in* Summary of Field Work, 1978; Ontario Geological Survey, Miscellaneous Paper 82, p.105-111.

Bennett, G. 1982. Geology of the Two Horse Lake Area, District of Algoma; Ontario Geological Survey, Geological Report 210, 63p.

Bennett, G. and Sawiuk, Myron, 1978. Jarvis Lake Garden River area (Southern Part) District of Algoma, Geological Survey of Ontario Preliminary Map 2241, Geological series, scale15 840, geology 1977.

Bennett, G., Dressler, B.C. and Robertson, J.A. 1991. The Huronian Supergroup and associated intrusive rocks; *in* Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 1, p. 549-592.

Bennett, G., Leahy, E.J. and Walmsley, J. 1990. The Sault Ste. Marie Resident Geologist's District-1989; *in* Report of Activities, Regional and Resident Geologists, Ontario Geological Survey, Miscellaneous Paper 147, p.205-215.

Burns, R.D. 1956. The geology of the Jardun Mine, Sault Ste Marie, Ontario; unpublished M.Sc. thesis Michigan College of Mining and Technology, 58 p.

Burnside 2005. Vulnerability of Municipal Groundwater Study, Sault Ste. Marie PUC.

Burnside, R.J. and Associates Limited. 2003. Sault Ste. Marie area groundwater management and protection study, Volume 1 – Main report.

Coleman, A. P 1899. Copper Regions of the Upper Lakes; Ont. Bur. Mines, Ann. Rep. V. 8, pt. II, pp. 168, 171.

Collins, W.H. 1925. North shore of Lake Huron; Geological Survey of Canada, Memoir 143.

Corfu, F., and Andrews, A. 1986. A U-Pb age for mineralized Nipissing diabase, Gowganda, Ontario; Canadian Journal of Earth Sciences, v.23, p.107-112.

Cowan, W.R. and Broster, B.E. 1988. Quaternary geology of the Sault Ste. Marie area, District of Algoma, Ontario. Ontario Geological Survey Map P.3104, Geological Series Preliminary Map, scale 1:100,000.Geology 1976.

Cowan, W.R., 1978. Radiocarbon dating of Nipissing Great Lakes events near Sault Ste. Marie, Ontario. Canadian Journal of Earth Sciences, Vol. 15, No.12, p.2026-2030.

Cowan, W.R., 1985. Deglacial great lake shorelines at Sault Ste. Marie, Ontario. P. 33-37 in Quaternary evolution of the Great Lakes, edited by P.F. Karrow and P.E. Calkin, Geological association of Canada Special Paper 30, 258p.

Cowan, W.R., McAuley, P. and Bennett, G. 1998. Urban geology, City of Sault Ste. Marie, Ontario, P 197-205 in Urban geology of Canadian cities, edited by P.F. Karrow and O.L. White, Geological Association of Canada Special Paper 42, 500p.

Fahrig, W.F. 1987. The tectonic setting of continental mafic dike swarms: failed arms and early passive margins; *in* Mafic Dike Swarms, Geological Association of Canada, Special Paper 34, p.331-348.

Frarey, M.J. 1977. Geology of the Huronian belt between Sault Ste. Marie and Blind River, Ontario; Geological Survey of Canada, Memoir 383, 87p.

Giblin, P. and Leahy, E. J. 1976. Drift Thickness of the Sault Ste. Marie, District of Algoma; Ontario Div. of Mines, Prelim. Map P. 1213, Drift Thickness Ser., Scale 1:25 000. Geological Compilation 1975.

Griffith, John. Dec. 7th, 2005. Sault Ste. Marie Public Utilities Commission. Personal communication with T. Westman.

Hay, R.E. 1963. The Geology of the Sault Ste. Marie map area; unpublished PhD thesis, McGill University, Montreal, Quebec, 325p.

Heaman, L.M. 1988. A precise U-Pb zircon age for a Hurst dike; *in* Program with Abstracts. Annual Meeting Geological Association of Canada-Minera1ogical Association of Canada, v. 13, p. A53.

Hemson, 2006. Population, Household & Labour Force Forecast (2001-2026), City of Sault Ste. Marie

IJC, 1992. International Joint Commission

International Water Consultant Ltd., 1995. Report Investigation of Increasing Chloride Concentrations Goulais, Steelton, Shannon, and Lorna Wells, Sault Ste. Marie, Ontario.

International Water Consultants, 1997. Sault Ste. Marie Groundwater Recharge Area, Land Use Study 1997

IWS, 1971. Report of Groundwater Investigation, Public Utilities Commission, Sault Ste. Marie

Joubin, F. R. and Associates Mining Geologists Limited 1963: Ile Parisienne - Pancake Bay, District of Algoma, Ontario; Algoma Central and Hudson Bay Railway Company Geological Map, Sheet 41 K 10 & 15, Scale 1 inch to 1 mile.

Kresin Engineering and Planning Limited, 1992. Gros Cap Estate Plan

Long, D.G.F. 1976. Stratigraphy and sedimentology of the Huronian (Lower Aphebian) Mississagi and Serpent Formations; unpublished PhD thesis, University of Western Ontario, London, Ontario, 291 p.

Lundrigan, 2005. *Supervisor*, Water Treatment Operations, PUC Services Inc. SSM

M. M. Dillon Ltd. 1977. Flood Plain Mapping Report.

McConnell, R.G. 1927. Sault Ste. Marie area, District of Algoma; Ontario Department of Mines, v.35, pt.2, p.1-52.

Ministry of Environment of Ontario & Michigan Department of Natural Resources. 1992. St. Mary's River Area of Concern, Environmental Conditions and Problem Definitions: Remedial Action Plan Stage 1.

MOE, Nov. 2001. Ontario Ministry of the Environment Groundwater Studies 2001/2002 Technical Terms of Reference.

MOE Technical Rules - Assessment Report - Clean Water Act, 2006 (November 2009)

Public Utilities Commission of the City of Sault Ste. Marie Annual Reports 2006, 2007 and 2008.

Osmani, L.A. Proterozoic Mafic Dike Swarms in the Superior Province of Ontario; in Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 1, p. 661-681.
Proctor & Redfern, 1982. Sault Ste. Marie Public Utilities Commission, Report – New Water Supply

Ref 1. http://www.foundlocally.com/Sault/Local/Info-CityHistory.htm, October 26, 2005

Ref 2. http://www.pas.gov.on.ca/scripts/en/BoardDetails.asp?boardID=1306

Ref 3. (http://www.rom.on.ca/ontario)

Roscoe, S.M. 1969. Huronian Rocks and Uraniferous Conglomerates. Geological Survey of Canada, Paper 68-40, 205p.

Russell, D.J. 1987. The Jacobsville Formation and associated units in Ontario, District of Algoma : Map P. 3058, Geological Series – Preliminary Map, Scale 1:100 000. Geology 1982.Ontario Geological Survey, 1982.

Sims. P.K., Card, K.D. and Lumbers, S.B. 1981. Evolution of early Proterozoic basins of the Great Lakes Region; *in* Proterozoic Basins of Canada, Geological Survey of Canada, paper 81-10, p. 379-397.

Tomlinson, K.Y. The geochemistry and tectonic setting of early Precambrian greenstone belts, Northern Ontario, Canada; unpublished Ph.D. Thesis, University of Portsmouth, 278p.

Walker, 1987. Sunnyside Beach Subdivision, Groundwater Control Study.