THUNDER BAY

STORMWATER MANAGEMENT PLAN

FOR SUSTAINABLE SURFACE WATER MANAGEMENT

APRIL 2016

VOLUME I:
The Plan

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Thunder Bay Stormwater Management Plan Prepared by Emmons & Olivier Resources, Inc. (EOR)

CITY OF Thunder Bay
Superior by Nature

EOR water ecology community
Emmons & Olivier Resources, Inc.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF VOLUMES

Volume I. The Plan

Volume II. Appendices
Appendix A. Related Studies, Plans and Reports
Appendix B. Land Use Determination
Appendix C. Public Participation & Consultation Plan
Appendix D. Model Development
Appendix E. IDF Curves Development & Climate Change Assessment
Appendix F. Inventory of Retrofit BMP Opportunities & Cost-Benefit Analysis

Volume III. Watershed Maps

LIST OF ACRONYMS

AANDC	Aboriginal Affairs and Northern Development Canada
AMP	asset management plan
ANSIs	areas of scientific and natural significance
AOC	area of concern
BMP	best management practice
BOD	biochemical oxygen demand
BUIs	beneficial use impairments
CaCO3	calcium carbonate
CCAP	Climate Change Adaption Program
CEAP	community environmental action plan
CIP	capital improvement projects
Cl	chloride
CN	cyanide
CSO	combined sewer overflow
CSP	corrugated steel pipe
CTB-UDLG	City of Thunder Bay - Urban Design and Landscape Guidelines
CV	coefficient of variation
CWA	Clean Water Act
DEM	digital elevation model
DFO	Department of Fisheries and Oceans Canada
DO	dissolved oxygen
EA	Environmental Assessment
EAA	Environmental Assessment Act
EBR	Environmental Bill of Rights 1993
EIRP	Thunder Bay Enhanced Infrastructure Renewal Program
EOR	Emmons & Olivier Resources, Inc.
EPA	Environmental Protection Agency
ERU	equivalent residential unit
ESC	erosion and sediment control
ESR	environmental study report
FCM	Federation of Canadian Municipalities
FWFN	Fort William First Nation
GIS	geographic information systems
GLWGA	Great Lakes Water Quality Agreement
GTF	Gas Tax Fund
GW	groundwater
HDPE	high density polyethylene
HSG	hydrologic soil group
ICLEI	International Council for Local Environmental Initiatives
IDF	intensity duration frequency curves
IJC	International Joint Commission
kg	kilograms
LaMPs	lakewide management plans

LGU	local government unit
LID	low impact development
LRCA	Lakehead Region Conservation Authority
masl	metres above sea level
mg	milligrams
MIDS	minimal impact design standards
mm	millimetre
MNRF	Ministry of Natural Resources and Forestry
MOECC	Ministry of Environment and Climate Change
MS4	Municipal Separate Storm Sewer System under the Phase II NPDES program
MTO	Ministry of Transportation
NaCl	sodium chloride or common table sea salt used for roadway de-icing
NMA	Nutrient Management Act
NO_3	Nitrate
NPDES	National Pollutant Discharge Elimination System
NWP	Northern Woods Preserves
NWWBI	Canada’s National Water and Wastewater Benchmarking Initiative
O&M	operation and maintenance
OCIF	Ontario Community Infrastructure Fund
ODWS	Ontario Drinking Water Standard
ODWSP	Ontario Drinking Water Stewardship Program
OGS	oil/grit separator
OPG	Ontario Power Generation
OTF	Ontario Trillium Foundation
OTTHYMO	Ottawa hydrologic model
OWES	Ontario Wetland Evaluation System
OWRA	Ontario Water Resources Act
PCSWMM	software program for stormwater, wastewater, and watershed modelling
PSW	provincially significant wetlands
PWQMN	Provincial Water Quality Monitoring Network
QA/QC	quality assurance / quality control
RAPs	remedial action plans
ROW	right-of-way
SAFL	St. Anthony Falls Laboratory
SAMP	Stormwater Asset Management Plan
SCF	small communities fund
SDI	spatial data infrastructure
SMP	Stormwater Management Plan
SS	suspended solids
SSC	suspended sediment concentration
SUF	stormwater utility Fee
SWAMP	Stormwater Assessment Monitoring and Performance Program of the Toronto and Region Conservation Authority
SWM	stormwater management
SWPPP	stormwater pollution prevention plan/program

TBD	to be determined
TDS	total dissolved solids
TKN	total Kjeldahl nitrogen
TMDL	total maximum daily load
TN	total nitrogen
TP	total phosphorus
TPC	total present cost
TSS	total suspended solids
UAL	unified area load
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
WinSLAMM	Windows-based Source Loading and Management Model
WQ	water quality
WQV	water quality volume
WR	water resources
WWG	water working group

GLOSSARY

Adaptive Management is a management approach where objectives are set, monitoring is implemented and results are compared against objectives understanding that management strategies may be adjusted as necessary to attain the overall objectives.

Aggregate is a broad category of particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates, and available in various particulate size gradations.(1)

Aquifer is a body of permeable rock that can contain or transmit groundwater.(2)

Beneficial Use is a legal term that implies greater rights than mere possession of land or infrastructure, but also the natural resources affiliated with the land, such as air, light, and water. Beneficial use of a property can be impaired by a variety of influences, such as development or pollution.

Best Management Practice (BMP) is one of many different structural or non–structural methods used to treat runoff, including such diverse measures as ponding, street sweeping, filtration through a rain garden and infiltration to a gravel trench.(2)

Bog is a peat-covered area or peat-filled depression with a high water table and a surface carpet of mosses, chiefly Sphagnum. The water table is at or near the surface in the spring, and slightly below during the remainder of the year. The mosses often form raised hummocks, separated by low, wet interstices. The bog surface is often raised, or, if flat or level with the surrounding wetlands, it is virtually isolated from mineral soil waters. Hence, the surface bog water and peat are strongly acidic and upper peat layers are extremely deficient in mineral nutrients. Peat is usually formed in situ under conditions of closed drainage and low oxygen levels.(3)

Bounce – The change or fluctuation in water level of a water body during a rainfall event.

Climate Change Adaptation is any measure taken to reduce the vulnerability of ecosystems, infrastructure and people to the negative impacts of climate change.

Detention is the temporary storage of stormwater to control discharge rates, and allow for sedimentation.(1)

Eutrophication is the process in which freshwater bodies are enriched by high concentrations of inorganic nutrients, such as nitrates and phosphates, promoting excessive algae growth. As the algae decompose, the water is depleted of available oxygen, causing the death of other aquatic organisms. Eutrophication may occur naturally, but can be the result of anthropogenic influences, such as fertilizer runoff and sewage discharge.(4)

Evaluated Wetland is the indicator used to identify whether a wetland has been evaluated through OWES.

Evapotranspiration is the combined loss of water to the atmosphere from land and water surfaces by evaporation and from plants by transpiration.(1)

Fens are peatlands characterized by surface layers of poorly to moderately decomposed peat, often with well-decomposed peat near the base. Fen peats generally consist of mosses and sedges. Sphagnum, if present, is usually composed of different Sphagnum species than occur in bogs. There are two main fen types: nutrient rich fens typically are fed by groundwater and have a high pH. Nutrient-poor fens, such as those in moraine dominated landscapes, can occur in isolated depressions with less groundwater inputs and a lower pH (but not as low as in bogs).[3]

Fill Line is intended to define an area further inland than the flood line which may be hazardous for development or where the placing of fill can increase flood levels and erosion. It defines an area, in which the Lakehead Region Conservation Authority has jurisdiction to enforce regulations related to flooding and erosion hazards may exist.[5]

Filtration is the technique of removing pollutants from runoff as it infiltrates through the soil.

Flow-Weighted Mean Concentration is calculated by dividing the total load of a pollutant over the estimation time period by the total streamflow.

Geomorphology is the study of the processes responsible for the shape and form, or morphology, of watercourses; describes the processes whereby sediment (e.g., silt, sand, gravel) and water are transported from the headwaters of a watershed to its mouth.[1]

Geotextile is a filter fabric that is installed to separate dissimilar soils and provide runoff filtration and pollutant removal benefits while maintaining a suitable rate of flow; may be used to prevent fine-textured soil from entering a coarse granular bed, or to prevent coarse granular from being compressed into underlying finer-textured soils.[1]

Green infrastructure means natural vegetation and vegetative technologies in urban settings such as: urban forests; green roofs; green walls; green spaces; rain gardens; bioswales; community gardens; natural and engineered wetlands and stormwater management ponds; and porous pavement systems. These systems are designed to provide multiple benefits, such as moderate temperatures, clean air and water, and improve aesthetics.[1]

Greenway means a trail or undeveloped strip of land set aside for recreational use or habitat conservation. Greenways can resemble linear parks and are found in urban and rural areas; commonly created out of a railway, former industrial land, utility, or similar right of way.

Hydrologic Soil Groups is a soil classification system based on the ability to convey and store water; divided into four groups[1]:

- A – Well drained sands and gravel, high infiltration capacity, high leaching potential and low runoff potential;
- B – Moderately drained fine to coarse grained soils, moderate infiltration capacity, moderate leaching potential and moderate runoff potential;
- C – Fine grained, low infiltration capacity, low leaching potential and high runoff potential;
- D – Clay soils, very low infiltration capacity, very low leaching potential and very high runoff potential.

Impervious is a hard surface area (e.g., road, parking area or rooftop) that prevents or retards the infiltration of water into the soil.

Infiltration is the penetration of water through the ground surface.

Lot level refers to the treatment of urban runoff as close to the source area as possible through application of small scale stormwater management practices on individual properties that are linked to downstream conveyance and end-of-pipe practices.[1]

Low Impact Development (LID) is a stormwater management strategy that seeks to mitigate the impacts of increased urban runoff and stormwater pollution by managing it as close to its source as possible. It comprises a set of site design approaches and small scale stormwater management practices that promote the use of natural systems for infiltration and evapotranspiration, and rainwater harvesting.(1)

Major Drainage System includes natural streams, valleys, swales, artificial channels, roadways, stream road crossings and ponds in urban areas. The major system conveys runoff from infrequent events that exceed the minor system capacity. For good design, the major system will reduce the risk to life and property damage by providing overland flow routes to a safe outlet. Most flow routes will follow the natural topography.(5)

Marshes are wet areas periodically inundated with standing or slowly moving water, and/or permanently inundated areas characterized by robust emergents, and to a lesser extent, anchored floating plants and submergents. Surface water levels may fluctuate seasonally, with declining levels exposing drawdown zones of matted vegetation or mud flats. Water remains within the rooting zone of plants during at least part of the growing season(3)

Minor Drainage System is frequently used for collecting, transporting and disposing of snowmelt, miscellaneous minor flows and storm runoff up to the capacity of the system. The capacity should be equal to the maximum rate of runoff to be expected from the minor design storm. For urban areas, the minor system is composed of the grading design on lots, ditches, backyard swales, roof leaders, foundation drains, gutters, catchbasins, and storm sewers.(5)

Ontario Wetland Evaluation System (OWES) is maintained by the Ministry of Natural Resources and Forestry (MNRF) to provide a consistent method of assessing wetland functions and their values to society. OWES enables the province to rank the relative value of wetlands for land use planning purposes. The OWES manuals are technical guidance documents that use scientific criteria to quantify wetland values and allow comparisons among wetlands.(6)

Open Water (Marsh) areas are not to be confused with lakes and rivers. They have been identified as wetlands but they may overlap or be coincident with Ontario Hydro Network (OHN) lakes and rivers. All wetlands are dominated by submergents, floating plants, free floating plants or un-vegetated are considered to be open water marsh. Typically there is enough open water for a duck to swim or to navigate a canoe.(6)

Provincially Significant Wetland is the determination of whether a wetland is provincially significant is based on an OWES evaluation that has been approved by MNRF. For both northern and southern Ontario a provincially significant wetland is any wetland that(6):

1. Achieves a total score of 600 or more points, or
2. Achieves a score of 200 or more points in either the Biological component or the Special Features component.

In Ontario, there are two evaluation manuals – one for the area generally south of the southern edge of the Canadian Shield (encompassing Hills Site Regions 6 & 7) and one for the area north of this line (encompassing Hills Site Regions 2 through 5). Both manuals provide direction for gathering data on an assortment of functions and values of wetlands which are divided into four categories (biological, social, hydrological and special features). These functions and values are assigned numerical scores which cannot exceed 250 points in any category or 1000 points overall.

Regional Storm is the storm used to establish flood lines. The Regional Storm is determined for different regions in Ontario by the MNRF in accordance with probable meteorological occurrences. For those areas which are under the jurisdiction of the Lakehead Region Conservation Authority, the Regional Storm is assigned as the greater of the Timmins Storm or the 100-year storm, whichever results in greater peak flows.(6)

Riparian means a vegetated ecosystem alongside a waterbody, characteristically have a high water table and are subject to periodic flooding.

Runoff is water from rain, snow melt, or irrigation that flows over the land surface.

Stream channel is a natural waterway, formed by fluvial processes, that conveys running water.(1)

Sublimation is the conversion between the solid and the gaseous phases of matter, with no intermediate liquid stage. Sublimation is referred to with regards to the water cycle to describe the process of snow and ice changing into water vapor in the air without first melting into water.

Suspended Sediment Concentration (SSC) is a measure of the amount of particulate material in suspension in a water column; is the result of a particular method of analysis that uses the entire volume sample, provides a more accurate sample than TSS, and eliminates the errors associated with subsampling.

Swamps are wooded wetlands with 25% or more cover of trees or tall shrubs. In swamps, standing to gently flowing waters occur seasonally or persist for long periods on the surface. Frequently there is an abundance of pools and channels indicating subsurface water flow.(3)

Total Suspended Solids (TSS) is the amount of particulate material in suspension in a water column.(2)

Treatment train approach uses a combination of lot-level, conveyance, and end-of-pipe stormwater management practices.(2)

Underdrain is an underground drain or trench with openings through which the water may percolate from the soil or ground above.(2)

Unknown Wetland may be used for wetland polygons that have not had the type identified and may be updated when the type is known.(6)

Water balance is the accounting of inflow and outflow of water in a system according to the components of the hydrologic cycle.(2)

ACKNOWLEDGEMENTS

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Councillor Frank Pullia
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Thunder Bay Stormwater Management Plan – <u>Volumes I, II, and III</u>

Standard of Care

The standard of care for all professional engineering and related services performed or furnished by Engineer in the attached report was the care and skill ordinarily used by members of the subject profession practicing under similar circumstances at the same time and in the same locality. Engineer and its consultants have utilized outside information provided by the City of Thunder Bay, Lakehead Region Conservation Authority, Ministry of Environment and Climate Change, Ministry of Natural Resources and Forestry, Ontario Power Generation, Department of Fisheries and Oceans, Land Information Ontario and others as the basis for a significant portion of the work. Engineer has relied on this data and makes no warranties, express or implied, as to the accuracy of this data.

EXECUTIVE SUMMARY

The overall purpose of this Stormwater Management Plan (SMP) is to guide the City of Thunder Bay (City) in the development of an integrated stormwater management program that meets the goals and objectives, as outlined herein, for the next 20 years. The development of the SMP is driven by City Council's vision contained in the 2011-2014 Strategic Plan which states:

Goal 10: *"Promote greening & protect the City's environment, including natural areas"*

Action 10.1 (c): *"Develop a Stormwater Master Plan to reduce stormwater outflow, flooding and protect Lake Superior and its watershed"*

The City has developed an approach to improve the stormwater system over the next 20 years. The guide includes identifying additional capital works, incorporating Low Impact Development (LID) and Green Infrastructure where appropriate, and recommends changes in the standards and By-Laws to green the community, to promote liveability and build resilience into the system in the face of changing climatic conditions.

Watershed Assessment

The City is located at the downstream end of the Lakehead Watershed. Stormwater in the City is, for the most part, a reflection of the health of the upstream watersheds. Therefore, this SMP looks beyond the City's municipal boundary and takes a watershed-wide perspective when assessing stormwater systems, infrastructure, and natural resources.

The watershed assessment provides detailed information for each of the seven watersheds draining through the City: Current River, Kaministiquia River, McIntyre River, McVicar Creek, Mosquito Creek, Neebing River, and Pennock Creek. There is an eighth watershed in the City, which is the Waterfront watershed, where runoff drains to channels and storm sewers discharging directly to the Thunder Bay Harbour. The information for each watershed includes a description of the climatic and physical setting, a description of existing land use and land cover, and an assessment of natural resources and water quality.

Assessment of Priority Needs

The assessment of priority needs evaluates existing stormwater infrastructure, considers water quality targets for the City's water resources, and considers the change in precipitation based on climate change. The City's on-going climate adaptation efforts were closely coordinated with the SMP.

The SMP also presents state-of-the-science trends in stormwater management, including Low Impact Development and Green Infrastructure. The SMP contains preliminary information on the location, sizing, design and construction of Best Management Practices (BMP). Recommendations for stormwater BMP opportunities are presented for 552 locations throughout the City.

Goals and Objectives

The following main elements of a sustainable and integrated stormwater management program are established by the City's stormwater management goals and objectives:

1. Ecosystem Health
2. Water Quality
3. Water Quantity
4. Operations and Maintenance
5. Monitoring and Data Assessment
6. Regulation and Enforcement
7. Education and Outreach
8. Funding and Organization
9. Climate Change Adaptation

For each of these elements, a number of implementation activities are recommended to be carried out over the 20-year time frame of the SMP. While the information presented in this Plan incorporates the latest in engineering design and management practices, the SMP also acknowledges that stormwater management is a constantly changing field. The City recognizes that the implementation of the SMP requires an adaptive management approach. As standard practices evolve, new information is collected and evaluated, and the availability of financial resources changes, the City may decide to reprioritize its course of action to achieve the goals and objectives laid out in this Plan.

Corrective Actions and Implementation Plan

Implementation of the SMP starts with the City's existing organizational structure. The SMP recommends a suitable structure later in the implementation period. Responsibilities related to stormwater management are currently shared by several City Divisions. The Planning Services Division, which is part of the Development & Emergency Services Department, oversees land development and planning while four other divisions within the Infrastructure and Operations Department (the Engineering, Roads, Environment, and Parks Divisions) hold all other responsibilities, including the maintenance and capital replacement programs. As the City implements the SMP, a new organizational structure is recommended for achieving the goals and objectives presented in the Plan in a more effective manner. The SMP recommends creating a single area for managing the City's stormwater system. The SMP identifies the role a centralized area would play in stormwater management, its responsibilities and the services to be provided to its constituents. Examples of various municipalities in Ontario and Minnesota with independent stormwater departments are discussed in the SMP.

The SMP provides recommendations for modifications to the City's existing Engineering and Development Standards and the City's By-Laws. If implemented, the recommendations would enable the City to more effectively apply a new stormwater management approach. The new approach focuses on keeping the raindrop where it falls, thereby mimicking natural hydrology in order to minimize the amount of runoff, prevent pollution from reaching lakes, rivers, streams and wetlands, and maintain recharge of the groundwater system.

The SMP's Implementation Plan includes detailed annual costs and a schedule for implementing the recommended Programs, Projects and Studies/Inventories over the next 20 years. As the City continues to expand its stormwater management program and collect more information, the Implementation Plan will need to be periodically reviewed and revised. The revisions will then reflect the changing needs and priorities of the City and its constituents at all times. The Implementation Plan can then be assessed against the needs and merits of other applicable programs.

To provide the financial support needed for a successful implementation of the SMP, the applicability and benefits of potential funding sources are also discussed in the SMP. The funding sources and strategies considered are varied in magnitude and scope. The most effective funding approach would likely be a combination of some of the strategies presented in the Plan. The funding approach recommended in the SMP can be summarized as follows:

1. To implement existing stormwater management activities in Year 1, add preparatory training and administrative programs in Year 2, and phase in the remaining recommendations to match the annual funding in Years 3 to 20;
2. To develop and initiate a Stormwater Utility in the second year following the adoption of the SMP. Once created, the utility will then be further increased by approximately $1 Million annually for implementing the SMP recommended Operations/Programs, Capital Projects and Studies/Inventories, while the levy for tax based funding to stormwater activities is decreased; and
3. To supplement these funds by securing grants, leveraging partnerships and considering the adoption of other funding strategies where needed to fully fund the implementation plan as the Stormwater Utility is phased-in.

Framework for a Stormwater Asset Management Plan

The final section of the SMP presents the framework for an expanded Stormwater Asset Management Plan (SAMP) that would incorporate the City's entire existing and future stormwater infrastructure. It builds on the existing 2014 Asset Management Plan (AMP) and provides specific recommendations on all asset management components (i.e. system inventory, levels of service, management strategy and financing) to be included in a future SAMP.

Conclusion

The City's SMP outlines a recommended path towards sustainable stormwater management in Thunder Bay that can be funded through a refined financing strategy. Implementation will prepare the City's infrastructure for the growing challenges of climate change and will need to adapt to lessons learned through evaluating progress over the next 20 years.

1 INTRODUCTION

1.1 Purpose

The overall purpose of this Stormwater Management Plan (SMP) is to guide the City of Thunder Bay (City) in the development of an integrated stormwater management program. The SMP provides an assessment of existing stormwater systems recognizing the inter-relationship with natural systems (creeks, wetlands, and open spaces), existing infrastructure and land uses, as well as the hydrologic cycle (surface water/groundwater interactions). It also recognizes the City's efforts to address the impacts of climate change by highlighting those stormwater management activities that provide a direct benefit for climate adaptation.

While the City and the Lakehead Watershed have a long history of stormwater management (see Section 1.2), the development of the SMP was driven by City Council's vision contained in the 2011-2014 Strategic Plan which states:

Goal 10: *"Promote greening & protect the City's environment, including natural areas"*

Action 10.1 (c): *"Develop a Stormwater Master Plan to reduce stormwater outflow, flooding and protect Lake Superior and its watershed"*

1.2 Background

The City is located on the north shore of Lake Superior within the Great Lakes Basin. Thunder Bay is the tenth largest city in Ontario, and is the largest metropolitan centre in Northwestern Ontario. As the largest Canadian city on Lake Superior, Thunder Bay has a relatively stable population of about 109,000 (2011 Census). It occupies an area of approximately 323 square kilometres, of which 130 square kilometres are developed. The City was founded in 1970 by the amalgamation of the former cities of Port Arthur and Fort William and portions of the adjacent geographical Townships of Neebing and McIntyre.[7] Its waterfront along Lake Superior stretches approximately 52km. Approximately 1,000 lakers and ocean-going ships travel to Thunder Bay Harbour annually to transport millions of tonnes of cargo. Paper and wood products, as well as wheat and other grains, iron ore, bulk cargo, oil and coal are the major commodities handled.

Highlights throughout the history of stormwater management in Thunder Bay are outlined in Table 1.

Table 1. History of Stormwater Management Activities in Thunder Bay

Date	Stormwater Management Activity
1963	The Lakehead Region Conservation Authority (LRCA) was formed by an expansion of the Neebing Valley Conservation Authority, which was constituted in 1954.
1970	The Cities of Port Arthur and Fort William and portions of the Townships of McIntyre and Neebing amalgamated into the City of Thunder Bay.
1977	Memorial Avenue Reconstruction Project included extensive work on improving overland drainage and storm sewer systems. As part of this project, two stormwater pumping stations were constructed: one at the Harbour Expressway and Memorial and a second at Central Avenue and Memorial.
1980	The Neebing McIntyre Floodway was constructed.
1987	The City published the *Master Drainage Study* to confirm that future development within the City will not have adverse impacts.
1999	The City's *Pollution Prevention and Control Plan* led to the initiation of a program to separate sanitary sewers from storm sewers.
1999	The Rain Barrel Program started and continued running in various forms until an ongoing sales program started in 2003. The City and EcoSuperior partnered in 2009 to provide rebates to residents purchasing rain barrels.
2000	The City began converting mapping to GIS in an ongoing effort to support infrastructure management.
2001	The City almost doubled the area of public waterfront land by securing ownership of the 25 ha area now known as Prince Arthur's Landing and the Pool 6 Lands.
2005	EarthWise®[1] (now EarthCare) was launched
2005-2009	The Intercity Drainage Improvement Project was implemented in three phases which included improvements to overland drainage and storm sewer systems. As part of this project two storm sewer pumping stations were built: one at Ontario Street in 2006 and a second on Third Avenue in 2008.
2008	The EarthWise®[1] *Community Environmental Action Plan* (CEAP) was endorsed by City Council. The plan included the development of a comprehensive stormwater management plan in the list of proposed actions.
May 2010	EarthWise®[1] Water Working Group facilitated discussion on stormwater management in Thunder Bay between City, Ministry of Environment and Climate Change (MOECC), and the Water Working Group.
Nov 2010	EarthWise®[1] Water Working Group gave a presentation *"Towards a Stormwater Management Plan for Thunder Bay"* to City staff and recommended the development of a Stormwater Master Plan.
2011	The City continues regularly updating the Engineering and Development Standards as an interim adjustment to Stormwater Management practices until the SMP is developed.
2011	The City's first Low Impact Development (LID) Demonstration Project was constructed at the Bare Point Water Treatment Plant.
Feb 2011	Conference concerning Innovative Approaches to Stormwater Management hosted by EcoSuperior Environmental Programs in partnership with the City, Lakehead Region Conservation Authority, Lakehead University, and the Thunder Bay District Stewardship Council
May 2011	The City completed the Phase 1 Scoping Study for the Stormwater Management Plan.
2012	A second LID Demonstration Project was constructed at the Port Arthur Arena.
Feb 2012	The City, EcoSuperior, and other partners held the 2nd Innovative Approaches to Stormwater Management Conference.
Nov 2012	The Request for Proposals went out for tender to Develop a Terms of Reference for the SMP and was awarded to MMM Group Ltd. two months later.
2013	City initiated the Rain Garden Rebate Program and the Residential Drainage Assistance Program in collaboration with community groups to improve stormwater management.
2013	Two LID Projects were constructed at the Beverly Street site and Sir Winston Churchill Pool parking lot.
Dec 2013	The Request for Proposals went out for tender for Consulting Services to Develop the SMP and was awarded to Emmons & Olivier Resources, Inc. shortly thereafter.
2014	The City implemented three additional LID Demonstration Projects throughout the City at County Park, Madeline Street (Grandview Arena), and Delaney Arena parking lot.
Jul 2014	The City published the *Neighbourhood Master Stormwater Drainage Study* with infrastructure recommendations to address drainage issues in four priority neighbourhoods. The City also published the *McVicar Creek Protection & Rehabilitation Plan* to continue the progress towards restoring the environmental health of the watershed.

[1] EarthWise is a trademark of Cambridge and North Dumfries Energy Solutions Inc. that was used under a license agreement until 2012, and consequently replaced by the name EarthCare.

1.3 Connection to Other Planning Efforts

Within the City, a number of planning efforts have been completed that have identified the need for an integrated approach to stormwater management. The resulting municipal-wide planning documents are summarized below. Connections between the stormwater management activities recommended in this SMP and the goals identified in the planning documents are highlighted in Section 5.5 *Capital Improvement Plan / Implementation Plan*.

Official Plan (2002)(8) and Draft Updated Official Plan Review (2014)(9)
[*City Planning Services Division*]:

> The Official Plan is the City's primary land use policy document. It guides development in the community and provides direction for the City's decision making. The Plan's policies recognize the importance of the City's surface and groundwater resources and they identify development criteria to address stormwater management concerns. The Plan supports the Watershed Planning process to promote development and land use practices that protect and enhance the ecological, recreational and aesthetic potential of the City's water resources. The Plan's Natural Environment policies and Environmental Protection designations support the protection of natural heritage features and the preparation of Environmental Impact Studies to identify appropriate mitigation measures prior to development.

Site Plan Control [*City Planning Services Division*]:

> Site Plan Control is a process used to guide development in an orderly and efficient manner, and to improve the overall appearance and quality of development in the community. Through Site Plan Control, the appropriate treatment of development-related features such as landscaping, parking, grading, drainage, and buffering can be achieved. As it relates to stormwater, Site Plan Control is used to require the appropriate grading and contouring of land to address the handling of stormwater in accordance with the current Engineering and Development Standards. Site Plan Control is also used to require that the massing, conceptual design and bulk of development is generally compatible with the natural landscape and facilitates a functional stormwater system. Currently, the Site Plan Control process is applied only to development that requires a planning approval, or has already been designated as an area of Site Plan Control through a previous planning approval.

Urban Design and Landscape Guidelines (2012)(10) [*City Planning Services Division*]:

> The City's Urban Design and Landscape Guidelines provide detailed direction for the implementation of the policies and objectives of the Official Plan to guide development throughout the City. The guidelines identify a set of guiding principles supported by performance standards to be applied during the design, review and approvals process for new development. The preservation and enhancement of existing natural heritage features; the integration of open space areas, trails, and natural corridors; the design of stormwater management facilities, and the greening of City streets and boulevards through tree and buffer planting are all identified as important components of a natural and functional drainage system.

McVicar Creek Protection & Rehabilitation Plan (2014)[11]
[*City Infrastructure and Operations Department*]:

Related to stormwater runoff, this plan aimed to address the higher sediment loads specifically within the McVicar Creek watershed.

Lake Superior Lakewide Management Plan Annual Report (2013)[12]
[*Environment Canada and USEPA*]:

Lakewide Management Plans (LaMPs) were first implemented in 1987 as an amendment to the Great Lakes Water Quality Agreement, which was originally signed by Canada and the United States in 1972. The environmental agencies from these two federal governments, Environment Canada and the Environmental Protection Agency (EPA), agreed to implement LaMPs and Remedial Action Plans (RAPs) for specific Areas of Concern (AOC). The plan found pollutants such as mercury and PCBs continue to cause fish advisories and exceedances of water quality guidelines. The primary objective related to the City resulting from the LaMPs was to increase monitoring of potential pollution sources in order to identify potential impacts of expected increases in mining activity and hydropower development. Such monitoring will also help identify suitable options for cleaning up contaminated sediment adjacent to former industrial sites.

Urban Forest Management Plan (2011)[13] [*City Parks Division*]:

The plan identified many of the ecosystem services provided by intact urban forests, as they relate to stormwater management. Trees reduce the volume of stormwater runoff in neighbourhoods and the larger community. The runoff reduction function and benefit is especially important in developed settings with increased quantities of impervious surfaces (roads, driveways, homes, parking areas) and in areas in close proximity to surface waters. A tree's surface area, particularly leaf and trunk surfaces, intercept and store rainfall. The interception of rain before it hits the ground reduces soil compaction and improves the soil's absorptive properties. The tree's root system absorbs water from infiltration, thereby decreasing runoff. Trees can in some cases intercept a portion of pollutants such as oils, solvents, pesticides, and fertilizers which are often part of stormwater runoff, reducing pollutant discharges into waterways.

Stormwater Management Plan Scoping Study, Phase 1 (2011)[14] [*City Environment Division*]:

The City initiated and completed the scoping study for the SMP in consultation with EarthCare's Water Working Group (WWG) to review the then current approaches to SWM throughout Ontario at the provincial and municipal scale and recommend expectations of the SMP. The study suggested that conventional end-of-pipe SWM practices, such as those detailed in the MOECC Stormwater Management Planning and Design Manual (2003)[5], do not serve municipal and environmental SWM needs effectively. The study recommended that the SMP should foster a soft path approach to SWM, including new and emerging Low Impact Development (LID) practices. LID practices can reduce the volume of stormwater requiring management in conventional end-of-pipe SWM facilities and can provide additional reduction of Total Suspended Solids (TSS), Total Phosphorus (TP), and other pollutants.

EarthWise®2 Community Environmental Action Plan (2008)(7) [*City*]:

The EarthWise® Community Environmental Action Plan included the proposed action "Develop a Comprehensive Stormwater Management Plan," (p. 71). It also contains a number of other goals and objectives that relate directly to stormwater, including alternatives to pesticide use and universal site-plan control.

EarthCare Sustainability Plan 2014-2020 (2014)(15) [*City*]:

The plan outlines objectives in areas relating to sustainability, such as energy, land use planning, climate adaptation, and water. Two of the objectives relating to water are: "by 2020, integrated approaches to improve the management of water, wastewater, and stormwater based on best practices are supported" (p. 61) and "by 2020, water conservation, stewardship and water management practices for healthy watersheds are promoted to the community" (p. 61). The plan recommends multiple actions to achieve greater water sustainability. Other actions relating to stormwater are identified to address climate impacts and encourage stakeholder partnerships.

Climate Adaptation Strategy (December, 2015) [*City*]:

The goal of this strategy is to build resilience within the Corporation to reduce the risks inherent in climate change and take advantage of opportunities while building upon existing adaptive actions to help the City prepare for, respond to, and recover from the potential impacts of climate change with an emphasis on increasing the resilience of infrastructure and the natural environment. The strategy used the guide for municipal climate adaptation developed by ICLEI Local Governments for Sustainability. ICLEI is the world's leading association of over 1,000 cities and urban regions dedicated to promoting global sustainability through local action. The guide *Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Adaptation* provides a milestone based framework to assist local governments in the creation of adaptation plans to address the climate change impacts associated with their communities.

Recreation and Parks Master Plan (not adopted by Council, 2008) [*City Parks Division*]:

The Plan promoted continued planning for a comprehensive, linked green space system. The green space would support natural environment objectives and accommodate recreation. The green space would be comprised of parks and open space areas, trail corridors, valley systems, and natural areas.

McVicar Creek Stewardship Plan (2007) [*LRCA*]:

In 2002, the LRCA conducted Phase One of the McVicar Creek Stewardship Plan. Phase One was an inventory of the riparian corridor to determine its overall health. Phase Two consisted of three public meetings which were held in April 2007. The Phase Two report contains details of the meetings as well as recommendations which included the development of a Watercourse Protocol and developing a contact list dealing with areas of jurisdiction for various concerns raised at the meetings.

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[2] EarthWise is a trademark of Cambridge and North Dumfries Energy Solutions Inc. that was used under a license agreement until 2012, and consequently replaced by the name EarthCare.

Current River Greenway Master Plan (2000) [*Forest Capital of Canada-2000*]:

The plan identified the need for community outreach since the majority of the Core Greenway is privately owned and it is important that land owners be made aware of the Core Greenway concept. While specific Greenway boundaries were not recommended, a 200 metre area of concern on either side of the Current River riparian zone was recommended for planning purposes. It is intended that the Core Greenway's 400 metre area of interest be managed for habitat diversity and for enhancing aesthetic and recreational opportunities.

Pollution Prevention Control Plan (1999)[(16)] [*City*]:

Phase 1 included an assessment of wastewater collection and treatment facilities and evaluation of the area's water resources. In Phase 2 of the study, pollution prevention and control strategies were evaluated. An implementation plan addressing short and long term control objectives and servicing needs of the City was prepared.

Thunder Bay Remedial Action Plan [*City Public Advisory Committee*]:

Thunder Bay is home to one of 42 Areas of Concern (AOC) identified by the International Joint Commission (IJC) in conjunction with Canadian and U.S. federal, state and provincial governments on the Great Lakes System. The *Revised Great Lakes Water Quality Agreement (GLWQA) of 1978,* as amended by Protocol in 1987 between Canada and the United States, calls for the development of Remedial Action Plans (RAPs) for these AOCs.[(17)] In 1986, the governments of Canada and Ontario signed the Canada-Ontario Agreement on Great Lakes Water Quality, thereby committing to develop RAPs for the 17 AOCs in Ontario. Thunder Bay was identified as an AOC because environmental conditions failed to meet the General or Specific Objectives of the GLWQA, where "such failure has caused or is likely to cause impairment of beneficial use or impairment of the area's ability to support aquatic life".[(18)] Degraded water quality was resulting in fish consumption advisories, impacted biota and beach closings. The main pollutants contributing to these beneficial use impairments included conventional pollutants (e.g. biochemical oxygen demand), heavy metals, toxic organics, and contaminated sediments. Many of these pollutants entered the landscape from industrial and municipal point sources, long range atmospheric transport, agriculture and in-place pollutants.[(18)] The AOC is defined as the harbour area, the Kaministiquia River upstream to the Highway 61 Bridge, and a portion of the Bay proper (occupies the southwest corner of Thunder Bay proper). Other tributaries to the Thunder Bay harbour (i.e. Neebing River, McIntyre River, Current River and McVicar Creek) are included up to the Highway 11/17 crossing to include stormwater runoff inputs. By improving stormwater quality and quantity, the implementation of the SMP will impact several of the Beneficial Use Impairments identified for the Thunder Bay Harbour Area of Concern including degradation of fish and wildlife populations, loss of fish and wildlife habitat, and aesthetics and beach closures.

1.4 Regulatory Setting

Stormwater management in Ontario is regulated by multiple pieces of legislation and administered by each level of government, including federal, provincial, and municipal. In particular, provincial legislation gives various levels of authority and power to municipal governments and conservation authorities to regulate the management of stormwater. This section outlines the regulations and policies that apply to stormwater management in Ontario that must be considered in the City's SMP.

1.4.1 Federal Legislation

There is currently no federal legislation that relates directly to stormwater, although the federal government has two main pieces of legislation focused on its constitutional responsibility for protecting fisheries and navigation. In addition, the *Canadian Environmental Protection Act* (SC 1999, c.33) also relates to stormwater management by mandating emergency planning for industrial accidents and the guidelines for the Act include treatment of stormwater before runoff containing toxic substances reaches ecosystems.

1.4.1.1 Department of Fisheries and Oceans

The Department of Fisheries and Oceans (DFO) administers the *Fisheries Act* (RSC 1985, c F-14), which prohibits the release of deleterious substances into fish habitat, which is defined very broadly in the Act and can include roadside ditches and watercourses that are only intermittently wet. Proponents conduct a self-assessment to determine if DFO authorization is required.

1.4.1.2 Transport Canada

Transport Canada requires works that affect navigable waters, such as bridges and culverts, to obtain approval through the *Navigation Protection Act* (RSC 1985, c N-22), formerly named the *Navigable Waters Act*, if the affected waterway is included in the Act's List of Scheduled Waters. Although the majority of waterways in Canada are not included in the list, the public right to navigation exists for all navigable waters under Common Law. Proponents of work on navigable waterways not included in the List of Scheduled Waters can opt in and seek Transport Canada's approval, making the application subject to Transport Canada's compliance monitoring and enforcement regime.

1.4.2 Provincial Legislation

Provincial legislation is administered by multiple ministries of the Ontario government and grants powers and obligations to other government actors, such as Conservation Authorities and municipalities, in matters relating to stormwater management.

1.4.2.1 Lakehead Region Conservation Authority

The *Conservation Authorities Act* (RSO 1990, c-27) grants conservation authorities the power to control the flow of surface waters to prevent flooding and to reduce adverse effects thereof.(19) The Lakehead Region Conservation Authority (LRCA) provides input and review of land use planning to municipalities and developers in accordance with provincial, federal, and conservation authority policies and regulations. Unlike other conservation authorities in Ontario, the jurisdiction of the LRCA covers the lower portions of the Lakehead Watershed to align with the boundaries of participating municipalities instead of including the entire grouping of natural watersheds. Territories that are not covered by a Conservation Authority in the Province of Ontario fall under the jurisdiction of the MNRF.

The following development requirements apply specifically to the SMP:

- Any development within the approximate regulated area will require a permit from the Lakehead Region Conservation Authority (LRCA).

Regulated Areas

- Areas within the LRCA Area of Jurisdiction considered to be regulated by the Conservation Authority include (but not limited to):
  - All watercourses including streams, rivers and creeks and area adjacent
  - Provincially Significant Wetlands plus 120 metres surrounding the wetland
  - In-land lakes and shorelines
  - 15 metres landward and one kilometre lakeward from the 100 year flood level of Lake Superior
  - Ravines, valleys, steep slopes and talus slopes
  - Hazardous lands including unstable soil and bedrock
  - Property zoned "Use Limitation", "Hazard Land" and "Environmental Protection"

Regulated Activities

- The Regulation applies to development including (but not limited to):
  - The construction, reconstruction, erection or placing of a structure of any kind
  - The temporary or permanent placing, dumping or removal of any material, originating on the site or elsewhere
  - Any alteration to a watercourse including culvert, bridge and boat launch installations

1.4.2.2 *Ministry of Environment and Climate Change*

The MOECC administers multiple acts with relationships to stormwater management, as follows:

Ontario Water Resources Act, RSO 1990, c O-40	• Regulates stormwater works, including requirements of owners to conduct ongoing maintenance and monitoring. • Prohibits the discharge of any material that may impair surface or groundwater quality. • Requires erosion controls to protect downstream watercourses. • Regulates permits to take water in addition to well construction, operation and abandonment.
Environmental Protection Act, RSO 1990, c E-19	• Prohibits release of contaminants into the natural environments that may cause adverse effects and requires prompt reporting and clean-up of pollutant spills. • Requires projects to comply with conditions defined in provincial Certificates of Approval.
Clean Water Act, SO 2006, c 22	• Requires local communities to reduce or eliminate significant existing or potential threats to their municipal drinking water sources through development and implementation of source protection plans and followed by ongoing monitoring and reporting.
Safe Drinking Water Act, SO 2002, c 32	• Requires municipal drinking water systems to obtain approval from the director of the MOECC in order to operate. Operators must be trained and certified to provincial standards. • Defines framework for testing with legally-binding drinking water contaminant standards.
Nutrient Management Act, SO 2002, c 4	• Defines standards for nutrient storage and application and a framework for best practices for nutrient management to reduce potential for surface water, groundwater, or other environmental contamination.
Environmental Assessment Act, RSO 1990, c E-18	• Requires an environmental assessment of any major public or private undertaking in order to determine the ecological, cultural, economic and social impact of the project. • Establishes a “Class Environmental Assessment” process for planning certain municipal projects, including road, water, and sewage and stormwater projects.

The Ministry of Environment and Energy published Water Management: Policies, Guidelines, Provincial Water Quality Objectives (PWQO) in 1994 (also referred to as the Blue Book) to assist in managing quality and quantity of surface and groundwater as required for approval under the *Ontario Water Resources Act* and the *Environmental Protection Act*.(20)

The MOECC published the Stormwater Management Planning and Design Manual (2003)[5] as a technical guide for planning, designing and reviewing stormwater management practices for approval under the *Ontario Water Resources Act*. The manual articulates development guidelines and criteria for water balance, water quality, water quantity, and erosion and sediment control. Some of the guidelines, such as the enhanced level control for water quality, are the minimum standards required in the City's Engineering and Development Standards (2015).

The MOECC recently published an Interpretation Bulletin: Ontario Ministry of Environment and Climate Change Expectations Re: Stormwater Management (February 2015) to clarify the expectations of the MOECC regarding stormwater management as defined in the existing policies and guidance.[21] The bulletin also announces that the MOECC will release an LID stormwater management guidance document in late 2016. Until then, the bulletin clarifies the following regarding the application of and justification for Low Impact Development approach to stormwater management:

> "…the ministry's existing guidance emphasizes an approach to stormwater management that mimics a site's natural hydrology by controlling precipitation as close as possible to where it falls so water quality remains satisfactory for aquatic life and recreation and water quantity is managed to ensure a fair sharing among users, water conservation, and sustainability of the resource (p. 1 of letter)."
>
> "…the MOECC's current guidelines and policies support locally derived site-specific performance criteria based on watershed/subwatershed studies and source control measures such as low impact development (LID). This Bulletin is also intended to encourage stormwater management applications that emphasize low impact development techniques while the ministry undertakes the development of a low impact development stormwater management guidance document, targeted for completion in 2016 (p. 1 of letter)."
>
> "Low impact development stormwater management is relevant to all forms of development, including new development, redevelopment, infill, and retrofit development. Compact urban development and urban intensification helps to prevent sprawl and thus protect farmland, wetlands, and green spaces, and also provides for efficient use of land, water and energy resources and existing infrastructure. Employing LID facilities to the greatest extent possible, when undertaking intensifying urban development, will add to these benefits (p. 2 of bulletin)."
>
> "…it has been demonstrated that LID installations, when properly sited, designed and maintained, can meet all of the requirements and no end-of-pipe controls are required (p.4 of bulletin)."

1.4.2.3 Ministry of Natural Resources

The Ministry of Natural Resources and Forestry (MNRF) provides guidelines on protection of wetlands and management of Natural Hazards as they relate to river and stream systems. The MNRF also administers multiple acts with relationships to stormwater management, as follows:

Lakes and Rivers Improvement Act, RSO 1990, c L-3	• Regulates public and private use of Ontario's lakes and rivers, including construction, repair, and use of dams • Requires Water Management plans for waterpower facilities to ensure environmental, social and economic concerns are addressed. • Prohibits the discharge of substances into lakes and rivers that may impair water quality and/or quantity.
Public Lands Act, RSO 1990, c P-43	• Guides the use, management, sale and disposition of public lands and forests, including public land use planning and development.

The Northern and Southern Manuals for the Ontario Wetland Evaluation System (OWES)[3] published by the MNRF are guidelines for evaluating the functions of wetlands. Wetlands evaluated through the OWES that meet certain criteria are identified as Provincially Significant Wetlands (PSW) and have protection under the Provincial Policy Statement (PPS). The OWES Northern Manual (2014) reinforces that the significance of wetlands can also be assigned by municipalities at a local scale:

> "Municipalities may determine that some of these 'other' wetlands are significant on a local scale and may decide to protect them. These wetlands can include: (a) evaluated wetlands that have been identified as not provincially significant; and (b) partially evaluated and unevaluated wetlands that have been confirmed as wetland habitat and mapped using the ground-based OWES methodology or interpretations of remote-sensed imagery. In addition, the following attributes may assist the municipality in identifying these locally important wetlands.
>
> 1. Ground Water discharge: Accurate identification of ground water discharge requires detailed hydrogeological studies. Full score (30 points) in the ground water discharge section of the wetland evaluation suggests a ground water discharge function for the wetland. Before development occurs in such a wetland, additional hydrogeological studies are encouraged.
> 2. Hydrology: A high score on the hydrological component indicates that the wetland likely performs an important function at a local or even regional scale.
> 3. Social value: High scores for Educational Uses and/or any of the sub-components of Recreational Activities suggest a high local value for the wetland.
> 4. Aboriginal Values/cultural Heritage: A wetland that receives the bonus score for either of these values may be important at the local scale (p. 215)."

The Natural Hazards Policies applied under the Provincial Policy Statement issued under the Planning Act are administered by the MNRF according to the Technical Guide for River & Stream Systems. The policies and guidelines aim to reduce risk to public safety and property damage relating to flooding, erosion, and slope stability by directing development away from Natural Hazards. The following policies apply to the SMP:

- Mitigate offsite flood impact by providing flood control (post- to pre-development peak flow control), conveyance improvements, or securing permission from any impacted land owners, if appropriate.
- Provide hydraulic structures that provide safe access and egress for emergency vehicles.

1.4.2.4 Ministry of Transportation

The Ministry of Transportation (MTO) has a series of guidelines addressing drainage considerations in highway design and corridor management. In particular, the following design requirement for hydraulic structures crossing watercourses apply to the SMP:

- Provide hydraulic structures that meet MTO guidelines for freeboard (Directive B-100, Highway Design Standards, MTO, January 2008).[22]

1.4.2.5 Ministry of Agriculture, Food, and Rural Affairs

The Ministry of Agriculture, Food, and Rural Affairs (OMAFRA) administers the *Drainage Act* (RSO 1990, c D-17) to regulate the creation of Mutual Agreement Drains between landowners and provide a democratic procedure for construction, improvement, and maintenance of drainage works, for which grants are made available to municipalities.

1.4.3 Municipal Regulation

Municipalities such as the City are given authority by the provincial legislature through the *Municipal Act* (SO 2001, c 25) to enact By-Laws and provide services to the public, including stormwater management. Additional authorities regarding stormwater management are provided to municipalities through the *Planning Act* (RSO 1990, c P-13) and *Building Code Act* (SO 1992, c 23), such as the ability to require land owners to manage stormwater from their property and operate stormwater systems to be in compliance with the *Building Code Act*.[19] Overall, the *Planning Act* provides municipalities with the powers to establish municipal Official Plans, zoning By-Laws, and other land use planning tools, which include the ability to place conditions on development approvals. The following sections outline the policies, By-Laws, regulations, and guidelines developed by the City regarding stormwater management.

1.4.3.1 Policies

As discussed in Section 1.3, the City's Official Plan and Site Plan Control relate to stormwater management through their guidance of land use changes and development in the City. The Official Plan's policies recognize the importance of the City's surface and groundwater resources and they identify development criteria to address stormwater management concerns. The Plan's natural environment policies support the protection of natural heritage features and water resources. The Draft Updated Official

Plan is considering a wider application of Site Plan Control, which would enhance the applicability of the City's development requirements.

Another policy of the City's is to outline requirements for the processing of development applications, as stated in the Engineering and Development Standards Policy (02-03-01). The requirements include including are those for design, construction, and acceptance into the City System for roads and services included in the development.

The City's Driveway Control Policy (11-02-04) defines requirements for new driveways, including construction specifications, locations, and area of responsibility.

The City's Laneway Maintenance Policy (11-06-02) outlines general maintenance standards for the laneways.

The Zoning By-Law Violation Enforcement Policy (10-02-02) gives the City authority to enforce Zoning By-Law infractions, such as exceeding minimum landscape requirements and driveway widths.

1.4.3.2 By-Laws

Several of the City's By-Laws relate to aspects of stormwater management, the most applicable of which are the Zoning By-Law and the Site Alteration By-Law summarized in this section and discussed in more detail in Section 5.3.1.

The intent of the current Site Alteration By-Law in Thunder Bay is to protect the land of property owners from significant disturbance as a result of development on adjacent properties and to establish regulatory requirements for land development and land disturbing activities. The By-Law is generally used as a tool to guide activities during the construction process.

Section 34 of the Planning Act authorizes councils of municipalities to pass Zoning By-Laws to standardize the use of land in a community and specify the permitted type, use and locations of permitted buildings and structures. Zoning By-Laws also define lot sizes and dimensions, building heights and sizes, parking, and landscaped open space requirements. Zoning By-Laws implement land-use policies specified in the Official Plan and contain specific, legally enforceable requirements. In general, no person shall use any land, building, or structure within a Zone for a use that is not permitted within that Zone, unless a variance is approved by Council. The City's current Zoning By-Law is applicable to all land and all buildings or structures erected, altered, enlarged, or used within the City.

The Property Standards By-Law (66-2008) includes several sections applicable to stormwater management:

> "2.31 Prevention of Ponding
> The Owner of a Building or Structure must provide a roof drainage system and, where necessary, sump pit system, that are configured, installed and maintained to prevent recurrent ponding of water on the Lands or on neighbouring Lands.
>
> 2.32 Prevention of Trespass
> The Owner of a Building or Structure must provide a roof drainage system and, where necessary, sump pit system, that are configured, installed and maintained to prevent roof water or sump pump discharge from depositing on any abutting Lands, including highways, ditches or sidewalks.
>
> 2.33 Rain Water Leader – Disconnection from Sanitary Sewer
> The Owner of a Building or Structure that is equipped with rain water leaders must prevent the rain water leaders from discharging or draining into the Corporation's sanitary sewer system.
>
> 2.34 Prevention of Drainage into Building
> The Owner of a Building or Structure that is equipped with rain water leaders must prevent the rain water leaders from creating a concentrated flow of water which may penetrate the Building or Structure."

The Sewer Use By-Law relates to stormwater management because it prohibits the discharge of pollutants into stormwater drainage systems, including land drainage works, private branch drains, or connections to any storm sewer. The By-Law also restricts the discharge of water with numerous properties, such as temperature, pH, and pollutant concentration or presence.

The Control of Waste Discharge to Municipal Sewers By-Law (373-1992) prohibits the discharge of certain pollutants to land drainage works, private branch drains or connections to any sanitary or combined sewer.

The Yard Maintenance By-Law (068-2008) requires land owners and occupants to maintain land grading and fill to prevent recurring ponding of stormwater.

1.4.3.3 Standards

The City's Engineering and Development Standards (2015)[23] provide minimum standards for the design of development, drainage infrastructure, and stormwater management in the City. Further discussion of the standards and potential revisions are provided in Section 5.3.2.

1.4.3.4 Guidelines

The City's Urban Design and Landscape Guidelines, and Image Route Guidelines and Detailed Streetscape Designs (2012) provide suggestions for development with several relationships to stormwater management, such as road cross sections and urban tree canopies.

1.5 Class Environmental Assessment Process

Although extensive community and stakeholder consultation was completed including regulatory agencies, special interest groups, Aboriginal communities and City staff as detailed in Appendix C, the SMP was not done in accordance with the formal Municipal Class Environmental Assessment (MCEA) process. However the document provides baseline data and some alternatives assessment that can be used to support MCEA approvals that will be required going forward. As individual projects recommended in the SMP are planned and implemented, the City will undertake formal environmental assessments as required under the MCEA.

All projects will be reviewed to identify the appropriate Class EA Schedule requirements prior to any planning or design work being undertaken. In general it is understood that the following project types and schedules will, at a minimum, be considered for implementation of the SMP:

- Schedule A Projects: are limited in scale, have minimal adverse environmental effects and include a number of municipal maintenance and operational activities. Projects are pre-approved and may proceed without following the Class EA. *Project example: establish new or replace or expand existing stormwater detention/retention ponds or tanks and appurtenances including outfall to receiving water body provided all such facilities are in either an existing utility corridor or an existing road allowance where no additional property is required.*

- Schedule A+ Projects: Projects are pre-approved and may proceed without following the Class EA however, the public is to be advised prior to project implementation. *Project example: modify, retrofit, or improve a retention/detention facility including outfall or infiltration system for the purpose of stormwater quality control. Biological treatment through the establishment of constructed wetlands is permitted.*

- Schedule B Projects: have the potential for some adverse environmental effects. The proponent is required to undertake a screening process involving mandatory contact with directly affected public and relevant review agencies, to ensure that they are aware of the project and that their concerns are addressed. If there are no outstanding concerns, then the proponent may proceed to implementation. Schedule B projects generally include improvements and minor expansions to existing facilities. *Project examples: Construct a stormwater control demonstration or pilot facility for the purpose of assessing new technology or procedures, establish stormwater infiltration system for groundwater recharge, and establish new stormwater retention/detention ponds and appurtenances or infiltration systems including outfall to receiving water body where additional property is required.*

- Schedule C Projects: projects have the potential for significant environmental effects and must proceed under the full planning and documentation procedures specified in the Class EA. Schedule C projects require that an Environmental Study Report be prepared and filed for review by the public and review agencies. Schedule C projects generally include the construction of new facilities and major expansions to existing facilities. *Project example: Construct new or modify, retrofit or improve existing retention/detention facility or infiltration system for the purpose of stormwater quality control where chemical or biological treatment or disinfection is included, including outfall to receiving water body.*

2 WATERSHED ASSESSMENT

The purpose of the watershed assessment is to characterize the physical resources of, and existing infrastructure in, the Lakehead Watershed, which encompasses the watersheds of the Current River, Kaministiquia River, McIntyre River, McVicar Creek, Mosquito Creek, Neebing River, and Pennock Creek. To gain a sufficient overview and understanding of the system, the assessment includes a description of each watershed including information on natural resources, population distribution, land use, water quantity and water quality. Given that the City is located on the downstream end of the Lakehead Watershed, this assessment sets the stage for future natural resource and stormwater management for the City, the Lakehead Region Conservation Authority, and other communities in the watershed.

The watershed assessment was written in large part by drawing from existing studies, plans and reports. Appendix A *Related Studies, Plans and Reports* identifies the outside documentation used to characterize the Lakehead Watershed.

GIS data was accessed through various sources, including the GeoBase National Hydro Network, Land Information Ontario, Ontario Base Mapping, and Natural Resources Canada.

2.1 Location

The City is located at the bottom of the Lakehead Watershed, which is approximately 8,930 square kilometres in size and extends from the headwaters of Dog Lake and Greenwater Lake to Lake Superior. The SMP considers the entire watershed draining through the City. As illustrated in Figure 1, the main water resources in this watershed that pass through the City include the Current River, Kaministiquia River, McVicar Creek, McIntyre River, Mosquito Creek, Neebing River, and Pennock Creek. Another area draining directly to Lake Superior is referred to as the Waterfront. The majority of the McVicar Creek, Mosquito Creek, and Neebing River Watersheds are within City limits. The McIntyre River Watershed is divided almost in half between the area within and outside of the City. The majority of the Current, Pennock, and Kaministiquia Watersheds are outside of the City's municipal boundary. Maps of each watershed with aerial photography are provided in Volume 3 (Maps 1 to 8).

The extents of these watersheds at the City scale are illustrated in Figure 2. The Neebing River and McIntyre River Watersheds cover the largest area within the City while the Pennock Creek, Mosquito Creek, and Current River are the smallest.

Within the Lakehead Watershed there are three organized townships, Fort William First Nation, three municipalities, multiple unorganized townships, and one city. Table 2 is a summary of the area, population and population density of the eight organized geographic regions.

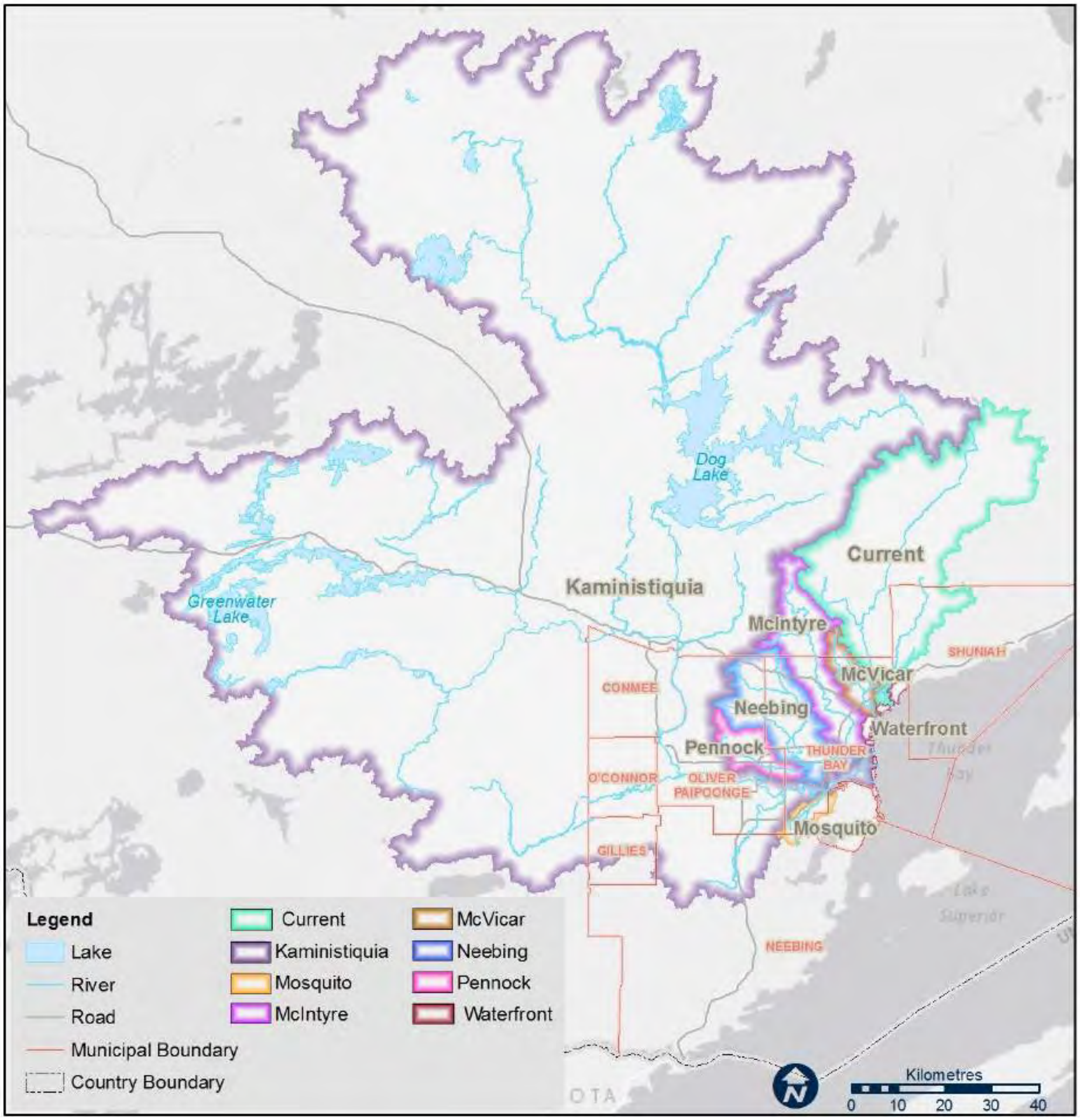

Figure 1. Lakehead Watershed

Figure 2. Watershed Boundaries within City Limits

Table 2. Municipalities and Townships within the Watershed

Geographic Name	Type	Area* (km^2)	Population*	Population* (Persons per km^2)
Conmee	Township	169	764	4.5
Fort William Reserve 52	First Nations Reserve	58.3	860	14.7
Gillies	Township	93.0	473	5.1
Neebing	Municipality	878	1,986	2.3
O'Connor	Township	109	685	6.3
Oliver Paipoonge	Municipality	351	5,732	16.3
Shuniah	Municipality	571	2,737	4.8
Thunder Bay	City	328	108,359	330.1

*Source: 2011 Census "Population and dwelling counts, for Canada, provinces and territories, and census divisions, 2011 and 2006 censuses (Ontario)". Statistics Canada. January 30, 2013. Retrieved September 26, 2014.

2.2 Climate and Precipitation

2.2.1 Climate

Thunder Bay has a climate with extremes in temperature, low humidity and moderate winds, as expected for a mid-latitude inland location. The lake has a slight warming effect in the winter and slight cooling effect in the summer.(24) Daily mean temperatures range from a low of –14.8°C in January to a high of 17.6°C in July, with an average annual temperature of 2.5°C. The temperatures recorded at the Thunder Bay Airport Weather Station from 1981 to 2010 are summarized in Table 3.

Table 3. Temperature Data from Thunder Bay Airport (1981-2000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily Max (C)	-8.6	-5.6	0.3	9.0	16.4	20.6	24.2	23.1	17.1	10.4	1.7	-6.1
Daily Mean (°C)	-14.8	-12.0	-5.5	2.9	9.5	14.0	17.6	16.6	11.0	5.0	-3.0	-11.6
Daily Min (°C)	-21.1	-18.4	-11.2	-3.3	2.5	7.3	11.0	10.1	4.9	-0.5	-7.7	-17

Source: Canadian Climate Normals, Environment Canada.

Environment Canada has operated numerous weather stations in the Thunder Bay region over the past six decades. The stations, including the seven currently operating, are listed in Table 4. The longest and most consistent record of temperature and precipitation records within the City are from the Thunder Bay A / CS station at Thunder Bay International Airport, in operation since 1941 and with hourly records since 1960. A comparison of temperature data from Thunder Bay A (Airport) and Kakabeka Falls illustrates the moderating effect of Lake Superior.(24) Minimum temperatures in Thunder Bay are about 3°C warmer on an annual basis than at Kakabeka Falls. In addition, the inland areas receive most of their snow in November, while the City receives most of its snow in January.(25) The locations of the active and inactive Environment Canada weather stations are shown in Map 9 of Volume 3.

Table 4. Environment Canada Weather Stations

Station	Climate ID	From	To	Data Interval	Years of Record
Abitibi Camp 11	6040010	1978	1983	Daily	5
Abitibi Camp 11	6040011	1983	1988	Daily	5
Abitibi Camp 228	6040018	1969	1978	Daily	9
Abitibi Camp 230	6040020	1969	1991	Daily	22
Dog Lake Dam	6042036	1923	1958	Daily	35
Dog River	6042045	1957	1960	Daily	3
Dona	6042063	1926	1958	Daily	32
Dorion TCPL 70	6042067	1970	1984	Daily	14
Flint	6042MJ7	1979	2014	Daily	35
Kakabeka Falls	6043930	1908	1977	Daily	69
Kaministiquia	6043949	1973	1974	Daily	1
Kingfisher Lake	6044138	1975	1977	Daily	2
Lakehead University	6044298	1968	2002	Daily	34
Loon	6044612	1979	1980	Daily	1
Nolalu	6045675	1973	1980	Daily	7
Nolalu SSW22	6045676	1979	1985	Daily	6
One Island Lake	6045781	1992	1993	Daily	1
Pigeon River	604FNL6	1970	1978	Daily	8
Port Arthur	6046588	1877	1941	Daily	64
Port Arthur CKPR	6046590	1959	1963	Daily	4
Raith TCPL 64	6046856	1969	1984	Daily	15
Thunder Bay	6048260	2012	2014	Daily / Hourly	2
Thunder Bay A*	6048261	1941	2004	Daily / Hourly	63
Thunder Bay Airport Maintair	6048270	2003	2005	Daily	2
Thunder Bay Awos	6048264	1994	2012	Daily	18
Thunder Bay Burwood	6048266	2005	2014	Daily	9
Thunder Bay CS*	6048268	2002	2014	Hourly	12
Thunder Bay Firehall	604S003	1995	2014	Daily	19
Thunder Bay MCS Centre	6048K6J	1980	1984	Daily	4
Thunder Bay Pomber	604H26A	1979	1988	Daily	9
Thunder Bay Provincial Paper	604HK61	1990	1990	Daily	1
Thunder Bay WPCP	604HBFA	1960	1989	Daily	29
Tranquillo Ridge	6048864	1991	2006	Daily	15
Trout Lake	6048951	1980	1981	Daily	1
Trowbridge (Aut)	6048955	1992	1993	6-hourly	1
Upsala (Aut)	6049096	1947	1972	Daily	25
Upsala (Aut)	6049095	1973	2014	Daily / Hourly	41
Welcome Island (Aut)	6049443	1967	2014	Daily / Hourly	20
Whitefish Lake	6049466	1980	2008	Daily	28

*Both stations located at Airport. Thunder Bay A (6048261) had hourly data starting in 1960.
Shaded rows are active stations

2.2.2 Precipitation

The precipitation recorded at the Thunder Bay Airport weather station from 1981 to 2000 is summarized in Table 5. The average total annual precipitation at the station during that same period is 711.6 mm, consisting of about 559 mm of rainfall and 187.6 cm of snowfall. The total precipitation is the sum of rainfall and snowfall in millimetres of water, where 12 mm of snowfall is approximately equal to 1 mm of water, although the Snow Water Equivalent can vary.

Table 5. Precipitation Data from Thunder Bay Airport (1981-2000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	2.5	2.8	17.5	29.5	65	85.7	89	87.5	87.5	57.0	31.5	3.6	559.1
Snowfall (cm)	41.2	26.9	26.8	12.4	1.7	0	0	0	0.5	6.1	27.8	44.1	187.6
Total Precipitation (mm)	31.3	24.9	41.6	41.5	66.5	85.7	89	87.5	88	62.6	55.6	37.5	711.6

Source: Canadian Climate Normals, Environment Canada.

In addition to the precipitation monitored at the Environment Canada weather stations, the LRCA operates eight tipping bucket rain gauges that collect precipitation data every 15 minutes at the flow monitoring stations operated by Water Survey Canada, a branch of Environment Canada. The LRCA precipitation gauges are summarized in Table 6 and their locations are shown in Map 10 of Volume 3 with labels corresponding to the Water Survey Canada station identification numbers.

Table 6. Lakehead Region Conservation Authority Precipitation Stations

Station Name	LRCA ID	Water Survey Canada ID	Data Interval	From	To	Years of Record
Neebing River	29	02AB008	15 min	1986	2015	29
McVicar Creek	30	02AB019	15 min	1986	2015	29
Whitefish River	31	02AB017	15 min	1986	2015	29
Current River	32	02AB021	15 min	1989	2015	26
North Current River	33	02AB014	15 min	2003	2015	12
Corbett Creek	34	02AB022	15 min	2003	2015	12
McIntyre River	45	02AB020	15 min	1987	2015	28
Slate River	57	02AB023	15 min	2007	2015	8
Upper Neebing River	58	02AB058	15 min	2007	2015	8

2.3 Physical Geography

This section of the SMP describes processes and patterns in the natural environment including topography, geology and hydrogeology or groundwater. Since these processes and patterns occur throughout the Lakehead Watershed, this information is presented in a more regional manner. Subsequent sections of the *Watershed Assessment* present information on a watershed-by-watershed basis.

2.3.1 Topography

At the mouth of the Kaministiquia River, the City is at an elevation of 183 m above sea level (masl). The eastern boundary of the bay, which is about 50 kilometres long and 22 kilometres wide, is marked by the Sibley Peninsula (with the iconic Sleeping Giant at its end), a 33 kilometre long formation of hills and mesas that reaches 250 masl. The southern boundary of the City is bordered by the Nor'Wester Mountains, a series of peaks that reach up to 331 masl and are characterized by very steep slopes. The southern downtown of the City occupies flat alluvial land along the Kaministiquia River and features two islands at the mouth of the Kaministiquia: Mission and McKellar Islands. The northern section of the City is more typical of the Canadian Shield with gently sloping hills. The 1 m City contours and 10 m provincial contours are shown in Volume 3 (Maps 11 to 17).

Two digital elevation models (DEMs) are available for the watersheds, one at the City scale with a 15 m grid provided by the City and another at the Lakehead Watershed scale with a 10 m grid prepared by Canadian Digital Elevation Data. Both DEMs were generated based on topographic contours. The average slopes and maximum elevation of each watershed are summarized in Table 7. The McVicar Creek Watershed has the steepest watercourse, while the Neebing River Watershed has the flattest. The slope of the many ditch systems along the waterfront varies from very flat slopes in the central and southern subcatchments of the watershed to steeper slopes in the northern areas. The Neebing-McIntyre Floodway has an average gradient of 0.05%.

Table 7. Topography in each Watershed

Watershed	Average Slope of Watercourse (%)	Maximum Elevation (masl)
Current	0.5 %	542
Kaministiquia	0.4 – 0.5%	678
McIntyre	0.7 – 0.8%	542
McVicar	1 – 2%	542
Mosquito	0.4 – 0.7%	472
Neebing	0.1 – 0.7%	493
Pennock	0.6	361
Waterfront	0.5 – 4%	322

2.3.2 Geology

2.3.2.1 Surficial Geology

Surficial deposits within the study area are of Late Wisconsinan age, deposited by the retreating ice margin around 12,500 years ago. A re-advance approximately 11,500 years ago by the Superior Lobe incorporated some lacustrine sediments, deposited between the glacial advances into subsequent till units.[24]

Overall, surficial deposits are thin throughout the area, with local exceptions. North of the Kaministiquia River, all watercourses contain bedrock cuts, indicative of thin cover. The maximum overburden thickness within the study area is near the mouth of the Kaministiquia River, where wells show the combination of glacial deposits and lacustrine sediments to be up to 50 m thick. Moderately thick outwash gravels to the north of the City can reach a thickness of 12 m, but depths of 3 to 5 m are more common. Units of glacial till within the study area are relatively thin, usually less than 14 m in thickness.[24]

A number of overburden types occur throughout the area, as shown in Map 18 of Volume 3. A large area of till occurs west of the City and north of the Kaministiquia River, and is subdivided into stoney sand till, clay till and silt till units. The tills typically contain a significant proportion of fine-grained material. Additional fine-grained material was deposited in glacial meltwater lakes, ponded behind the Superior ice lobe, and flooded the area to an elevation of at least 260 masl (75 m above present Lake Superior elevation of 185 masl). Lacustrine deposits from earlier intervals of glacial retreat occurring at elevations to 366 masl are also noted in logs of water wells northwest of Kakabeka Falls.

2.3.2.2 Bedrock Geology

The majority of the study area is underlain by Precambrian rocks. Bedrock of the Thunder Bay area consists entirely of rocks of Precambrian age, in excess of 2.5 Ga (billion years) in age.(26) These rocks have been extensively deformed through metamorphism, with erosional and intrusional contacts further complicating the local geology. In general, the oldest rocks are metavolcanics, overlain by metasediments with this sequence locally intruded by smaller ultramafic and felsic units. Bedrock categories across the entire Lakehead Watershed are shown in Map 19 of Volume 3 and general stratigraphy of the area is summarized in Table 8.

A younger sequence of rocks overlies the oldest Precambrian, and consists mainly of sedimentary rocks of the Animikie Series. The Animike is comprised of the Gunflint and Rove Formations. The formations are made up of a variety of rock types, ranging from cherts to conglomerates, with interbedded argillites and carbonates.(24)

The youngest of the Precambrian rocks in the Thunder Bay area are the Logan Sills, which were emplaced approximately 1.1 Ga ago. The sills are essentially sheets of diabase rock up to 60 m thick.(26) The Logan Sills form the cap of the highest hills in the area, the Nor'Westers, which are located immediately south of the City.

Table 8. General Stratigraphy in the Thunder Bay Area

Type of Formation	Description	Comments
Overburden	Recent Alluvium	Mainly found along and within the stream beds
	Deltaic and lacustrine plains, beach ridges	Groundwater source possible in lacustrine and beach material
	Intola Moraine and ice-contact Deposits	Groundwater source possible in moraine and ice-contact material
	Hazelwood Delta and glaciolacustrine plains	Groundwater source possible in delta and glaciolacustrine material
	Till, and Dog Lake and Mackenzie Moraines	Groundwater source possible in moraine material
	Till, and Brule Creek Moraine	Groundwater source possible in moraine material
	Till and ground moraine	Discontinuous till
Bedrock	Proterozoic age: Intrusive diabase sills and dikes	Sills are cap rock to Nor'Westers, etc.
	Sibley Group sediments	Upper fractured and weathered portions, and open structural zones, may provide limited groundwater source.
	Animikie Group sediments (Rove and Gunflint Formations)	Upper fractured and weathered portions, and open structural zones, may provide limited groundwater source.
	Archean age: metavolcanics and metasediments	Upper fractured and weathered portions, and open structural zones, may provide limited groundwater source.
	Archean Granite	Upper fractured and weathered portions, and open structural zones, may provide limited groundwater source.

Source: Thunder Bay Area Aquifer Characterization, Groundwater Management and Protection Study (2005)

2.3.2.3 Bedrock Valleys

Bedrock valleys are important local features because they correspond to low areas in the topography, have thick sequences of overburden, and significantly influence infiltration and groundwater flow. They frequently host confined aquifers and can be local sources of drinking water. Bedrock valleys are also important hydrologic features between the bedrock sills that formed the Nor'westers.

The Thunder Bay Area Aquifer Characterization, Groundwater Management and Protection Study[(24)] has the following discussion about bedrock valleys:

> "The lowest bedrock elevation within the study area underlies the Kaministiquia River valley and the City of Thunder Bay, where the bedrock surface lays approximately 150 mamsl. This elevation is approximately 30 m below the elevation of Lake Superior. Two bedrock valleys trend westward from the Kaministiquia bedrock valley, and underlie the Whitefish and Slate River valleys to the north and south respectively. In addition, bedrock valleys underlie Hawkeye Lake and the area to the east, the Current River valley and the Greenwich Lake – Mackenzie River valleys, indicating likely structural bedrock control for the location of these surface drainage features (p. 16)."

2.3.2.4 Potential for Stormwater Infiltration

The MOECC's Interpretation Bulletin on stormwater management made the following recommendations regarding stormwater infiltration:

> "Infiltration of stormwater is needed to maintain ground water sources of drinking water, and to maintain stream base flows. At the same time, ground water quality must be protected from contamination, requiring the appropriate selection of LID measures, which would be determined by the hydrogeology of an area. Assessment reports under the Clean Water Act can provide local and watershed based hydrogeological information, including the delineation of 'vulnerable areas', to support this analysis (p.3 of bulletin).[21]"

Stormwater infiltration can be an effective management practice in areas that have the following characteristics:

- Permeable soils
- Low potential for groundwater contamination

These characteristics are often at odds with each other. Scientific research and years of practical experience have shown that stormwater infiltration can be accomplished without groundwater contamination under the right conditions, including:

- Sufficient soil above bedrock
- Adequate separation between the ground surface and the water table.

In addition to provincial soils mapped in Volume 3 (Maps 20 to 26), maps from The Thunder Bay Area Aquifer Characterization, Groundwater Management and Protection Study[24] can be helpful for identifying general areas where stormwater infiltration can be a significant management practice. Conditions can vary over short distances, so every individual site should be investigated to determine whether atypical site conditions make stormwater infiltration feasible.

The bedrock units throughout the study area generally have very low permeability unless the rock is locally weathered or fractured. A site needs to have sufficient permeable soil (glacial granular overburden in most cases) above bedrock in order to infiltrate and convey stormwater away from the site surface. Map 27 in Volume 3 (Figure 4.4 from the Aquifer Study) shows the overburden thickness throughout the Thunder Bay Area. As a general guideline, a minimum of one metre of unsaturated material is required from the bottom of a stormwater BMP and the underlying bedrock.

High permeability (high hydraulic conductivity) soils are preferred over low permeability soils for stormwater infiltration. Low permeability soils require more area and/or more time to infiltrate the same volume of stormwater. Generally, soils classified as gravel, sand, or silty sand are suitable for stormwater infiltration. Map 28 in Volume 3 (Figure 8.1 of the Aquifer Study) shows Intrinsic Susceptibility throughout the Thunder Bay Area. While permeability and "intrinsic susceptibility" are not the same thing, they are closely related enough that Map 28 in Volume 3 can be used to identify areas with soils that have high permeability (high intrinsic susceptibility).

Unsaturated soil between the water table and the stormwater infiltration area can effectively prevent contamination of the groundwater. As stormwater percolates down through unsaturated soil, filtration and biological activity remove potential contaminants. There are no standards for the thickness of soil required to treat stormwater, but at least 1.0 metre is recommended at all times. It is important to consider that seasonal variations in the water table elevation, localized areas of perched groundwater, and groundwater mounding effects caused by concentrated recharge can all cause high groundwater elevations during the life of a stormwater infiltration facility. The Aquifer Study does not include a map showing depth to groundwater. Map 29 in Volume 3 (Figure 4.13 of the Aquifer Study) shows the Water Table Surface elevations. These elevations can be subtracted from the ground surface elevation to identify general areas that are likely to have sufficient unsaturated soils for stormwater infiltration.(24)

2.3.3 Groundwater

Regional groundwater flow is generally from the higher elevation areas in the northern part of the study area, southwards, toward Lake Superior. Local groundwater flow will generally parallel surface topography, particularly adjacent to major river valleys. Regional recharge occurs mainly where thick units of coarse sand and gravel are exposed and from bedrock topographic highs. Groundwater recharge occurs through direct infiltration of precipitation, and recharge from surface streams and wetlands if the groundwater table is below the surface of the streams and wetlands.(24)

Numerous lakes and water bodies are located in the northern portion of the study area with (see Map 30 in Volume 3), which is indicative of the impermeable nature of the surficial soils over that area. Thus, the surface runoff over this area is expected to be high. Gravel pit operations in the area may also be facilitating increased recharge locally by collecting water in the gravel pits. The water use and water budget assessments indicate that there is potential for future groundwater development in the area.(24)

Water chemistry data was analyzed for 253 wells in the study area. According to the figures reporting water chemistry results (Maps 31 to 36 in Volume 3), it is evident that many of these wells are within the municipal boundary of Thunder Bay. The six parameters that were used to characterize water quality in the study area include: Nitrate, Sodium, Chloride, Iron, Manganese and Hardness. The results of the water quality analysis are provided in Table 9.

Table 9. Summary of Groundwater Water Quality

Parameter	Nitrate (mg/L)	Sodium (mg/L)	Chloride (mg/L)	Iron (mg/L)	Manganese (mg/L)	Hardness (mg/L)
Ontario Drinking Water Standard	10	200	250	0.3	0.05	80
Maximum	11.5	1,171	2,022	51.6	6.14	8,284
Minimum	0	0.2	0	0	0	5.5
Average	0.54	72.4	123.7	1.55	0.16	349.13
Standard Deviation	1.32	154.1	259.3	5.22	0.53	783.21
Percentage Exceeding ODWS	0.5%	60%	12.4%	35.2%	44.2%	91.5%

Source: Thunder Bay Area Aquifer Characterization Groundwater Management and Protection Study, 2005.

2.4 Land Use and Land Cover

This section of the SMP identifies the existing land uses (i.e. physical material at the surface of the earth) within the Lakehead Watershed as well as within the City.

2.4.1 Land Use

2.4.1.1 Land Use within the City

The most significant land uses in terms of stormwater impacts are urban and industrial developments. Urban and suburban sprawl extending from the shoreline of the Bay covers approximately 40% of the City. The existing land uses in the City are summarized in Table 10 as identified by the City's zoning, in addition to areas identified for future development.

Table 10. Percentage of Land Uses in Each Watershed (in City)

	Percentage of Watershed Area in City (%)								
Land Use	Current	Kaministiquia	McIntyre	McVicar	Mosquito	Neebing	Pennock	Waterfront	All
Residential	5	20	14	16	26	10	49	17	15
Residential Future	2	1	1	2	6	2	5	2	2
Rural	39	11	33	47	35	49	31	4	36
Rural Residential	0	0	23	15	0	3	0	0	8
Commercial	0	2	2	1	1	1	0	6	2
Future Development	0	2	1	0	0	2	0	0	1
Industrial	1	29	8	3	0	7	1	48	11
Institutional	1	4	4	0	9	1	0	2	3
Environmental Protection	19	24	9	5	13	16	8	6	13
Open Space	34	7	4	10	11	4	3	17	8
Airport	0	0	0	0	0	3	2	0	1
Urban Subtotal	8	58	31	21	42	28	57	74	35
Rural Subtotal	39	11	56	63	35	52	31	4	44
Natural Subtotal	53	31	13	16	23	20	12	22	21

Source: City of Thunder Bay, Zoning shapefile (2014) with analysis to group land use categories

The land use in each watershed is also illustrated in Maps 37 to 43 in Volume 3. The zoning GIS shapefile provided by the City was used to identify existing land use categories in more detail than the City's Official Plan mapping, which groups land uses more generally. The simplified land uses are outlined in Appendix B.

The most common land use throughout the entire City is rural, which includes both farmed and natural lands beyond the urban area limit, followed by residential and then environmental protection areas. The fraction of the watersheds with urban, rural, or natural areas is summarized in the subtotals in Table 10.

The Current River Watershed is predominantly open space and environmental protection lands, including Boulevard Lake and Centennial Park. The Kaministiquia and Waterfront Watersheds have the highest percentage of industrial land. The extractive industrial areas are mainly found in the McIntyre River and McVicar Creek Watersheds.[27] The land use is predominantly rural in the Neebing River Watershed. Residential land use is more common in the adjacent Pennock Creek Watershed.

It is projected that growth will continue to be accommodated within the current Urban Area Limit, including the future development and urban residential areas identified above. In addition, a proposed Designated Growth Area beyond the current Urban Area Limit, and mainly within the McIntyre River Watershed, has been identified in the City's Draft Updated Official Plan.

Much of the industrial land in the Harbour was built up through a combination of draining and filling of shoreline areas, including wetlands. The harbour front lands were historically used for railway activities, industry, grain elevators, aggregate supply, and marinas. Environmental investigations of Prince Arthur's Landing and the Pool 6 Lands site indicated that much of the near surface fill soils contain elevated levels of heavy metals and petroleum hydrocarbons whereas native soils are generally uncontaminated. The principal sources of contamination are believed to be deleterious foreign matter included in old fill materials (e.g., coal, clinker, ash, etc.) or in old contaminated soils (e.g., with petroleum hydrocarbons) excavated elsewhere in Thunder Bay and formerly deposited on the two sites.[28]

2.4.1.2 Land Use outside of the City

The upper portions of the watersheds outside of the City are predominantly undeveloped land with significant forested, wetland, lake, and bedrock coverage. A detailed summary of the Land Cover is provided in Section 2.4.2 *Land Cover*. The land uses in the upper watersheds include development in the adjacent municipalities, rural development, agriculture, mining, and timber harvesting, as summarized in Table 11. Industrial land uses, such as mining and timber harvesting, are identified in the latest version of the Land Cover 2000 shapefile by Natural Resources Canada (2009) as exposed or barren land. Other land cover data sources, such as the MNRF mapping, are outdated in comparison.[17] Past studies identify Timber Harvesting as a major land use in the Thunder Bay region but mining to be of less importance in the area.[3,7] Significant agricultural activities are present, in particular in the Kaministiquia River valley, including raising beef and dairy cattle and to a lesser extent, fruit and vegetable production. Most of the area has only low to moderate agricultural potential.

Table 11. Percentage of Land Uses in Each Watershed (outside of City)

	Percentage of Watershed Area outside of City (%)								
Land Use	Current	Kaministiquia	McIntyre	McVicar	Mosquito	Neebing	Pennock	Waterfront	All
Rural	0	2	1	1	2	18	34	0	2
Developed	2	2	7	7	2	6	15	4	2
Exposed/Barren Land	0	0	7	0	0	0	0	0	0
Natural	98	96	85	92	96	75	51	96	96

Source: GeoGratis, Natural Resources Canada, Land Cover 2000 shapefile (2009)

2.4.2 Land Cover

The majority of the Lakehead Watershed is natural land outside of urban areas, including forested, wetland, lake, and bedrock coverage. The land cover types in each watershed identified in the latest version of the Land Cover 2000 shapefile by Natural Resources Canada (2009) are summarized in Table 12 and illustrated in Maps 44 to 50 of Volume 3. The predominant land cover in most watersheds is forested, including mixed wood dense, mixed wood sparse, and coniferous dense.

The extent of development is minor in the largest watersheds (Current and Kaministiquia) and only 10% in Mosquito. Development in the other watersheds exceeds 20% of the entire watershed area. The watersheds with the most agricultural land cover include Neebing, Pennock, and Mosquito. Evidence of clear cut forestry practices are evident in the aerial map of the Current River Watershed (Map 1 in Volume 3), although this is not reflected in the provincial land cover data.

Table 12. Percentage of Land Covers in Each Watershed Within and Outside of City Limits

	Percentage of Watershed Area (%)								
Land Cover	**Current**	**Kaministiquia**	**McIntyre**	**McVicar**	**Mosquito**	**Neebing**	**Pennock**	**Waterfront**	**All**
Agr-Annual Cropland	0	1	1	0	6	4	12	0	1
Agr-Pasture/Forage	0	1	2	2	16	11	21	0	2
Broadleaf	0	0	0	0	0	0	0	0	0
Broadleaf Dense	24	16	17	18	20	17	16	10	17
Coniferous Dense	7	11	4	5	1	4	2	2	10
Developed	3	2	23	26	10	20	21	71	3
Exposed/Barren Land	0	0	4	0	0	0	0	0	0
Herbaceous	7	8	1	1	0	0	0	1	7
Mixed wood Dense	38	26	27	27	22	19	11	8	27
Mixed wood Sparse	13	20	21	20	24	23	17	4	20
Other	0	0	0	0	0	0	0	2	0
Rock/Rubble	0	0	0	0	0	0	0	0	0
Shrubland	0	0	0	0	0	0	0	0	0
Water	7	10	1	1	2	1	0	3	10
Wetland-Shrub	0	0	0	0	0	0	0	0	0
Wetland-Treed	1	3	0	0	0	1	0	0	3

Source: GeoGratis, Natural Resources Canada, Land Cover 2000 shapefile (2009)

2.5 Watersheds

The entire Lakehead Watershed is approximately 8,930 square kilometres extending from the headwaters of Dog Lake and Greenwater Lake to the receiving waters of Lake Superior. The Lakehead Watershed includes seven smaller watersheds, each draining to the main water resources passing through the City: the Current River, Kaministiquia River, McVicar Creek, McIntyre River, Mosquito Creek, Neebing River, and Pennock Creek. The waterfront is the eighth watershed in the City, where runoff drains to channels and storm sewers discharging directly to the Thunder Bay Harbour.

Characterization of the existing drainage is summarized by the eight watersheds in the following sections and maps of the watersheds are provided in Volume 3. To facilitate interpretation of watershed-specific information for this planning effort as well as for future reference, this information has been consolidated in a summary table for each watershed. The scope of further analysis in each watershed presented later in the SMP, such as hydrologic model development, did not include the Waterfront Watershed.

2.5.1 Current River

The second largest watershed, Current River, is located northeast of the City and includes a portion of the Municipality of Shuniah. The river originates in Current Lake and then drains to the south through Ray Lake and Onion Lake, successively. The river crosses into Thunder Bay and is joined by the North Branch tributary on the north side of the Thunder Bay Expressway. It continues south, eventually crossing the Expressway, and flows through Boulevard Lake. Urban discharges to the Current River and Boulevard Lake include storm sewers and open ditches. The lake's water level is controlled by a dam on the north side of Cumberland Street. A small hydroelectric generating station operates at the dam. Downstream of the Boulevard Lake Dam, the Current River's bank elevations are relatively low in comparison to the river bed although there are relatively large elevation drops along its profile totalling approximately 25 m of drop over 700 m in creek length. The lowest section of the river crosses Cumberland Street, two railway lines, and Shipyard Road before discharging to the Bay. All of the lower reach is currently protected through a series of municipal parks and conservation areas, however the final kilometre of the river has been subjected to past impacts from industrialization dating to 1866.(29) The flows in this portion of the river are generally supercritical, characterized by high velocities and shallow depths, through a wide range of flow conditions.(30) The physical features of the Current River watershed are summarized in Table 13.

Table 13.Current River Watershed Facts

Watershed	Current River
Drainage Area	662 km^2
River Length	64 km
Headwaters	Current Lake
Tributaries	North Branch, Ferguson Creek
Area within City	19 km^2
% Impervious [1]	0.1% (1 km^2)
% Protected Land [2]	2%
% City Owned Land [3]	1%
Future Land Use Projections [4]	Two future residential developments on west side of Boulevard Lake
% Bedrock Coverage [5]	65%
Soils	Thin layer of silty to sandy till overlying bedrock and clay (Map 20)
Area of Natural and Scientific Interest [6]	None
Thermal Property Classification	Coldwater
Fisheries	• Historically supported migratory coaster brook trout (*Salvelinus fontinalis*) and Pink Salmon (*Oncorhynchus gorbuscha*) • Rainbow trout (*Oncorhynchus mykiss*) • Brook trout (*Salvelinus fontinalis*), upstream of dam • Mouth of river supports walleye (*Sander vitreus*) • Rainbow smelt (*Osmerus mordax*) spring spawning run
Total length of Storm Sewer Main [7]	5 km
Sewershed (% of Watershed) [8]	0.5%
Date of Floodplain Delineation	1979
Water Control Structures	Boulevard Lake and Hazelwood Lake Dams

Notes:

[1] Source: City of Thunder Bay, Anthropogenic Impervious shapefile (2014) may be lower than other estimates
[2] Areas identified as an Area of Natural and Scientific Interest (ANSI), Zoned by City for Environmental Protection, Conservation Areas, or provincially significant wetlands
[3] Areas within City identified as City-owned in Parcel shapefile (2014)
[4] Source: City's Draft Updated Official Plan (2014)
[5] Source: Land Information Ontario, Ministry of Agriculture and Food, Soil Survey Complex shapefile (2003)
[6] Source: Land Information Ontario, MNRF, ANSI shapefile (2012)
[7] Source: City of Thunder Bay, Storm Sewer Main shapefile (2014)
[8] Source: Approximated based on coverage of City's Storm Sewer Main GIS layer in each watershed

2.5.2 Kaministiquia River

The Kaministiquia River and its tributaries form the largest drainage system in Lakehead Watershed. Numerous lakes provide storage for rainwater throughout the watershed. The system is regulated by multiple control structures, some of which are used to generate hydroelectric power. The headwaters of the Kaministiquia River are in Dog Lake which is controlled by the Silver Falls Dam and Hydroelectric Generating Station owned by Ontario Power Generation (OPG). From Silver Falls, the Kaministiquia River flows southward to the confluence with the Matawin River, the major tributary to the Kaministiquia River. The subwatershed of the Matawin River originates to the west in the uncontrolled lakes draining to the Matawin River and the controlled lakes draining to the Shebandowan River. These include: Greenwater Lake, Kashabowie Lake, and Shebandowan Lake, each of which are controlled by a dam owned by OPG.

From the confluence of the main river and Matawin River, the Kaministiquia continues south to the Kakabeka Falls, where flows are controlled by another dam and Hydroelectric Generating Station also owned by OPG. Downstream of Kakabeka Falls, multiple smaller tributaries join the river, including Whitefish River, Cedar Creek, Slate River, Corbett Creek, Brule Creek, and Mosquito Creek.

The Kaministiquia River crosses into the City south of 25th Side Road at Broadway Avenue and continues a winding path eastwards to the delta at Lake Superior, where the River splits into two other short watercourses: McKellar River and Mission River. Urban discharges to the Kaministiquia River include storm sewers and open ditches. Combined sewer overflows remain in the Kaministiquia River watershed.

There are multiple protected areas in the Kaministiquia River Watershed, including provincial parks, provincially significant wetlands, and Areas of Natural and Scientific Significance (ANSIs) identified by the MNRF.

The Canada Department of Public Works have dredged the Kaministiquia River from Lake Superior to the Westfort Turning basin below Canadian Pacific Forest Products to a depth of 7.6 metres for commercial shipping.

Additional information on the Kaministiquia River Watershed and its tributaries can be found in the following studies:

- Kaministiquia River System Water Management Plan by OPG, MNRF, and DFO (2004)
- Whitefish River Watershed Assessment Report by the LRCA (2012)
- Cedar Creek Watershed Assessment Update by the LRCA (2010)
- Slate River Watershed Assessment Report by the LRCA (2008)
- Corbett Creek Watershed Assessment Update by the LRCA (2010)
- Brule Creek Watershed Assessment by the LRCA (2007)

The physical features of the Kaministiquia River watershed are summarized in Table 14.

Table 14. Kaministiquia River Watershed Facts

Watershed	Kaministiquia River
Drainage Area	7,769 km^2, not including the tributary watershed of Mosquito Creek
River Length	185 km, including Dog River and Dog Lake
Headwaters	Dog Lake, Greenwater Lake, and Kashabowie Lake
Tributaries	Dog River, Matawin River, Whitefish River, Shebandowan River, Corbett Creek, Slate River, and Mosquito Creek
Area within City	41 km^2
% Impervious [1]	0.1% (5 km^2)
% Protected Land [2]	1%
% City Owned Land [3]	0.1%
Future Land Use Projections [4]	Future development on McKellar and Mission Islands in addition to a future residential development near City limits between Highway 61 and West Riverdale Road.
% Bedrock Coverage [5]	23%
Soils	Exposed bedrock, swamp and glacial deposits. Primarily sandy loam derived from fluvial deposits (Map 21)
Area of Natural and Scientific Interest [6]	Slate River, Squaretop Mountain, Stanley Bur Oak Stand, Sitch Creek Clay Till Plain, Mokomon, Nolalu, Swamp River (Map 45)
Thermal Property Classification	Coldwater
Fisheries	• Rainbow trout (*Oncorhynchus mykiss*) • Chinook salmon (*Oncorhynchus tshawytscha*) • Lake populations of walleye (*Sander vitreus*) • Northern pike (*Esox lucius*) at the mouth
Total length of Storm Sewer Main [7]	60 km
Sewershed (% of Watershed) [8]	0.1%
Date of Floodplain Delineation	1979
Water Control Structures	Kakabeka Falls Hydroelectric Generating Station (OPG) Silver Falls Hydroelectric Generating Station (OPG) Shebandowan Dam (OPG) Kashabowie Dam (OPG) Greenwater Dam(OPG) Matawin River weir (MNRF)

Notes:
[1] Source: City of Thunder Bay, Anthropogenic Impervious shapefile (2014) may be lower than other estimates
[2] Areas identified as an Area of Natural and Scientific Interest (ANSI), Zoned by City for Environmental Protection, Conservation Areas, or provincially significant wetlands
[3] Areas within City identified as City-owned in Parcel shapefile (2014)
[4] Source: City's Draft Updated Official Plan (2014)
[5] Source: Land Information Ontario, Ministry of Agriculture and Food, Soil Survey Complex shapefile (2003)
[6] Source: Land Information Ontario, MNRF, ANSI shapefile (2012)
[7] Source: City of Thunder Bay, Storm Sewer Main shapefile (2014)
[8] Source: Approximated based on coverage of City's Storm Sewer Main GIS layer in each watershed

2.5.3 McIntyre River

The McIntyre River originates north of the City in Trout Lake and drains south along Highways 591 and 589 until it crosses into the City at Gorevale Road. The river winds south and east through rural Thunder Bay until it crosses the Thunder Bay Expressway and then turns south through urban areas. A tributary of the McIntyre joins the River at Oliver Road and then the river continues south to the confluence of the Neebing-McIntyre diversion channel, where the river widens into the Neebing-McIntyre Floodway. The Floodway continues east towards Lake Superior. Urban discharges to the Floodway include storm sewers and open ditches, with the largest ditch system being the Lyon Channel which discharges to the Floodway east of Balmoral Street. Other ditch tributaries discharge to the Floodway at Memorial Avenue, Fort William Road, and the CPR main line bridge. The Neebing River also flows into the Floodway east of Fort William Road.

The Neebing-McIntyre Floodway was constructed in the early 1980's to address flooding in the intercity area.[27] The LRCA regularly inspects and maintains the floodway to remove sediment accumulation to renew the Floodway with its full design capacity. The main elements of the system are as follows:

- Diversion Structure on Neebing River at Ford Street
- Diversion Channel through Chapples Golf Course
- Enhanced channel for the McIntyre River from William Street to Fort William Road
- Sediment trap upstream of Balmoral Street
- Enlarged and realigned channel from Fort William Road to Lake Superior
- Sediment trap immediately downstream of the Neebing River confluence
- Outlet into Lake Superior

The subwatershed of Lyons Channel originates north of the channel and east of Balmoral Street, where a system of storm sewers and open ditches drain southerly along the former route of Oliver Creek. The system discharges to Lyons Channel south of Pasteur Road. Lyons Channel was originally constructed with a focus on stormwater conveyance but vegetation, minnows, and other forms of life have become established along the channel.[31]

The physical features of the McIntyre River watershed are summarized in Table 15.

Table 15. McIntyre River Watershed Facts

Watershed	McIntyre
Drainage Area	159 km^2
River Length	47 km
Headwaters	Near Trout Lake
Tributaries	Lyons Channel
Area within City	75 km^2
% Impervious [1]	6% (9 km^2)
% Protected Land [2]	5%
% City Owned Land [3]	7%
Future Land Use Projections [4]	Future residential development along the Northwest Arterial corridor. Future development between Oliver Road and Highway 11 on the west side of Highway 17.
% Bedrock Coverage [5]	11%
Soils	Low undulating glacial till plain with some marshy areas in the upper watershed. Primarily sandy loam and loamy sand, with bedrock in the northern part of the watershed (Map 22).
Area of Natural and Scientific Interest [6]	None
Thermal Property Classification	Coldwater
Fisheries	• Brook trout (*Salvelinus fontinalis*) • Migratory Rainbow trout (*Oncorhynchus mykiss*) • Rainbows are recovering from 1990's overharvest
Description	• Fairly narrow channel with very little storage • floodplain is not extensively developed • wetland vegetation predominate upper reaches • lower reaches are often cleared and grassed with tree cover
Total length of Storm Sewer Main [7]	101 km
Sewershed (% of Watershed) [8]	14%
Date of Floodplain Delineation	2015
Water Control Structures	Neebing-McIntyre Floodway Lake Tamblyn Dam and Weir

Notes:

[1] Source: City of Thunder Bay, Anthropogenic Impervious shapefile (2014) may be lower than other estimates
[2] Areas identified as an Area of Natural and Scientific Interest (ANSI), Zoned by City for Environmental Protection, Conservation Areas, or provincially significant wetlands
[3] Areas within City identified as City-owned in Parcel shapefile (2014)
[4] Source: City's Draft Updated Official Plan (2014)
[5] Source: Land Information Ontario, Ministry of Agriculture and Food, Soil Survey Complex shapefile (2003)
[6] Source: Land Information Ontario, MNRF, ANSI shapefile (2012)
[7] Source: City of Thunder Bay, Storm Sewer Main shapefile (2014)
[8] Source: Approximated based on coverage of City's Storm Sewer Main GIS layer in each watershed

2.5.4 McVicar Creek

McVicar Creek is the smallest of the five major watercourses in Thunder Bay and originates just north of the City. The creek flows south along Hazelwood Drive and crosses into the City at Gorevale Road. The creek continues to wind south and east through rural Thunder Bay with multiple confluences with tributaries from the northeast side of the creek. The creek enters the urban limits of the City near Wardrope Avenue, downstream of which an urban drainage channel discharges to the creek. Urban discharges to McVicar Creek include storm sewers and open ditches. After crossing the Thunder Bay Expressway, McVicar Creek winds through the urban core of Thunder Bay and flows into the Bay southeast of Cumberland Street and the Marina Park Overpass. The upper reaches of McVicar Creek (79% of the drainage basin) are generally undeveloped and located mostly in forested open meadows. The lower reaches (which represent 21% of the basin) are urbanized. The McVicar Creek Protection and Rehabilitation Plan (2014)[(11)] and the LRCA's McVicar Creek Stewardship Program (2007)[(32)] provide a comprehensive assessment of McVicar Creek. The physical features of the McVicar Creek watershed are summarized in Table 16.

Table 16. McVicar Creek Watershed Facts

Watershed	McVicar
Drainage Area	48 km^2
River Length	16 km
Headwaters	Gorevale Road and City Limits
Tributaries	None
Area within City	38 km^2
% Impervious [1]	9% (4 km^2)
% Protected Land [2]	4%
% City Owned Land [3]	18%
Future Land Use Projections [4]	Future residential developments between Wardrope Avenue and Highway 11/17 on the west side of Balsam Street. Other future residential developments will be between Hilldale Road and Highway 102.
% Bedrock Coverage [5]	4%
Soils	Undifferentiated soil in upper reaches transitions to shallow sand. Stratified sand and gravel in the lower reaches (Map 23)
Area of Natural and Scientific Interest [6]	None
Thermal Property Classification	Coldwater
Fisheries	• Sculpins *(Cottoidea family)* • Johnny darter *(Etheostoma nigrum)* • Inespine stickleback *(Pungitius pungitius)* • Blacknose dace *(Rhinichthys atratulus)* • Brook trout (*Salvelinus fontinalis*) • Rainbow trout (*Oncorhynchus mykiss*)
Total length of Storm Sewer Main [7]	42 km
Sewershed (% of Watershed) [8]	20%
Date of Floodplain Delineation	2015
Water Control Structures	Briarwood, Clayte, and a Weir at the mouth of the river

Notes:

[1] Source: City of Thunder Bay, Anthropogenic Impervious shapefile (2014) may be lower than other estimates

[2] Areas identified as an Area of Natural and Scientific Interest (ANSI), Zoned by City for Environmental Protection, Conservation Areas, or provincially significant wetlands

[3] Areas within City identified as City-owned in Parcel shapefile (2014)

[4] Source: City's Draft Updated Official Plan (2014)

[5] Source: Land Information Ontario, Ministry of Agriculture and Food, Soil Survey Complex shapefile (2003)

[6] Source: Land Information Ontario, MNRF, ANSI shapefile (2012)

[7] Source: City of Thunder Bay, Storm Sewer Main shapefile (2014)

[8] Source: Approximated based on coverage of City's Storm Sewer Main GIS layer in each watershed

2.5.5 Mosquito Creek

Mosquito Creek is a tributary of the Kaministiquia River that originates in the north side of the Nor'Wester Mountains and drains towards the northeast in poorly defined and flat drainage courses. The streams average less than 1 metre in depth at the headwaters of the watershed and deepen steadily to form well defined valleys averaging 10 metres in depth as they wind through the residential developments while approaching the Kaministiquia River. Although there are some areas serviced with local storm sewers, the majority of the watershed is drained by open ditches to the tributaries. The majority of the residents in this area obtain their drinking water from the municipal distribution system rather than individual private wells, and are serviced by individual, private septic systems. The physical features of the Mosquito Creek watershed are summarized in Table 17.

Table 17. Mosquito Creek Watershed Facts

Watershed	Mosquito
Drainage Area	31 km^2
River Length	12 km
Headwaters	Nor'westers mountains
Tributaries	None
Area within City	19 km^2
% Impervious [1]	1% (0.4 km^2)
% Protected Land [2]	9%
% City Owned Land [3]	6%
Future Land Use Projections [4]	Future residential throughout the central area of the watershed
% Bedrock Coverage [5]	35%
Soils	Highly erodible clay and silt loam (Map 24)
Area of Natural and Scientific Interest [6]	Squaretop Mountain (Map 47)
Thermal Property Classification	Warm water
Fisheries	• Small spawning area identified at mouth of creek to Kaministiquia River (See species in Table 14) • Potential for walleye or coldwater species near mouth to Kaministiquia River • Mottled sculpin, brook stickleback, white sucker, lake chub, rock bass, pearl dace, longnose dace, common shiner, smallmouth bass, johnny darter, fathead minnow, finescale dace, mudpuppy, creek chub, northern redbelly dace, trout-perch [9]
Total length of Storm Sewer Main [7]	4 km
Sewershed (% of Watershed) [8]	4%
Date of Floodplain Delineation	1984
Water Control Structures	None

Notes:

[1] Source: City of Thunder Bay, Anthropogenic Impervious shapefile (2014) may be lower than other estimates
[2] Areas identified as an Area of Natural and Scientific Interest (ANSI), Zoned by City for Environmental Protection, Conservation Areas, or provincially significant wetlands
[3] Areas within City identified as City-owned in Parcel shapefile (2014)
[4] Source: City's Draft Updated Official Plan (2014)
[5] Source: Land Information Ontario, Ministry of Agriculture and Food, Soil Survey Complex shapefile (2003)
[6] Source: Land Information Ontario, MNRF, ANSI shapefile (2012)
[7] Source: City of Thunder Bay, Storm Sewer Main shapefile (2014)
[8] Source: Approximated based on coverage of City's Storm Sewer Main GIS layer in each watershed
[9] Based on 1995 information provided by MNRF

2.5.6 Neebing River

The Neebing River Watershed is a short and wide watershed covering a large portion of rural Thunder Bay. Considerable storage is provided throughout the watershed in swampy marsh areas and behind beaver dams. The watershed originates along the northwest boundary of the City, where Pennock Creek and the north tributary drain wetland areas towards the southeast. The Pennock Creek Watershed is further discussed in Section 2.5.7. The northern tributary originates north of the Village of Murillo and joins the Neebing River just upstream of Pennock Creek, northwest of the Thunder Bay International Airport. The river continues easterly into the urban area of Thunder Bay. Urban discharges to the Neebing River include storm sewers and open ditches. Combined sewer overflows remain in the Neebing River watershed. The Neebing River weir is located upstream of Edward Street, before the diversion channel to the Neebing-McIntyre Floodway, with the sole purpose of sea lamprey control. The diversion structure mitigates flooding along the lower Neebing River by diverting excess flow from the Neebing River into the Neebing-McIntyre Floodway.[33] The Neebing River continues for 3.2 km downstream of the diversion structure where it discharges into the Floodway. The Floodway is further discussed in Section 2.5.3. The physical features of the Neebing River watershed are summarized in Table 18.

Table 18. Neebing River Watershed Facts

Watershed	Neebing
Drainage Area	174 km^2, not including tributary watershed of Pennock Creek
River Length	42 km
Headwaters	West of City limits along Townline Road
Tributaries	Pennock Creek and North Tributary
Area within City	113 km^2
% Impervious [1]	4% (8 km^2)
% Protected Land [2]	11%
% City Owned Land [3]	13%
Future Land Use Projections [4]	Future development between Oliver Road and Arthur Street on the east side of the Neebing River.
% Bedrock Coverage [5]	7%
Soils	Loamy sand & sandy loam with some large areas of organic soils (Map 25)
Area of Natural and Scientific Interest [6]	Intola (Map 49)
Thermal Property Classification	Coldwater
Fisheries	• Brook trout (*Salvelinus fontinalis*) • Migratory Rainbow trout (*Oncorhynchus mykiss*) • Mouth of river supports rainbow smelt (*Osmerus mordax*) • Spottail shiners (*Notropis hudsonius*) • Northern pike (*Esox lucius*) • Mottled sculpin, white sucker, lake chub, brook trout, northern redbelly dace, johnny darter, brook stickleback, longnose dace, pearl dace, rainbow trout, ruffe, northern pike, log perch, rock bass, trout-perch, northern brook lamprey [9]
Total length of Storm Sewer Main [7]	81 km
Sewershed (% of Watershed) [8]	9%
Date of Floodplain Delineation	1985
Water Control Structures	Neebing River Weir, Neebing-McIntyre Floodway

Notes:
[1] Source: City of Thunder Bay, Anthropogenic Impervious shapefile (2014) may be lower than other estimates
[2] Areas identified as an Area of Natural and Scientific Interest (ANSI), Zoned by City for Environmental Protection, Conservation Areas, or provincially significant wetlands
[3] Areas within City identified as City-owned in Parcel shapefile (2014)
[4] Source: City's Draft Updated Official Plan (2014)
[5] Source: Land Information Ontario, Ministry of Agriculture and Food, Soil Survey Complex shapefile (2003)
[6] Source: Land Information Ontario, MNRF, ANSI shapefile (2012)
[7] Source: City of Thunder Bay, Storm Sewer Main shapefile (2014)
[8] Source: Approximated based on coverage of City's Storm Sewer Main GIS layer in each watershed
[9] Based on 1995 information provided by MNRF

2.5.7 Pennock Creek

Pennock Creek is a tributary of the Neebing River almost entirely located within the Municipality of Oliver Paipoonge, with headwaters near the Village of Murillo. The flat, rural topography of the upper watershed contains numerous small bogs and depressions that reduce runoff rates. The creek transitions into a defined valley as it flows easterly into the City at 25th Side Road and passes through a residential area before joining the Neebing River on the west side of the Thunder Bay International Airport. Extensive flooding along Pennock Creek within the Municipality of Oliver Paipoonge has occurred in the past. Previous developments in the vicinity of Rosslyn Village have changed the characteristics of the drainage area. Head cutting is evident at multiple storm sewer outfalls to the ravine where the ravine is eroding in an upstream direction and undermines storm sewer outfalls.[34] The physical features of the Pennock Creek watershed are summarized in Table 19.

Table 19. Pennock Creek Watershed Facts

Watershed	Pennock
Drainage Area	55 km^2
River Length	17 km
Headwaters	Near Village of Murillo
Tributaries	None
Area within City	7 km^2
% Impervious [1]	0.4% (0.2 km^2)
% Protected Land [2]	1%
% City Owned Land [3]	2%
Future Land Use Projections [4]	Three future residential developments on northeast side of creek within City limits
% Bedrock Coverage [5]	0%
Soils	A variety of soils with a large area of silty clay loam (Map 26)
Area of Natural and Scientific Interest [6]	None
Thermal Property Classification	Coldwater
Fisheries	Unknown
Total length of Storm Sewer Main [7]	3 km
Sewershed (% of Watershed) [8]	1%
Date of Floodplain Delineation	1982
Water Control Structures	Dam west of 25th Side Road

Notes:
[1] Source: City of Thunder Bay, Anthropogenic Impervious shapefile (2014) may be lower than other estimates
[2] Areas identified as an Area of Natural and Scientific Interest (ANSI), Zoned by City for Environmental Protection, Conservation Areas, or provincially significant wetlands
[3] Areas within City identified as City-owned in Parcel shapefile (2014)
[4] Source: City's Draft Updated Official Plan (2014)
[5] Source: Land Information Ontario, Ministry of Agriculture and Food, Soil Survey Complex shapefile (2003)
[6] Source: Land Information Ontario, MNRF, ANSI shapefile (2012)
[7] Source: City of Thunder Bay, Storm Sewer Main shapefile (2014)
[8] Source: Approximated based on coverage of City's Storm Sewer Main GIS layer in each watershed

2.5.8 Waterfront

The lower portion of the Lakehead Watershed includes areas along the waterfront that drain directly to Lake Superior. The Waterfront drainage systems are a combination of storm sewers, ditches, pumping stations, and concrete channels (such as the Third Avenue Channel) draining easterly to Lake Superior. The intercity area of the waterfront watershed is also drained using a pumping station. Most neighbourhoods in the waterfront watershed are low lying, including homes and buildings at lower elevations than roads. The performance of the drainage system can be dependent on the water levels in Lake Superior.(25) Waterfront developments and redevelopments are ongoing, with consideration for restoring and protecting the ecological health of the Harbour marshes. The physical features of the Waterfront watershed are summarized in Table 20.

Table 20. Waterfront Watershed Facts

Watershed	Waterfront
Drainage Area	21 km^2, not including Whiskey Jack Creek Watershed
River Length	Varies
Headwaters	Varies
Tributaries	Third Avenue Channel and CN ditch
Area within City	21 km^2
% Impervious [1]	20% (4 km)
% Protected Land [2]	6%
% City Owned Land [3]	40%
Future Land Use Projections [4]	Redevelopment of waterfront
% Bedrock Coverage [5]	8%
Soils	Varying soils including sand, clay, sandy loam, and clay loam
Area of Natural and Scientific Interest [6]	Thunder Bay Lookout (Map 44)
Thermal Property Classification	Varies
Fisheries	• Brook trout (*Salvelinus fontinalis*) • Rainbow trout (*Oncorhynchus mykiss*) • Rainbow smelt (*Osmerus mordax*) • Spottail shiners (*Notropis hudsonius*) • Northern pike (*Esox lucius*) • Sculpins *(Cottoidea family)* • Johnny darter *(Etheostoma nigrum)* • Inespine stickleback *(Pungitius pungitius)* • Blacknose dace (*Rhinichthys atratulus)* • Lake Trout *(Salvenlinus Namaycush)* • Walleye *(Sander Vitreus)*
Total length of Storm Sewer Main [7]	40 km
Sewershed (% of Watershed) [8]	34%
Date of Floodplain Delineation	None
Water Control Structures	None

Notes:
[1] Source: City of Thunder Bay, Anthropogenic Impervious shapefile (2014) may be lower than other estimates
[2] Areas identified as an Area of Natural and Scientific Interest (ANSI), Zoned by City for Environmental Protection, Conservation Areas, or provincially significant wetlands
[3] Areas within City identified as City-owned in Parcel shapefile (2014)
[4] Source: City's Draft Updated Official Plan (2014)
[5] Source: Land Information Ontario, Ministry of Agriculture and Food, Soil Survey Complex shapefile (2003)
[6] Source: Land Information Ontario, MNRF, ANSI shapefile (2012)
[7] Source: City of Thunder Bay, Storm Sewer Main shapefile (2014)
[8] Source: Approximated based on coverage of City's Storm Sewer Main GIS layer in each watershed

2.6 Wetlands

Wetlands are habitats where water saturation is the primary environmental driver for plant and animal life. Wetlands occur between upland and aquatic environments where the water table is at or near the surface of the land, or where the land is covered by standing water that may be up to six feet deep. The single feature that most wetlands share is soil or substrate that is at least periodically saturated with or covered by water. This saturation creates physiological conditions requiring special adaptations by plants and animals for life in an oxygen-deprived (anaerobic) environment.

Wetlands provide numerous direct benefits depending on the type of wetland and the season, including the following:

- **Floodwater storage and retention**:
  Snowmelt or stormwater may be temporarily stored in wetlands. This, in turn, slows the rate of water outflow from the wetland compared to inflow to the wetland by extending lower outflow flow rates over a longer period of time.
- **Nutrient assimilation**:
  Wetland plants absorb nutrients during their growth and development that results in cleaner water leaving the wetland than came into it.
- **Sediment entrapment:**
  Sediments have time to settle out when the flow of water is slowed down, as previously described.
- **Ground water recharge:**
  Some wetlands collect and retain surface waters in ground water recharge areas.
- **Low flow augmentation:**
  A benefit of flow augmentation is that the steadier water outflow rates can reduce the impacts of short-term precipitation deficiencies in downstream rivers and streams.
- **Shoreland anchoring and erosion control:**
  Wetland vegetation can reduce shoreline and bank erosion by anchoring the soil from the forces of wave action.
- **Fish and wildlife habitat.**
  Many species of fish and wildlife spend part or all of their life cycle in wetland habitats used for breeding, feeding, cover protection, or brood rearing.
- **Aesthetics and recreation:**
  This includes scenic value in urban and suburban environments. Wetlands also provide a place for people to observe nature. Hunters, birders, and fisherman frequent wetlands.
- **Education:**
  Wetlands provide outdoor classrooms for learning.

2.6.1 Sources of Wetland Data

Mapping of wetlands in Thunder Bay was updated in April, 2014 by the Spatial Data Infrastructure (SDI) staff of the MNRF, Lakehead Forest Management Unit. Use of 3D summer leaf-on orthophotography to capture wetland features significantly increased the representation of features from past mapping efforts. Certain wetlands have been evaluated through the Ontario Wetland Evaluation System (OWES) in the past. Of the evaluated wetlands, those that meet certain criteria are identified as Provincially Significant Wetlands (PSW) and have protection under the Provincial Policy Statement (PPS). Delineation of the wetlands evaluated through the OWES were not altered during the 2014 update. All wetlands, evaluated or not, are identified based on wetland type, including bog, fen, marsh, open water marsh, swamp, and unknown. The MNRF's definitions of these identifiers in the Wetland User Guide (2013) and the Ontario Wetland Evaluation System Northern Manual (2014) are included in the Glossary. Additional details of the evaluation of specific wetlands can be requested from the MNR but may be subject to restrictions on what details can be provided.

2.6.2 Wetlands within the City

The City has prioritized the protection of wetlands by including both PSWs and non-PSWs in the Environmental Protection areas as identified in the Official Plan. The protected wetlands and others identified by the MNRF in 2014 (as discussed in Section 2.6.1) are illustrated in Map 51 of Volume 3. The wetlands cover a total of 4,620 ha, or approximately 14% of the City and 16% of the City outside of the Urban Area Limit.

The distribution of wetland types in each watershed within the City are summarized in Table 21, including bog, fen, marsh, open water, and swamp, as identified by the latest MNRF wetland shapefile. The majority of wetlands are swamps on a city-wide and watershed basis.

Table 21. Wetland Types within City

Wetland Type	Percentage of Total Wetland Area within City Limits (%)								
	Current	Kaministiquia	McIntyre	McVicar	Mosquito	Neebing	Pennock	Waterfront	All
Bog	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Fen	1.5	21.8	3.8	1.1	0.0	6.3	0.0	16.4	5.6
Marsh	1.1	9.6	5.3	2.2	13.9	4.6	0.0	61.0	5.9
Open Water	0.0	3.7	0.0	0.0	0.0	0.3	0.0	0.8	0.4
Swamp	97.4	64.8	90.9	96.8	86.1	88.7	100.0	21.7	88.2
PSWs	0.0	15.0	13.7	0.0	0.0	46.2	0.0	55.6	100.0

Source: GIS analysis of Land Information Ontario, MNRF, Wetland shapefile (2014)

Table 21 also identifies the percentage of wetlands in each watershed that have been evaluated and found to be PSWs. Four PSWs are identified in the upland areas of the City, including three in the Neebing River Watershed (William's Bog, Mills Block and the Neebing River PSW) and the Horseshoe Lake PSW located in the Kaministiquia River Watershed. Although referred to as a bog, William's Bog is identified as a swamp in the MNRF wetland shapefile. Five marshes of local concern are located on the harbour front, including the Mission Island PSW, Neebing PSW, Chippewa, McKellar Island and Northern Wood Preserves (NWP) marshes.

The Neebing, McKellar and Mission Marshes provide habitat to fish and wildlife communities and to species that migrate through this area, including a varied bird population. The Chippewa Marsh to the south has low species diversity, possibly due to the nearby construction of a dredged soils disposal facility in 1978.(18) Both the Chippewa Marsh and NWP Marsh were created to assist with the remediation of the industrial lands.

The wetlands provide a variety of benefits as previously discussed. One benefit which may be most important to the City is the volume of rain and runoff stored in these wetlands. Using the total footprint of wetlands identified in the MNRF wetland shapefile within the City (4,620 ha) and conservatively assuming the active storage depth of a wetland to be 300 mm, the wetlands provide approximately 13,860,000 m^3 of stormwater storage. This active storage depth does not include analysis of topography, soils, or vegetative cover and does not account for interception and sublimation occurring in forested wetlands.

2.6.2.1 Wetland Susceptibility to Stormwater Impacts

A desktop analysis of wetlands in the City was conducted to estimate each wetland's susceptibility to stormwater impacts as an indicator for the need for updated environmental protection areas. First, the land cover on each wetland was identified and mapped (Map 52 of Volume 3). As summarized in Table 22, most wetlands in the City are wooded, including mixed wood dense and sparse, coniferous dense, and broadleaf dense.

Table 22. Land Cover on Wetlands within City

Land Cover	Percentage of Total Wetland Area in City (%)
Mixed Wood Dense	34
Coniferous Dense	21
Mixed Wood Sparse	18
Broadleaf Dense	12
Developed	8.3
Water	2.5
Wetland-Treed	2.3
Agr-Annual Cropland	1.5
Agr-Pasture/Forage	0.6
Exposed/Barren Land	0.1
Herbaceous	0.04

Source: GeoGratis, Natural Resources Canada, Land Cover 2000 shapefile (2009)

Second, a framework for ranking susceptibility (high, moderate, slight, and least) was defined as summarized in Table 23 based on the best available guidelines published by the Minnesota Stormwater Advisory Group (1997).(35) Although Ontario has comprehensive guidelines for evaluating the significance of wetlands, a Minnesotan reference was used for this analysis because there is no comparable Ontario guideline on identifying and mitigating stormwater impacts on wetlands.

Table 23. Wetland Susceptibility to Stormwater Impacts based on Wetland Type and Land Cover

Land Cover	Susceptibility to Stormwater Impacts				
	Fen	Marsh	Open Water	Swamp	Bog
Developed	Developed	Developed	Developed	Developed	n/a
Agr-Annual Cropland	Farmed	Farmed	n/a	Farmed	Farmed
Agr-Pasture/Forage	Farmed	Farmed	n/a	Farmed	Farmed
Broadleaf Dense	High	Slight[1]	Slight[1]	High	n/a
Coniferous Dense	High	Moderate[1]	n/a	High	n/a
Herb	n/a	n/a	n/a	High[1]	n/a
Mixed wood Dense	High	Moderate[1]	Slight[1]	High	High
Mixed wood Sparse	High	Moderate[1]	Slight[1]	High	High
Exposed/Barren Land	High[1]	n/a	n/a	Least[1]	n/a
Water	High[1]	Slight	Slight	Slight[1]	n/a
Wetland-Treed	High	Moderate[1]	n/a	High	n/a

Notes:
[1] Unlikely land cover and wetland type combinations needing further investigation.
n/a – Areas with this combination of land cover and wetland type were not found within the City.

Third, the susceptibility of each wetland to stormwater impacts was determined based on wetland type and land cover, as illustrated in Map 53 of Volume 3 and summarized in Figure 3. The analysis found that the majority of the wetlands in the City are highly susceptible to stormwater impacts. A tenth of the wetlands were shown as having developed or farmed land cover, which may be due to the scale of the land cover mapping. Additional investigation of these wetlands is needed to confirm susceptibility. The susceptibility ranking is subject to change upon evaluation of each wetland in the field.

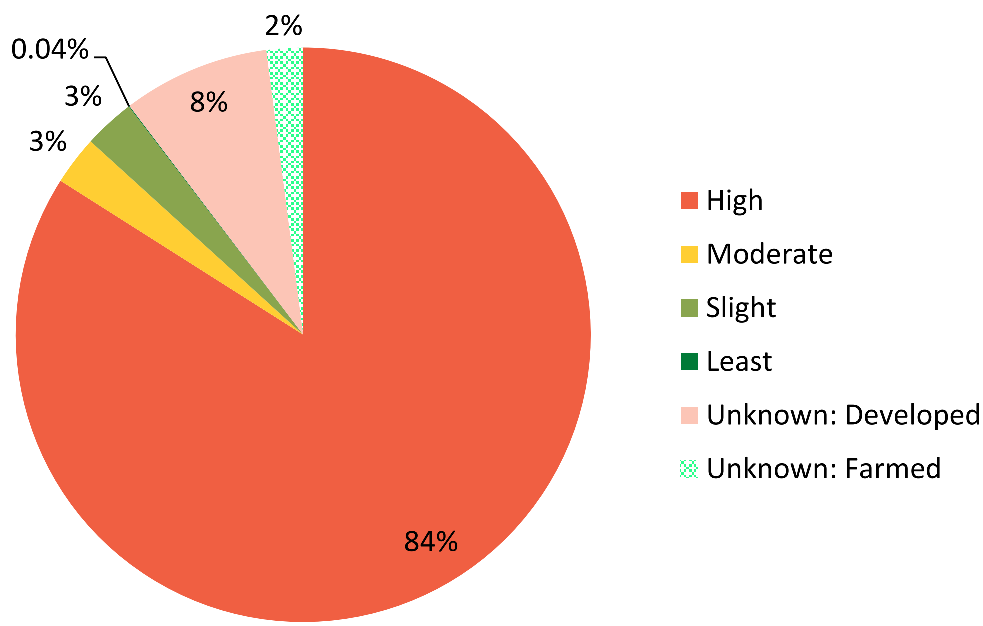

Figure 3. Susceptibility of Wetlands to Stormwater Impacts (Percent of Wetland Area)

2.6.3 Wetlands Located outside of the City

The distribution of wetland types in each watershed outside of the City are summarized in Table 24 which highlights that the majority of the wetlands in all watersheds are swamps, except for the Kaministiquia River Watershed where most of the wetlands are of an unknown type. A total of 1.5% of the wetlands outside of the City have been identified as PSWs, including a portion of the Neebing River PSW and, in the Kaministiquia River Watershed, the Rosslyn and Matawin River PSWs. The wetlands outside of the City are also illustrated in Map 54 of Volume 3.

Table 24. Wetland Types outside of City

Wetland Type	Percentage of Total Wetland Area outside of City Limits (%)								
	Current	Kaministiquia	McIntyre	McVicar	Mosquito	Neebing	Pennock	Waterfront	All
Bog	0.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Fen	13.4	5.5	14.6	17.4	0.0	23.0	0.4	0.0	6.3
Marsh	10.0	7.3	15.6	16.0	2.0	12.4	11.1	0.0	7.7
Open Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swamp	46.0	18.9	69.8	66.5	98.0	64.6	88.5	100.0	22.8
Unknown	29.7	68.2	0.0	0.0	0.0	0.0	0.0	0.0	63.0
PSWs	0.0	1.6	1.5	0.0	0.0	3.1	0.0	0.0	1.5

Source: GIS analysis of Land Information Ontario, MNRF, Wetland shapefile (2014)

Wetlands provide a variety of benefits. As discussed in the previous section, one benefit which may be most important to the City is the approximate rain and runoff volume they store. Using the total footprint of wetlands identified in the MNRF wetland shapefile in the Lakehead Watershed outside of the City (67,060 ha) and assuming conservatively the active storage depth of a wetland is 300 mm, the wetlands provide approximately 201,180,000 m^3 of stormwater storage. Again, this storage depth does not include analysis of topography, soils, or vegetative cover and does not account for interception and sublimation occurring in forested wetlands.

2.7 Water Quality

This section of the Watershed Assessment presents available monitoring data for the predominant resources flowing through the City and assesses the quality of these resources by comparing the monitoring data to existing water quality standards.

2.7.1 Summary of Available Monitoring Data

A number of entities have conducted water quality monitoring of streams within the Lakehead Watershed (Table 25). Stream water quality is sampled by the Lakehead Region Conservation Authority (LRCA) as part of the Provincial Water Quality Monitoring Network (PWQMN), a program run by the MOECC. The LRCA selected sampling locations in six watersheds that have been tested monthly during the ice free period since 2008. Samples are sent to the MOECC for analysis using a standard set of water quality indicators including chloride, nutrients, suspended solids and other pollutants. The objective of the PWQMN is to protect human health and aquatic ecosystems by providing reliable and current information on stream water quality. The LRCA conducts annual watershed assessment of an area watercourse to document baseline conditions (*http://www.lakeheadca.com/watermgt.htm*).

A Stormwater Impact Assessment was conducted in the McVicar Creek Watershed by Lakehead University, in the lower Neebing River by the Lakehead Region Conservation Authority, and in the Lyons Drainage Ditch by EcoSuperior Environmental. The objective of this assessment was to highlight specific areas along the studied watercourse that were highly susceptible to urban and stormwater impacts, with a focus on stormwater outfall monitoring sites. The study was previously summarized in the 2014 McVicar Creek Restoration and Rehabilitation Plan.(11) Several local utilities also maintain ongoing monitoring programs; these data were not assessed as part of this plan.

To better understand spatial and temporal trends in water quality concentration and loads across the PWQMN, data were analyzed and summarized by stream watersheds as shown in Section 2.7.2. The PWQMN data was chosen because it was collected across multiple watersheds on a similar temporal and spatial scale. Other water quality data exist from other studies, but these data tend to be more targeted or focused on a particular watershed for a finite length of time and are, therefore, not as useful for comparing water quality trends across watersheds in a consistent way.

PWQMN data results were also used to assess potential overall watershed targets for water quality, as identified in Section 4 *Goals and Objectives*. Because little to no data exists at the urban boundary for all seven watersheds, specific targets for water quality from the urban areas could not be developed herein. Future addition of monitoring stations at the urban boundary will help identify the type and amount of pollutants coming from non-urban areas. In turn, this information will aid in the development of realistic urban water quality targets.

Table 25. Water Quality Monitoring in the Lakehead Watershed

Watershed (contributing tributary)	Monitoring Program	Sampling Year(s)
Current River	Provincial Water Quality Monitoring Network	2008-present
Kaministiquia River	Provincial Water Quality Monitoring Network	2002-present
Kaministiquia River (Brule Creek)	Lakehead Region Conservation Authority Watershed Assessment	2007
Kaministiquia River (Cedar Creek)	Lakehead Region Conservation Authority Watershed Assessment	1998, 2010
Kaministiquia River (Corbett Creek)	Lakehead Region Conservation Authority Watershed Assessment	1997, 2010
Kaministiquia River (Slate River)	Lakehead Region Conservation Authority Watershed Assessment	2008
Kaministiquia River (Slate River)	Provincial Water Quality Monitoring Network	2008-present
Kaministiquia River (Whitefish River)	Lakehead Region Conservation Authority Watershed Assessment	2012
McIntyre River	Provincial Water Quality Monitoring Network	2008-present
McVicar Creek	Provincial Water Quality Monitoring Network	2008-present
McVicar Creek/ Neebing/ Lyons Drainage Ditch	Stormwater Impacts Assessment	2010-2011
Mosquito Creek	n/a	n/a
Neebing River	Provincial Water Quality Monitoring Network	2008-present
Pennock Creek	Lakehead Region Conservation Authority Watershed Assessment	2010
Mosquito Creek	Watershed Assessment	2015

2.7.2 Summary of Provincial Water Quality Monitoring Data by Watershed

All available Environment Canada flow and PWQMN data parameters were downloaded for the Current, Kaministiquia, McIntyre, McVicar, and Neebing Rivers and summarized in Table 26 through Table 35 below. In addition, locations of the PWQMN monitoring stations and the nearest Environment Canada flow station are shown in Map 10 of Volume 3. Active monitoring stations are shown on a watershed basis in Maps 55 to 61 of Volume 3.

2.7.2.1 Current River

Table 26. Environment Canada flow data for Current River by monitoring station

Station	Description	Drainage Area (km^2)	Year Range
02AB021	At Stepstone	392	1989-present
02AB014	North Current River near Thunder Bay	492	1972-1986

Note: Stations are listed in order from upstream to downstream and are shown in Maps 10 and 55

Table 27. Water quality parameter inventory for Current River at station 1010400202

Parameter	N	Year Range
Metals		
Metals (26 different types of metals analyzed)	variable	2008-present
Nutrients		
Total Phosphorus	27	2008-present
Reactive Phosphorus	26	2008-present
Nitrate	27	2008-present
Total Kjeldahl Nitrogen	27	2008-present
Physical Characteristics		
Temperature	29	2008-present
pH	29	2008-present
Chloride	29	2008-present
Dissolved Oxygen	26	2008-present
Suspended Solids (residue, particulate)	25	2008-present

Note: N is number of samples. Station is shown in Map 55.

2.7.2.2 *Kaministiquia River*

Table 28. Flow data for Kaministiquia River by monitoring station

Station	Description	Drainage Area (km^2)	Year Range
02AB001	Near Dona	3,630	1921-1956
02AB004	At Outlet of Dog Lake	3,760	1923-1994
02AB006	At Kaministiquia	6,475	1926-2010
02AB010	At Kakabeka Falls Powerhouse	6,710	1923-1994
02AB003	At Mokomon	6,790	1922-1924
02AB007	At Stanley	7,740	1927-1931
02AB026	Above West Fort Williams	8,101	2007-present
02AB025	At West Fort Williams	8,111	2007-present

Note: Stations are listed in order from upstream to downstream and are shown in Maps 10 and 56

Table 29. Water quality parameter inventory for Kaministiquia River at station 1010800102

Parameter	N	Year Range
Metals		
Metals (26 different types of metals analyzed)	variable	2002-present
Nutrients		
Total Phosphorus	194	2002-present
Reactive Phosphorus	194	2002-present
Nitrate	196	2002-present
Total Kjeldahl Nitrogen	196	2002-present
Physical Characteristics		
Temperature	190	2002-present
pH	202	2002-present
Chloride	203	2002-present
Suspended Solids (residue, particulate)	186	2002-present

Note: N is number of samples. Station shown in Map 56

2.7.2.3 McIntyre River

Table 30. Flow data for McIntyre River by monitoring station

Station	Description	Drainage Area (km^2)	Year Range
02AB020	Above Thunder Bay	90	1987-present
02AB016	At Thunder Bay	145	1972-1986

Note: Stations are listed in order from upstream to downstream and are shown in Maps 10 and 57

Table 31. Water quality parameter inventory for McIntyre River at station 1010600202

Parameter	N	Year Range
Metals		
Metals (26 different types of metals analyzed)	variable	2008-present
Nutrients		
Total Phosphorus	27	2008-present
Reactive Phosphorus	26	2008-present
Nitrate	27	2008-present
Total Kjeldahl Nitrogen	27	2008-present
Physical Characteristics		
Temperature	29	2008-present
pH	29	2008-present
Chloride	29	2008-present
Dissolved Oxygen	26	2008-present
Suspended Solids (residue, particulate)	25	2008-present

Note: N is number of samples. Station shown in Map 57

2.7.2.4 *McVicar Creek*

Table 32. Flow data for McVicar Creek.

Station	Description	Drainage Area (km^2)	Year Range
02AB019	At Thunder Bay	45.63	1985-present

Note: Station is shown in Maps 10 and 58

Table 33. Water quality parameter inventory for McVicar Creek at station 1010500102.

Parameter	N	Year Range
Metals		
Metals (26 different types of metals analyzed)	variable	2008-present
Nutrients		
Total Phosphorus	27	2008-present
Reactive Phosphorus	26	2008-present
Nitrate	27	2008-present
Total Kjeldahl Nitrogen	27	2008-present
Physical Characteristics		
Temperature	29	2008-present
pH	29	2008-present
Chloride	29	2008-present
Dissolved Oxygen	26	2008-present
Suspended Solids (residue, particulate)	25	2008-present

Note: N is number of samples. Station shown in Map 58.

2.7.2.5 Neebing River

Note that a second PWQMN site was established on the Neebing River at stream flow gauge 02AB024 in November 2011. The data was not summarized in the SMP because the data period of record for this new site did not match the data period of record of the other PWQMN sites. Parameters collected at the Neebing River 02AB024 site also include turbidity, soil moisture, water temperature and air temperature.

Table 34. Flow data for Neebing River by monitoring station

Station	Description	Drainage Area (km^2)	Year Range
02AB024	Near Intola	N/A	2007-present
02AB008	Near Thunder Bay	187	1953-present

Note: Stations are listed in order from upstream to downstream and are shown in Maps 10 and 60

Table 35. Water quality parameter inventory for Neebing River at station 1010700202

Parameter	N	Year Range
Metals		
Metals (26 different types of metals analyzed)	variable	2008-present
Nutrients		
Total Phosphorus	27	2008-present
Reactive Phosphorus	26	2008-present
Nitrate	27	2008-present
Total Kjeldahl Nitrogen	27	2008-present
Physical Characteristics		
Temperature	29	2008-present
pH	29	2008-present
Chloride	29	2008-present
Dissolved Oxygen	27	2008-present
Suspended Solids (residue, particulate)	25	2008-present

Note: N is number of samples. Station shown in Map 60.

2.7.3 Existing Pollutant Concentrations

PWQMN data were assessed against Provincial Water Quality Objectives (PWQOs) for the Current, Kaministiquia, McIntyre, McVicar, and Neebing Rivers and are summarized by watershed below. All standards are PWQOs with the exception of Canada Water Quality Guidelines for aluminum and nitrate. Parameters are reported as percent of samples exceeding the standard except chloride and phosphorus which are based on average concentrations.

Metal concentrations tend to be high and exceed water quality objectives in all streams. There may be natural background conditions of high metal concentrations due to local geology. That is to say, high metal concentrations are found in streams from the local bedrock and not human disturbances or activities in the watershed. LRCA Watershed Assessments completed in the Kaministiquia River watershed have documented naturally high concentrations of metals in the Thunder Bay area with routine exceedances compared to the most applicable provincial, state, or federal surface water quality standards for aluminum, chromium, copper, and iron, in addition to high phosphorus concentrations.

Establishing monitoring stations at the upstream boundary of the City will aid in the determination of natural background levels of pollutants from the undeveloped portions of the watersheds. Due to the large fraction of watershed located outside of the urban boundary in the Kaministiquia and Current River watersheds, pollutant load associated with urban runoff in these watersheds is likely masked by the quantity and quality of upstream flow. In addition, upstream wetlands in the fraction of the watershed located outside of the urban boundary may play a role in contributing to elevated phosphorous loads and downstream phosphorus concentrations.

The Lakehead Region Conservation Authority developed a Watershed Report Card in 2013 for surface water quality based on phosphorus and *Escherichia coli* (bacteria) levels. The Lakehead Region received an overall grade of B based on individual watershed grades which ranged from A to C. This indicates that the surface water quality within the Lakehead Region is healthy and efforts should continue to be made to maintain and improve water quality.

2.7.3.1 Current River

Cadmium and iron exceeded water quality objectives in the Current River (Table 36). One single exceedance was observed for aluminum and vanadium. Average phosphorus and chloride concentrations were very low and met water quality objectives (Table 37).

Table 36. Number of samples exceeding existing surface and groundwater water quality objectives or standards in Current River.

Parameter	Unit	Standard	% Samples Exceeding (# Exceeding/ # Total)
Aluminum[3]	µg/L	100	3% (1/29)
Berylium[1]	µg/L	11	0% (0/29)
Cadmium[1]	µg/L	0.1 (<100 mg/L $CaCO_3$)	31% (9/29)
Copper[1]	µg/L	5 (>20 mg/L $CaCO_3$)	0% (0/29)
Dissolved Oxygen[1]	mg/L	>4	0% (0/26)
Iron[1]	µg/L	300	61% (17/28)
Nitrate[3]	mg/L	13	0% (0/27)
pH[1]		6.5-8.5	0% (0/29)
Suspended Solids[2]	mg/L	15 (April – September)	0% (0/19)
Vanadium[1]	µg/L	6	3% (1/29)
Zinc[1]	µg/L	20	0% (0/29)

[1] MOECC provincial water quality objective.
[2] Minnesota Pollution Control Agency cold water standard. Total suspended solids standards are applicable from April through September to represent the ice-free season when stream aquatic life is active.
[3] Canada Water Quality Guideline

Table 37. Average concentration and water quality objective for phosphorus and chloride for Current River.

Parameter	Objective (mg/L)	Average Concentration (mg/L)
Phosphorus	0.03	0.007
Chloride	230	3.47

*Note that the average phosphorus concentration is based on the growing season mean (June-September).

2.7.3.2 Kaministiquia River

Aluminum, cadmium, and iron exceeded water quality objectives in at least half of the samples in Kaministiquia River (Table 38). Copper, suspended solids, vanadium, and zinc also exceeded water quality objectives but less frequently than aluminum, cadmium, and iron. Average phosphorus concentrations were double the water quality objective but chloride concentrations were low and met the water quality objective, suggesting natural sources of phosphorus in Kaministiquia River (Table 39). High chloride concentrations are usually associated with human sources of pollutants.

Table 38. Number of samples exceeding existing water quality objectives or standards in Kaministiquia River.

Parameter	Unit	Standard	% Samples Exceeding (# Exceeding/ # Total)
Aluminum[3]	µg/L	100	98% (195/198)
Berylium[1]	µg/L	11	0% (0/199)
Cadmium[1]	µg/L	0.1 (<100 mg/L $CaCO_3$)	48% (96/199)
Copper[1]	µg/L	5 (>20 mg/L $CaCO_3$)	7% (14/199)
Dissolved Oxygen[1]	mg/L	>4	N/A
Iron[1]	µg/L	300	77% (150/196)
Nitrate[3]	mg/L	13	0% (0/195)
pH[1]		6.5-8.5	0% (0/202)
Suspended Solids[2]	mg/L	15 (April – September)	26% (38/145)
Vanadium[1]	µg/L	6	4% (7/196)
Zinc[1]	µg/L	20	3% (5/198)

[1] MOECC provincial water quality objective
[2] Minnesota Pollution Control Agency cold water standard
[3] Canada Water Quality Guideline

Table 39. Average concentration and water quality objective for phosphorus and chloride for Kaministiquia River.

Parameter	Objective (mg/L)	Average Concentration (mg/L)
Phosphorus	0.03	0.065
Chloride	230	9.96

*Note that the average phosphorus concentration is based on the growing season mean (June-September).

2.7.3.3 McIntyre River

Several metals (aluminum, cadmium, and iron) exceeded water quality objectives in McIntyre River (Table 40). One single exceedance was observed for copper, pH, suspended solids, and vanadium. Average concentrations of phosphorus and chloride were also low compared to water quality standards and met water quality objectives in McIntyre Creek (Table 41).

Table 40. Number of samples exceeding existing water quality objectives or standards in McIntyre River.

Parameter	Unit	Standard	% Samples Exceeding (# Exceeding/ # Total)
Aluminum[3]	µg/L	100	24% (7/29)
Berylium[1]	µg/L	11	0% (0/29)
Cadmium[1]	µg/L	0.1 (<100 mg/L $CaCO_3$)	48% (14/29)
Copper[1]	µg/L	5 (>20 mg/L $CaCO_3$)	3% (1/29)
Dissolved Oxygen[1]	mg/L	>4	0% (0/26)
Iron[1]	µg/L	300	100% (28/28)
Nitrate[3]	mg/L	13	0% (0/27)
pH[1]		6.5-8.5	3% (1/29)
Suspended Solids[2]	mg/L	15 (April – September)	5% (1/19)
Vanadium[1]	µg/L	6	4% (1/28)
Zinc[1]	µg/L	20	0% (0/29)

[1] MOECC provincial water quality objective
[2] Minnesota Pollution Control Agency cold water standard
[3] Canada Water Quality Guideline

Table 41. Average concentration and water quality objective for phosphorus and chloride for McIntyre River.

Parameter	Objective (mg/L)	Average Concentration (mg/L)
Phosphorus	0.03	0.023
Chloride	230	58.18

*Note that the average phosphorus concentration is based on the growing season mean (June-September).

2.7.3.4 McVicar Creek

Aluminum, cadmium and iron exceeded water quality objectives in McVicar Creek (Table 42). One or two exceedances were observed for copper, pH, suspended solids, and vanadium. Average concentrations of phosphorus and chloride met water quality objectives in McVicar Creek (Table 43).

Table 42. Number of samples exceeding existing water quality objectives or standards in McVicar Creek.

Parameter	Unit	Standard	% Samples Exceeding (# Exceeding/ # Total)
Aluminum[3]	µg/L	100	14% (4/28)
Berylium[1]	µg/L	11	0% (0/28)
Cadmium[1]	µg/L	0.1 (<100 mg/L $CaCO_3$)	43% (12/28)
Copper[1]	µg/L	5 (>20 mg/L $CaCO_3$)	4% (1/28)
Dissolved Oxygen[1]	mg/L	>4	0% (0/26)
Iron[1]	µg/L	300	67% (18/27)
Nitrate[3]	mg/L	13	0% (0/27)
pH[1]		6.5-8.5	7% (2/29)
Suspended Solids[2]	mg/L	15 (April – September)	5% (1/19)
Vanadium[1]	µg/L	6	7% (2/28)
Zinc[1]	µg/L	20	0% (0/28)

[1] MOECC provincial water quality objective
[2] Minnesota Pollution Control Agency cold water standard
[3] Canada Water Quality Guideline

Table 43. Average concentration and water quality objective for phosphorus and chloride for McVicar Creek.

Parameter	Objective (mg/L)	Average Concentration (mg/L)
Phosphorus	0.03	0.011
Chloride	230	77.43

*Note that the average phosphorus concentration is based on the growing season mean (June-September).

2.7.3.5 Neebing River

Cadmium and iron exceeded water quality objectives in the Neebing River (Table 44). One single exceedance was observed for aluminum, pH, suspended solids, and vanadium. Average concentrations of phosphorus and chloride met water quality objectives in the Neebing River (Table 45).

Table 44. Number of samples exceeding existing water quality objectives or standards in Neebing River.

Parameter	Unit	Standard	% Samples Exceeding (# Exceeding/ # Total)
Aluminum[3]	µg/L	100	3% (1/29)
Berylium[1]	µg/L	1,100	0% (0/29)
Cadmium[1]	µg/L	0.5 (>100 mg/L $CaCO_3$)	21% (6/29)
Copper[1]	µg/L	5 (>20 mg/L $CaCO_3$)	0% (0/29)
Dissolved Oxygen[1]	mg/L	>4	0% (0/27)
Iron[1]	µg/L	300	90% (26/29)
Nitrate[3]	mg/L	13	0% (0/27)
pH[1]		6.5-8.5	3% (1/29)
Suspended Solids[2]	mg/L	15 (April – September)	5% (1/19)
Vanadium[1]	µg/L	6	4% (1/28)
Zinc[1]	µg/L	20	0% (0/29)

[1] MOECC provincial water quality objective
[2] Minnesota Pollution Control Agency cold water standard
[3] Canada Water Quality Guideline

Table 45. Average concentration and water quality objective for phosphorus and chloride for Neebing River.

Parameter	Objective (mg/L)	Average Concentration (mg/L)
Phosphorus	0.03	0.010
Chloride	230	42.95

*Note that the average phosphorus concentration is based on the growing season mean (June-September).

2.7.4 Existing Pollutant Loads

Stream pollutant loads are useful for setting stormwater management goals because load estimates account for both flow (i.e. the size of the watershed) and the concentration of pollutant in stormwater runoff (i.e. the degree of development in the watershed). In addition, the proportion of the total pollutant load to Lake Superior originating from individual watersheds may be useful for prioritizing implementation of stormwater Best Management Practices (BMPs). The flow-weighted mean concentration is the total load divided by the total flow and is a measurement that can be used to compare pollutant loads across different sized watersheds. Available flow data for each stream was acquired from the Environment Canada Website (*http://www.wateroffice.ec.gc.ca/index_e.html*). Continuous daily average flow was used for all available years on record for FLUX modeling. FLUX estimates the average mass discharge or loading that passes a given stream monitoring station, based upon grab-sample concentration data and a continuous flow record. Multiple monitoring stations were available just for some of the streams and were downloaded as well. Water quality data was collected through the PWQMN and the data was acquired from the Ontario Ministry of the Environment data downloads website (*https://www.ontario.ca/environment-and-energy/provincial-stream-water-quality-monitoring-network-pwqmn-data)*.

2.7.4.1 Pollutant Loading to Lake Superior

Pollutant loads were estimated using FLUX at each monitoring station using the flow-weighted average method in FLUX. The flow-weighted average method provides a loading estimate based on the flow-weighted average pollutant concentration multiplied by the mean flow. Water quality samples collected on dates without monitored flow were excluded from the analysis. On average, streams had water quality data from 2008-2012. Due to limited sampling at most sites, multiple years of data were analyzed together to estimate an approximate 5-year annual average load. By combining records for multiple years, data could be grouped by flow (greater than or less than the mean daily flow) to provide more accurate load estimates. Grouping water quality data by mean daily flow improves load estimates because the majority of annual load is derived during a small number of storm events. However, most water quality data is collected during baseflow conditions and this over representation of water quality data collected at low flow events can result in an underestimate of total load, due to the lack of samples collected at high flows which likely contribute the majority of pollutant loads.

The potential variance from reality in estimated total loads was also calculated in FLUX using coefficient of variation (CV). The modeled load CV was related to the number of pollutant concentration samples and the distribution of those samples over the annual flow regime. In general, the modeled load CVs were high and divergent among the various FLUX models used to estimate load, indicating an inadequate number of pollutant concentration samples collected or an uneven distribution of those samples over the annual flow regime. Modeled load CVs ranged from 12-58% and 25-75% for total phosphorus and total suspended solids, respectively. Ideally, modeled load CVs should be less than 10%. Total suspended solids load estimates are particularly sensitive to the number of water quality samples collected at very high flows. The amount of total suspended solids (TSS) samples collected at high flows should be greater than 90% for most sites to calculate reliable TSS load estimates.

Future monitoring work should focus on increasing the overall number of water quality samples and the number of samples collected at high flows to reduce uncertainty in total phosphorus (TP) and TSS load estimates. Regardless of the high uncertainty associated with this pollutant load assessment, the results are still useful to gauge the relative load contribution of the different watersheds.

Total annual loads and flow weighted average concentration of TP, total Kjeldahl nitrogen (TKN), nitrate (NO3), chloride, and suspended solids (SS) to Lake Superior by stream are summarized in Table 46 and Table 47 below. The Kaministiquia River contributes the greatest fraction of all pollutant loads to Lake Superior because it has the greatest average flow, but it also has the highest concentration of TP, TKN, and SS relative to the other streams. These pollutants may originate from the wetland dominated headwaters of this watershed (i.e. outside of the City municipal boundary). In contrast, McIntyre River, McVicar Creek, and Neebing River Watersheds have the highest concentrations of NO_3 and chloride. A greater fraction of these watersheds are within the City boundary suggesting a human source of nitrate and chloride.

Table 46. FLUX modeled annual load and average flow for each stream with available water quality and flow data, reported to four significant digits.

Stream	Annual Load to Lake Superior (kg/yr)					
	TP	TKN	NO_3	Chloride	SS	Average Flow (m^3/s)
Current	1,624	58,400	13,800	349,300	357,900	**4.0**
Kaministiquia	112,700	1,352,000	277,700	17,990,000	60,880,000	**73.3**
McIntyre	452	11,290	3,698	991,700	156,300	**0.7**
McVicar	174	4,722	2,479	520,800	81,970	**0.3**
Neebing	1,071	23,120	7,475	1,308,000	713,700	**1.3**
Totals	**116,000**	**1,450,000**	**305,200**	**21,160,000**	**62,190,000**	**79.7**

Note:
Active and inactive water quality and flow monitoring stations are shown in Map 10.
Active stations are shown on a watershed scale in Maps 55 to 61.

Table 47. Flow weighted average concentration for each water quality parameter. Concentrations reported to three significant digits.

Stream	Flow Weighted Average Concentration (mg/L)				
	TP	TKN	NO3	Chloride	SS
Current	0.013	0.457	0.108	2.73	2.80
Kaministiquia	0.049	0.585	0.120	7.77	26.3
McIntyre	0.020	0.507	0.166	44.5	7.01
McVicar	0.016	0.428	0.225	47.2	7.43
Neebing	0.026	0.553	0.179	31.3	17.1

2.7.4.2 Individual Stream Load Summaries

Table 48. FLUX modeled flow weighted mean concentration and loads for the Current River. Loads reported to four significant digits. Concentrations reported to three significant digits.

Parameter	Flow Weighted Mean Concentration (mg/L)	Load (kg/yr)	Flow < 4.0 m^3/s		Flow > 4.0 m^3/s	
			Average (mg/L)	N	Average (mg/L)	N
TP	0.013	1,624	0.006	17	0.017	10
TKN	0.457	58,400	0.339	17	0.510	10
NO_3	0.108	13,800	0.063	17	0.110	10
Chloride	2.73	349,300	3.85	19	2.73	10
SS	2.80	357,900	1.22	17	2.60	8

Note: Water quality data from station 1010400202 and flow data from station 02AB021.

Table 49. FLUX modeled flow weighted mean concentration and load for the Kaministiquia River. Loads reported to four significant digits. Concentrations reported to three significant digits.

Parameter	Flow Weighted Mean Concentration (mg/L)	Load (kg/yr)	Flow < 73.3 m^3/s		Flow > 73.3 m^3/s	
			Average (mg/L)	N	Average (mg/L)	N
TP	0.049	112,700	0.043	33	0.045	22
TKN	0.585	1,352,000	0.582	33	0.568	22
NO_3	0.120	277,700	0.112	35	0.112	23
Chloride	7.77	17,990,000	10.1	35	7.67	23
SS	26.3	60,880,000	9.78	28	25.5	20

Note: Water quality data from station 1010800102 and flow data from station 02AB025.

Table 50. FLUX modeled flow weighted mean concentration and load for the McIntyre River. Loads reported to four significant digits. Concentrations reported to three significant digits.

Parameter	Flow Weighted Mean Concentration (mg/L)	Load (kg/yr)	Flow < 0.7 m^3/s		Flow > 0.7 m^3/s	
			Average (mg/L)	N	Average (mg/L)	N
TP	0.020	452	0.016	15	0.021	12
TKN	0.507	11,290	0.443	15	0.508	12
NO_3	0.166	3,698	0.092	15	0.158	12
Chloride	44.5	991,700	68.4	17	43.8	12
SS	7.01	156,300	3.36	16	7.39	9

Note: Water quality data from station 1010600202 and flow data from station 02AB020.

Table 51. FLUX modeled flow weighted mean concentration and load for McVicar Creek. Loads reported to four significant digits. Concentrations reported to three significant digits.

Parameter	Flow Weighted Mean Concentration (mg/L)	Load (kg/yr)	Flow < 0.3 m^3/s		Flow > 0.3 m^3/s	
			Average (mg/L)	N	Average (mg/L)	N
TP	0.016	174	0.009	19	0.015	8
TKN	0.428	4,722	0.375	19	0.416	8
NO_3	0.225	2,479	0.435	19	0.202	8
Chloride	47.2	520,800	91.2	20	46.8	9
SS	7.43	81,970	2.50	19	4.77	6

Note: Water quality data from station 1010500102 and flow data from station 02AB019.

Table 52. FLUX modeled flow weighted mean concentration and load for Neebing River. Loads reported to four significant digits. Concentrations reported to three significant digits.

Parameter	Flow Weighted Mean Concentration (mg/L)	Load (kg/yr)	Flow < 1.3 m^3/s		Flow > 1.3 m^3/s	
			Average (mg/L)	N	Average (mg/L)	N
TP	0.026	1,071	0.008	20	0.017	7
TKN	0.553	23,120	0.425	20	0.569	7
NO_3	0.179	7,475	0.078	20	0.175	7
Chloride	31.3	1,308,000	46.7	22	31.1	7
SS	17.1	713,700	2.72	20	8.64	5

Note: Water quality data form station 1010700202 and flow data from station 02AB008.

2.8 Pollutant Sources

Many of the known contaminated sites located within the municipal boundary are old gas stations and others have been identified as having environmental concerns during preliminary site plan approval. Continuing to compile records of these sites in a database will serve as a useful source of information in the evaluation and siting of future stormwater management practices. For those practices that are incorporating stormwater infiltration, it will be important to make sure that they are not located on or in close proximity to sites of known or suspected environmental contamination (e.g. dumps, landfills, leak sites, petroleum brownfield, tank sites, etc.) as special precautions will be required (e.g. remediation).

2.9 Water Use

Stormwater management is an essential piece to protecting drinking water through source water protection planning. Stormwater management practices placed within or near drinking water source protection areas have potential for contaminating drinking water supplies. For example, runoff with toxic levels of pollutants may infiltrate into groundwater used as a source. Stormwater can also be used to lessen the demand for potable water. For example, stormwater harvesting (such as rain barrels or cisterns) uses rainwater instead of potable water for irrigation. Such stormwater practices can also be used as groundwater recharge opportunities, replenishing the drinking water source instead of directing runoff directly to the downstream surface water body.

2.9.1 Thunder Bay Municipal Water Supply and Water Treatment Plant

All of the City-provided drinking water comes from Lake Superior and is treated at the Bare Point Water Treatment Plant located in the northern part of the City. The intake pipe is located approximately 1 km offshore from Bare Point. The Plant has an operational capacity of 113.6 million L/d. Water drawn from Lake Superior passes through a screening process, and is filtered through an ultra-filtration membrane system before being disinfected and transported through the City’s extensive system of water supply pipes and reservoirs to the consumer’s tap. In total, the treatment plant serves approximately 92% of the population of the City, with the remaining 8% being serviced by private wells.

In addition to the City, the hamlet of Rosslyn Village (Municipality of Oliver-Paipoonge) also has a municipal water supply system. This system consists of two groundwater supply wells drilled in 1974, which serviced approximately 29 homes as of January 2010.[(36)] The source water for the system is a basal sand and gravel aquifer approximately 5 m thick immediately above the bedrock, confined beneath approximately 35 m of clay and silt rich material. Water is pumped from the two wells on an alternating basis to a single water treatment plant, where chlorine is added. Average water use is approximately 35 m^3/day, with maximum usage of approximately 50 m^3/day recorded.[(24)]

2.9.2 Industrial Water Supply

Several industries including Ontario Hydro and the pulp and paper industry draw their water directly from Lake Superior. It is understood that these industries have separate Permits to Take Water from the MOECC for these operations.

2.10 Stormwater Infrastructure

The existing stormwater infrastructure includes storm sewers, culverts, bridges, ditches, etc., as summarized in Table 53. The quantities of each infrastructure type are based on the best available information and are subject to change when a more detailed inventory is performed.

Table 53. Inventory of Existing Municipal Stormwater Infrastructure

Infrastructure Type	Quantity
Storm Sewers less than or equal to 600 mm [1]	243,547 m
Storm Sewers greater than 600 mm [1]	79,340 m
Manholes[4]	4,184
Catchbasins[4]	11,010
Oil-Grit Separators[5]	63
Pumping Stations [1]	4
Culverts (less than 3 m span)[2]	389
Culverts (greater than 3 m span)[1,3]	15
Bridges (greater than 3 m span)[3]	54
Regional Floodway	1
Ditches[4]	486,000 m
Regional Stormwater Management Facilities (i.e. Ponds)[4]	2
Low Impact Development Demonstration Projects	7
Dam	2
Fish Ladder	1

[1] AMP for the Corporation of the City of Thunder Bay, Version 2 (2014). Quantity of bridges in the above table is less than the quantity recorded in the AMP because only bridges crossing watercourses or water bodies were included in the above inventory.
[2] City of Thunder Bay small culvert GIS inventory provided February 18, 2015
[3] Municipal Structure Inspection Forms (2010)
[4] Estimate provided by the City, includes concrete lined channels
[5] Includes both municipally and private owned and operated facilities.

2.11 Gap Analysis

Section 2 *Watershed Assessment* includes the review of existing reports, watershed assessments, management plans, water quality studies and monitoring activities that have taken place in the Lakehead Watershed. This step in the plan development process provides a foundation for the identification of priority concerns and identifies gaps in the knowledge-base. The gaps are identified in this section of the SMP. Where the gaps have been identified as critical pieces of information needed to better evaluate the existing stormwater management system, they have been reflected in Section 4 *Goals and Objectives* as well as in Section 5 *Corrective Actions.*

The main findings of the gap analysis are as follows:

1. **Topography, Soils, and Land Use**
   a. The DEMs provided by the City and Canadian Digital Elevation Data have low resolutions with a 15 m and 10 m grid respectively, and elevations at 1 m intervals. Both appear to have been created using City and Ontario Base Mapping contours and limit the detail of hydrologic and hydraulic evaluation.
   b. No GIS shapefiles identify the existing land use in the City and the future land use separately with the same level of detail. Both the zoning and land use shapefiles provided by the City include both existing and future conditions, while the future conditions include less detail. This gap in input information requires assumptions to be made in hydrologic and hydraulic analyses comparing how infrastructure performs under existing and future land use conditions.
   c. The provincial land cover does not reflect forestry and mining practices.
   d. The provincial soils mapping does not cover the upper Current River and Kaministiquia River Watersheds.
2. **Stormwater Infrastructure**
   a. In some areas, the GIS shapefiles of the storm sewer mains, laterals, and structures have incomplete information on size, material, age, and elevations. Some of this information may be available in as-built drawings.
   b. The bridge and culvert inventory is missing crossings and does not include elevations. Roadside ditches are not included. The LRCA is collecting bridge and culvert data while updating floodplain mapping, such as the updated McIntyre River Floodplain Study completed in 2015. This information will continue to be collected in all future floodplain mapping updates and will assist in addressing this gap.
   c. Information on other structures and features of the watershed systems is incomplete.
   d. No comprehensive digitization of ditch lines in GIS.
3. **Wetlands**
   a. No evaluation as per MNRF guidelines of most wetlands within the City as of 2014. In 2015, the wetlands in the McVicar Creek watershed were evaluated per the Northern Ontario Wetland Evaluation System.
4. **Hydrologic and Hydraulic Modeling**
   a. The majority of past models could not be used as a starting point for the Base Models in 2014 for the following reasons:
      i. *They were developed in model platforms no longer in use,*
      ii. *More recent information was available than the hydrologic and hydraulic inputs used in the models, and/or*

iii. *The final and official version of models could not be confirmed in all cases except for the most recent studies.*

iv. *After the Base Models for this study were completed, models were also developed as part of the McIntyre River Floodplain Mapping Update in 2015, including a HEC-RAS model and VisualHymo (3.0) hydrologic model.*

5. Monitoring Data

a. As of 2014, there was no water quality or water quantity information available for the Mosquito Creek Watershed and limited monitoring data available for the Pennock Creek Watershed. The LRCA completed a Watershed Assessment of Mosquito Creek in 2015.

b. No monitoring data for groundwater resources was reviewed in preparation of this assessment. Future amendments to the plan should consider the groundwater monitoring data available through the Provincial Groundwater Monitoring Network supplemented with additional monitoring within the City. The network includes nine wells in the Lakehead Watershed, one of which is within the City, and is administered in partnership with the MOECC. Wells are sampled annually for water quality and monitored hourly for groundwater level. Given the groundwater-dependency of many of the City's resources, it is important to have a basic understanding of surface water and groundwater contributions to the resources. This will facilitate long-term management of the groundwater resource.

c. Lack of in-stream thermal monitoring data. This information could be used to gain a better understanding of surface water impacts (i.e. discharge to the resource from impervious and/or stormwater management facilities), effects of riparian buffer (or lack thereof), and response to climatic variability. Future amendments to the SMP should consider the water temperature monitoring conducted at the Water Survey Canada Gauge Stations, including Neebing River near Intola (02AB024), Neebing River near Thunder Bay (02AB008) and Slate River (02AB023).

d. No monitoring data for precipitation in the Pennock and Mosquito Creek Watersheds was available at the time of these Watershed Assessments. Tipping bucket precipitation gauges were recently installed at in the Village of Murillo (Pennock Creek watershed) and Kakabeka Falls at the Provincial Groundwater Monitoring Network sites.

e. No metadata is available to assist in the processing of the LRCA data, making it challenging to perform QA/QC on the data.

6. Fluvial Geomorphology Data

a. No monitoring data or analysis exists of fluvial geomorphology, bank stability, or changes in physical fish habitat

Addressing the findings of the gaps analysis will provide the City and its partners the resources and information needed to quantitatively assess infrastructure, natural resource health and the impacts climate change are having locally. While there is a lot of information available in the area, the quantity and quality of the data was not always sufficient to meet the goals and objectives of the SMP. As a result, the Capital Improvement Plan includes recommendations for collecting data, and developing the tools that will provide the City with the information needed to better manage its infrastructure and resources in the near future. To compensate for quantity and quality of baseline information, assumptions were made regarding the hydrologic and hydraulic system which limits the ability of the assessments made in this Plan to more accurately define the needs and actions recommended in the SMP.

3 ASSESSMENT OF PRIORITY NEEDS

3.1 Priority Needs

Priorities to be addressed in the SMP were identified through the consultation plan outlined in Appendix C, which included meetings with City Division Staff and a public engagement process. Priorities were also identified in plans and studies previously completed by the City and other entities and listed in Appendix A.

3.1.1 Review of Existing Plans, Studies and Other Reports

A technical review of existing documents was conducted for development of the watershed assessment section of the SMP as well as to bring forward needs identified in previously conducted studies, planning documents, regulatory documents etc. This step of the plan development process resulted in the review of 68 reports dating back to 1965 and in the compilation of priority needs that are driven by the goals and objectives presented in Section 4 *Goals and Objectives*.

3.1.2 Priorities Identified During Public Engagement Process

Over the course of the Public Engagement Process there were opportunities for the public to provide feedback (see Appendix C for more details on the Consultation Plan and Public Engagement Process). Two Public Open Houses were held:

- The First was to educate residents about stormwater management and to identify specific needs that should be evaluated during development of the Plan.
- The Second was to provide feedback on the stormwater management practices and implementation activities being proposed in the SMP.
- In addition, the City developed a survey designed to gauge the public's understanding of stormwater management and identify specific needs related to surface water, groundwater and natural resources management.

Comments and needs expressed at these meetings and in the survey were compiled with the needs identified in the review of existing plans, studies and other reports and were addressed by the goals and objectives presented in Section 4 *Goals and Objectives*.

3.2 Evaluation of Stormwater Infrastructure

Base Models of seven watersheds in the City were developed as a starting point for the City to assess stormwater infrastructure at a watershed scale in the future. The eighth watershed within the City, referred to as the Waterfront Watershed, includes all areas draining directly to Lake Superior and was not included in the scope of the Base Model development. An additional, local scale assessment was also completed as part of the SMP using a Feasibility-Level Model. The rainfall event simulations of all models used the Intensity-Duration-Frequency (IDF) Curves developed as part of this plan to reflect the latest precipitation information. Both modeling efforts are further discussed in more detail in this section and in Appendix D.

3.2.1 Base Models

A Base Model was developed for seven watersheds in the City, including the watersheds of the Current River, McVicar Creek, McIntyre River, Neebing River, Pennock Creek, Kaministiquia River, and Mosquito Creek. The Base Models are a step towards building a detailed understanding of the watershed systems in Thunder Bay. The models were developed in the PCSWMM modeling platform using the best available information, including GIS and past technical studies, to represent existing and future conditions scenarios.

Each model includes a rough division of subwatersheds, the major watercourse and tributaries, and the major watercourse crossings. Due to significant limitations in the available structural and monitoring information, the models cannot be immediately used to assess the specific hydraulics of infrastructure, such as culverts and bridges. The models do provide useful hydrological information under existing and future condition scenarios that can be used as an initial baseline for future evaluation of infrastructure capacity, impacts associated with future development, impacts of climate change, and scenario planning to improve stormwater quality.

The results of each base model, including verification and comparison of existing conditions scenario results to past technical studies and the future conditions scenario, are provided in Appendix D. Appendix D also details additional information required to ultimately develop Comprehensive Watershed Management Models. It is recommended that future data collection and model development efforts are compiled with other watershed-specific studies recommended in the SMP into Watershed Plans. In consultation with the LRCA, the Watershed Plans will further develop watershed specific goals and stormwater management performance criteria, as recommended in the MOECC's Interpretation Bulletin on expectations or stormwater management (2015).[(21)] Each Watershed Plan's recommendations can then be implemented and incorporated into the next 5-year review of the SMP.

3.2.2 Northwest Arterial Golf Links Feasibility-Level Model

A Feasibility-Level Model of the Northwest Arterial Golf Links neighbourhood (hereafter referred to as the Golf Links Study Area) was developed to compare the impacts of different levels of stormwater management for future urban expansion planned in the neighbourhood as outlined in the Renew Thunder Bay Golf Links Road / Junot Avenue Corridor Study.[(37)] As shown in Figure 4, the Golf Links Study Area is bounded by Oliver Road to the south, Golf Links Road and the Hydro One easement to the east, and the Thunder Bay Expressway (Highway 11/17) to the west and north.

The development scenarios in the model included the following three levels of stormwater management (See Appendix D for a more detailed description):

1. Uncontrolled runoff directed to storm sewers and ditches designed for the 2-year event.
2. SWM ponds designed to match existing peak flows and other standards defined in the City's Engineering and Development Standards (2014).
3. Infiltration facilities sized to retain 25 mm of runoff from impervious surfaces and SWM ponds designed to control the remaining runoff from the area to existing peak flows.

Figure 4. Northwest Arterial Golf Links Area Location Map

The impact of development on peak flow and runoff volume was estimated for each scenario using a Feasibility-Level Model in addition to pollutant loadings (See Appendix D). As shown in Figure 5, a wetland covers a significant portion of the 80 hectare Golf Links Study Area. The latest MNRF wetland mapping identifies this wetland as a coniferous forest type swamp.

Development scenarios with varying levels of stormwater management were assessed using PCSWMM. Annual pollutant loading calculations (including total suspended solids (TSS), total phosphorus (TP) and total nitrogen (TN)) and cost estimates were also developed for the different scenarios. The development scenarios were completed only for the 80 hectare Golf Links Study Area, while an additional existing conditions model was prepared to assess the local and regional drainage. The different SWM facilities were located and sized at a catchment scale (instead of a parcel scale) for comparison purposes and are subject to change during a more detailed design.

The increase in impervious area from 12% to 41% from existing conditions to proposed conditions without any stormwater management controls (Scenario 1) greatly increased peak flows, runoff volumes, and pollutant loadings. Peak flow and pollutant control was provided by stormwater management ponds in Scenario 2, although runoff volumes remained high. Infiltration facilities paired with stormwater management ponds in Scenario 3 provided the most control of peak flows, runoff volumes, and pollutant loadings (See Appendix D for more detail).

The capital and annual operation and maintenance costs of the stormwater infrastructure in each development scenario were calculated and compared to assess the relative costs of the approaches. The calculations included ditches, pipes, stormwater ponds, and infiltration facilities in addition to the retrofits required to mitigate the impacts of uncontrolled or minimally controlled runoff. The low impact development practices considered in Scenario 3 provide the most benefits at the lowest cost. The conclusion of this Feasibility-Level Model and cost-benefit analysis is also supported by case study evidence presented in the MOECC's Interpretation Bulletin: Ontario Ministry of Environment and Climate Change Expectations Re: Stormwater Management as follows(21):

> "LID can be less costly than conventional stormwater management practices. A 2007 US EPA report summarizes 17 case studies of developments that include LID practices and concludes that applying LID techniques can reduce project costs and improve environmental performance (p.5)."

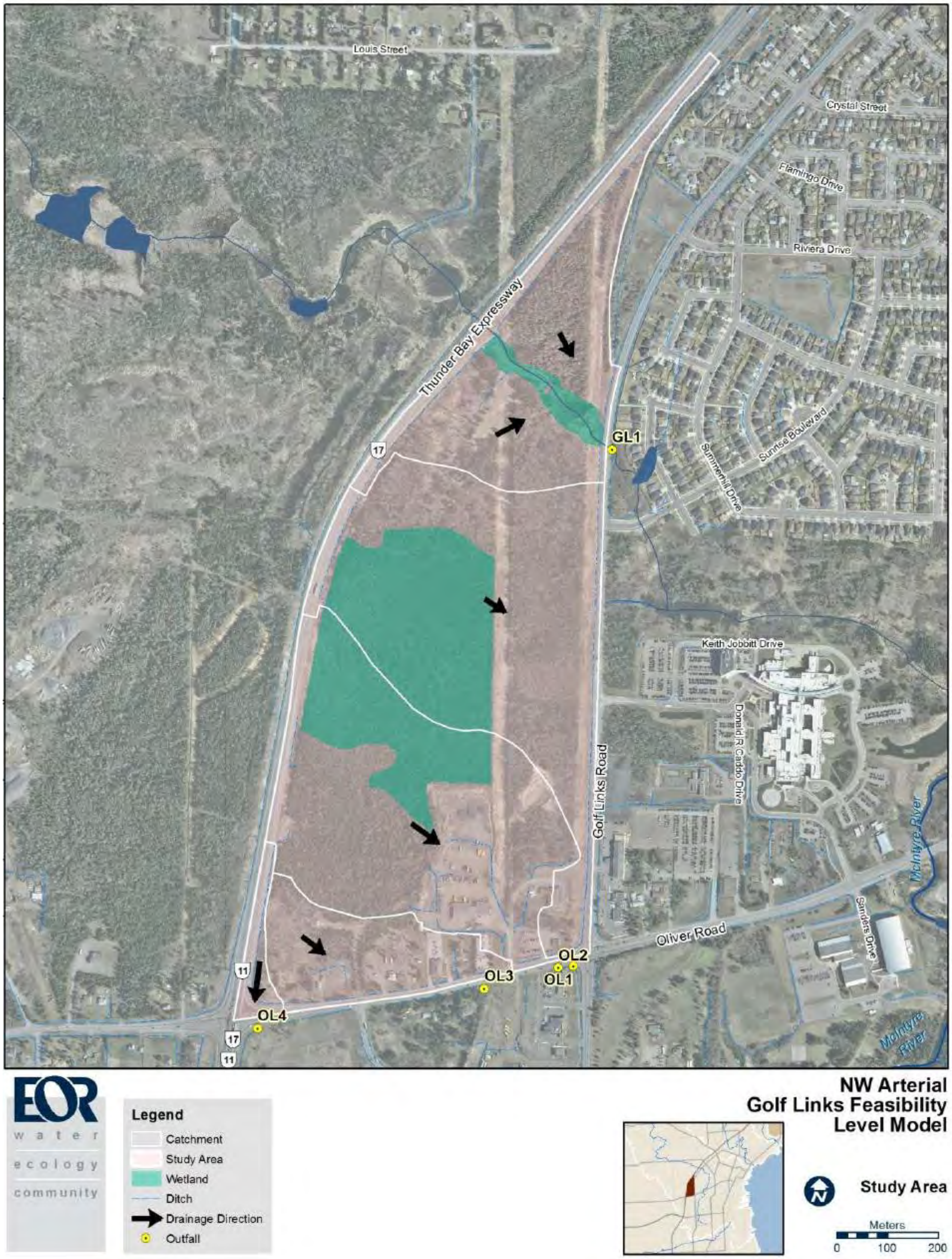

Figure 5. Northwest Arterial Golf Links Study Area

3.3 Establishment of Water Quality Targets and Ranking

3.3.1 Water Quality Targets

As stated in the Section 2 *Watershed Assessment*, a number of the streams and rivers flowing through the City have exceedances for the MOECC Provincial Water Quality Objectives and/or the Minnesota Pollution Control Agency cold water standard (see Table 54).

Table 54. Summary of Water Quality Standards Exceedances by Watershed

Watershed	% Samples Exceeding WQ Objective	Exceedances for Average Concentration
Current	Aluminum (3%) Cadmium (31%) Iron (61%) Vanadium (3%)	
Kaministiquia	Aluminum (98%) Cadmium (48%) Copper (7%) Iron (61%) Suspended Solids (26%) Vanadium (4%) Zinc (3%)	Phosphorous (0.065 mg/l vs 0.03 mg/l)
McIntyre	Aluminum (24%) Cadmium (48%) Copper (3%) Iron (100%) pH (3%) Suspended Solids (5%) Vanadium (4%)	
McVicar	Aluminum (14%) Cadmium (43%) Copper (4%) Iron (67%) pH (7%) Suspended Solids (5%) Vanadium (7%)	
Mosquito	*No monitoring data available*	*No monitoring data available*
Neebing	Aluminum (3%) Cadmium (21%) Iron (90%) pH (3%) Suspended Solids (5%) Vanadium (4%)	
Pennock	*No monitoring data available*	*No monitoring data available*

Until further information is collected to determine whether or not the exceedances for metals are attributed to background conditions, water quality targets for these parameters cannot be specifically established. However, given the well-established relationship between urban runoff and adverse impacts to receiving waters, water quality parameters which have exceedances are addressed in the SMP.

To develop water quality targets for the watersheds in Thunder Bay, a load estimation technique called the Unified Area Load (UAL) was used to quantify annual pollutant loads. Pollutant load estimation is an important step in the development of watershed management plans as it quantifies the pollutants delivered from various sources within the watershed so that a restoration and/or protection plans can be targeted to these sources. The load estimation technique estimates the nonpoint source load by multiplying the contributing drainage area by the pollutant load (kg/ha/yr) associated with a particular land use (e.g. urban, rural, agriculture and forest).

While UAL is a simple tool and requires minimum amount of data, it generates a rough estimate of the loadings and does not consider degradation and transformation processes. Until the City collects additional monitoring data to gain a better understanding of the loads at the municipal boundary, it is an appropriate tool to use in establishing preliminary or interim water quality targets.

The results of the UAL performed for each of the watersheds within the Thunder Bay are presented in Table 55.

Table 55. Results of the Unified Area Load Analysis per Watershed, reported to four significant digits

Parameter	Unit Area Load TP (kg/yr)						
	Current	Kaministiquia	McIntyre	McVicar	Mosquito	Neebing	Pennock
Total Contribution from Watershed	12,190	141,800	4,409	1,560	944	5,039	1,165
Contribution from Portion of Watershed w/in Municipal Boundary	334	1,461	2,440	1,049	615	2,925	257
% of Load from w/in Municipal Boundary	3%	1%	55%	67%	65%	58%	22%

The results in Table 55 identify the estimated total phosphorous (TP) load from the watershed as well as the TP load from that portion of the watershed that lies within the municipal boundary. In addition, Table 55 identifies the percentage of the total load that comes from within the municipal boundary. For the Current River Watershed and the Kaministiquia River Watershed, the percentage of the total load coming from within the municipal boundary is small (3% and 1%) because the total watershed area is much larger (approximately 67,000 ha and 777,585 ha) and the percentage of imperviousness within the watershed is small (0.06% and 0.02%). For the remaining watersheds, the estimated percentage of the TP load coming from within the municipal boundary is higher (22% to 67%).

3.3.2 Stream Pollutant Ranking

As Section 2.7 *Water Quality* indicates, there is no Provincial Water Quality Network monitoring data for the Mosquito River and Pennock Creek. Since this monitoring data was used in the stream pollutant ranking process, these two resources were not included in the SMP

The remaining five streams were given individual scores for the following characteristics:

1. **Metal pollutant score**:
   an individual score was assigned based on the number and degree of metal exceedances of Provincial Water Quality Objectives or equivalent standards. A 5 was assigned to the stream with the greatest number and most severe exceedances.

2. **Pollutant loading score:**
   an individual score was assigned between 1 and 5 based on the flow-weighted mean concentration of total phosphorus, total nitrogen, nitrate, chloride, and suspended sediment load contributed by all 5 streams to Lake Superior. A 5 was assigned to the stream with the highest flow-weighted mean concentrations.

3. **Impervious land cover score:**
   an individual score was assigned between 1 and 5 based on the fraction of each stream watershed with impervious land cover. A 5 was assigned to the stream with the largest fraction of impervious land cover in its watershed.

4. **Developed land cover score:**
   an individual score was assigned between 1 and 5 based on the fraction of each stream watershed within the City boundary. A 5 was assigned to the stream with the largest fraction of its watershed inside the city boundary.

A total score was calculated for each stream by summing the individual scores, and used to rank the streams in order of worst water quality (highest score) to best water quality (lowest score).

Table 56. Stream Pollutant Ranking

Individual Score	Current	Kaministiquia	McIntyre	McVicar	Neebing
Metals	1	5	4	3	2
Pollutant Loading	1	5	2	3	4
Impervious Land Cover	2	1	4	5	3
Developed Land Cover	2	1	3	5	4
Total Score	**6**	**12**	**13**	**16**	**13**

This information was used to prioritize objectives and action items for each watershed.

3.4 Climate Change Assessment and IDF Curves Development

A statistical trend analysis of precipitation was conducted using five Environment Canada Weather Stations and a period of record ranging from 24 years to 48 years. This analysis evaluated statistical trends for dry and wet periods ranging from 2 days to 12 days. The incidence of statistically significant trends was higher for dry periods than for wet periods, meaning that the occurrence of dry periods (drought) over time tend to increase comparatively more than the occurrence of wet periods. The overall trend in the data set is, nevertheless, for the dry and wet periods to occur more often, and for the precipitation depth during wet periods to increase (i.e. longer and more often dry periods and more common and intense wet periods). A more detailed summary of this analysis can be found in Appendix E.

It is recommended per Volume II, Appendix E, that the City's current IDF data be updated based on the latest Thunder Bay Airport rainfall gauge data (up to year 2014) with event durations extended beyond the current IDF curves. The updated IDF curves and data tables are provided in Volume II, Appendix E in Figure 24, Table 55 and Table 56 along with further details of the approach used to update the curves.

Runoff flow calculations for review of existing City CIP program infrastructure should use the updated IDF curves with an additional 15% increase in rainfall depth and intensity. Runoff flow calculations for review of development applications should use the updated IDF curves for pre-development conditions and use the updated IDF curves with an additional 15% increase in rainfall depth and intensity for post-development conditions. This proactive measure plans for the uncertainty associated with intensity and frequency of storms due to climate change. The approach is consistent with the policies of other municipalities in Ontario that will be implemented until additional guidance is provided by more senior levels of government.(38) The approach is also supported by precipitation analyses completed on a regional scale near Thunder Bay, where an update of the state-wide precipitation analysis in Minnesota (Atlas 14) resulted in rainfall depths approximately 10 to 20% higher than previous calculations performed in the 1980's referred to as TP-20 and TP-40. The MOECC Interpretation Bulletin on expectations regarding stormwater management released in February of 2015 encourages the use of the latest historical climate data and provides additional analyses in Projected IDF Curves publicly available on the Ontario Climate Change Data Portal that were not considered in the SMP.(21)

For areas incorporating one or more hectares of impervious surfaces, a unit hydrograph program such as PCSWMM, Visual OTTHYMO, or other suitable technique should be used to calculate the flows. As the use of hydrologic and hydraulic models becomes a more common design tool for stormwater management facilities in Thunder Bay, the City should consider defining a standard rainfall distribution for use in developing synthetic design storms. In the past, the 24-hour SCS Type II and the Chicago Storm distributions have been applied in Thunder Bay, but other options include nested distributions, distributions developed based on historical precipitation records in Thunder Bay, and recently updated distributions from Minnesota. Rainfall distributions applicable to all rural areas in Minnesota were recently updated from SCS Type II to MSE 3 MN by the National Resources Soil Conservation Service (NRSCS). The NRSCS also developed two other distributions for the areas of Minnesota closest to Thunder Bay referred to as MSE 4 and 5.(39)

3.5 Climate Change Adaptation

Changes in the amount and delivery of precipitation events in combination with land use changes can affect the amount of stormwater runoff that needs to be controlled. In some areas, the combination of climate and land use change may make existing stormwater-related issues (e.g. flooding) worse, while other areas may be less affected. Adaptation strategies for stormwater management serve to provide additional capacity in the existing system so that it is more resilient under more intense or multi-day precipitation events. Green infrastructure, Low Impact Development and integrated site design are examples of adaptation strategies that provide additional capacity within the existing stormwater management system (i.e. facilitates providing the same level of services under future climate projections). Stormwater management techniques that are designed to provide adaptation benefits would likely include (but not be limited to) the following design considerations:

- Drought effects/water resource protection
- Extreme weather/temperature mitigation
- Runoff temperature mitigation
- Infrastructure repair/mitigation of combined sewer overflows
- Carbon emission reduction
- Carbon sequestration

Until a formal climate change assessment is conducted, the City should promote the use of Green Infrastructure and other multi-functional stormwater BMPs to provide more distributed storage and treatment in the City's urban landscape.

3.6 New Stormwater Measures and Retrofit Opportunities

The large amount of impervious surfaces, coupled with urban drainage systems has altered the natural hydrology of the City. The results of increasing impervious surfaces include: more frequent flooding, higher flood peaks, lower base flow in streams, lower water table levels (generally in urban areas), and higher groundwater table levels (in areas served by municipal water but on septic systems) than in a natural, undeveloped state. Impervious surfaces and urban drainage practices have also accelerated the delivery of pollutants to rivers and lakes.[40]

Stormwater Best Management Practices (BMPs) "protect farmland, wetlands, and green spaces, and also provide for efficient use of land, water and energy resources and existing infrastructure. Employing LID facilities to the greatest extent possible, when undertaking intensifying urban development, will add to these benefits (p.2 of bulletin).[21]" One of the "low hanging fruit" options identified through this plan is to harness the potential of underutilized publicly owned lands, more specifically public park lands, for stormwater BMPs. There are many large parks within the City that contain underutilized lands with the potential for managing stormwater within the public view.

The sections below include descriptions of all BMPs recommended in the SMP, which are not limited to BMPs new to Thunder Bay stormwater management. A number of the recommended practices are an extension or continuation of BMPs currently implemented in the City. However, the sections below also include practices not currently implemented in the City. In the process of assessing the potential for BMPs there were two main considerations specific to Thunder Bay climate and physical landscape.

3.6.1 BMP Considerations for Thunder Bay

3.6.1.1 Winter Maintenance

The cold climate of Thunder Bay presents unique considerations for BMP retrofit opportunities. Freeze/thaw cycles and snow plowing are concerns for many BMPs in colder climates, however, there are specific measures that can mitigate these challenges. When well-designed and installed correctly, infiltration, and filtration practices should always drain properly and should never freeze solid. Many of the newly available proprietary sediment removal devices, for example, are installed below the frost line and, therefore, operate as designed under all weather conditions. Municipalities should take precautions after snowfall to prevent damage to permeable surfaces, conveyance structures, and infiltration practices.

Sand application on local, arterial, and collector roadways is another major concern for most BMPs. Sand application should be minimized, as it can inhibit BMP function. The addition of sand to roads and parking lots can lead to costly maintenance issues for conveyance systems and pond inlets, as well as clog infiltration and filtration systems. Reducing sand application to roadways, however, should be moderated as to not compromise the road safety and roadway function. While use of sand continues to be a reality, pre-treatment techniques are important for sediment removal before runoff is discharged to infiltration/filtration BMPs. This pre-treatment is mandatory to mitigate the impacts of required winter road maintenance.

Salt application can have significant maintenance costs to BMPs. In order to preserve the health and function of vegetation incorporated into many types of BMPs, there should be an effort to minimize or moderate road salt application. Plants selected for practices where road salts are applied should flourish in the regional climate conditions and include salt-tolerant species that are non-invasive.

3.6.1.2 Physical Landscape

In addition to cold climate, the shallow bedrock and thin soils that span the physical landscape of Thunder Bay also present stormwater management implications. Infiltration rates, ponding depths, and the use of underground practices may be limited in areas of shallow bedrock. However, there are general guidelines for designing, installing, and maintaining BMPs in bedrock-defined areas. Special caution for steep slopes and hidden bedrock fractures is recommended. Whenever there is contact with the bedrock or a lack of adequate soil depth, it is important to conduct a thorough hydrogeological and geotechnical investigation to identify any potential stormwater-related challenges.

Infiltration practices are typically impractical in shallow soils due to the limited soil separation distance between the bottom of the practice and bedrock. Implementation of infiltration practices is generally limited to a minimum 1 metre soil separation between bedrock and the bottom of the practice in order to allow proper filtering of pollutants and to prevent perched groundwater mounding. One effective response to this limitation can be engineered soil amendments to increase depth. Where infiltration practices are not feasible, other BMP types can be adapted to increase storage and filtration capacity. Modifications to the designed ponding depths for many types of

BMPs will help reduce the required surface area of these facilities. Because they are shallow by design, constructed stormwater wetlands will have greater storage potential than wet ponds, due to the limitation on ponding depths.

3.6.2 Low Impact Development BMPs

Stormwater BMPs are an effective means of surface water protection, stormwater volume control, and infiltration or groundwater recharge and are generally categorized according to scale and treatment function.

3.6.2.1 Runoff Reduction

Open Space Design and Land Conservation

Open space design is a form of residential development that concentrates lots in a compact area of the site to allow for greater conservation of natural areas. Minimum lot sizes, setbacks and frontage distances are relaxed so as to maintain the same number of dwelling units at the site. This form of development may also be called cluster design or conservation design. Conservation design can be a tool to conserve more natural areas beyond the minimum required under local By-Laws. Open space design can also be used to reduce or disconnect impervious cover and provide for greater on-site stormwater treatment. The natural areas conserved are protected by easement and managed by the City, homeowners associations, or designed utility organizations. Research has shown that open space designs can reduce overall site impervious cover compared to conventional subdivisions, and command higher prices and more rapid sales.(41) Other benefits include lower costs for grading, erosion control, stormwater and site infrastructure, as well as greater land conservation without the loss of developable lots.

Reducing Impervious Cover

This strategy relies on several techniques to reduce the total area of rooftops, parking lots, streets, sidewalks and other types of impervious cover created at a development site. The basic approach is to reduce each type of impervious cover by downsizing the required minimum geometry specified in local By-Laws, keeping in mind that there are minimum requirements that must be met for accessibility, fire, snow plow and school bus operations. Less impervious cover directly translates into less stormwater runoff and pollutant loads generated at the site. The Zoning By-Law and development standards should be modified to allow the use of this group of better site design techniques. By-Law and development standards that are the most common barriers to reducing impervious cover include:

1. Street Width
2. Sidewalk Width
3. Cul-de-Sac Diameter
4. Front Yard Setback (related to driveway lengths)
5. Parking Lots (stall dimensions, minimum parking demand ratios)

Stormwater Landscaping

Traditionally, landscaping and stormwater management have been treated separately in site planning. In recent years, engineers and landscape architects have discovered that integrating stormwater into landscaping features can improve the function and quality of both. The basic concept is to adjust the planting area to accept stormwater runoff from adjacent impervious areas and utilize plant species adapted to the modified runoff regime. A landscaping area may provide full or partial stormwater treatment, depending on site conditions.

Although numerous studies on how to match plant species to stormwater conditions have been completed in Ontario, the majority are not relevant to the northern climate in northern Ontario. However, there is guidance available from the northern Midwestern United States, which has climate similar to northern Ontario. One such resource on stormwater plant selection is the Minnesota Pollution Control Agency's publication *Plants for Stormwater Design: Species Selection for the Upper Midwest* (Shaw and Schmidt, 2003).[42][43]

An example of the use of landscaping for full stormwater treatment is bioretention. In other cases, landscaping can provide supplemental treatment such as green rooftops and stormwater planters. Even small areas of impervious cover should be directed into landscaping areas since stormwater or meltwater help to reduce irrigation needs.

Disconnecting Impervious Surfaces

Streets, parking lots, roofs, and other impervious surface can often provide the same function as traditional designs with less impact on the stormwater system. A better site design strategy seeks to maximize the use of pervious areas at the site to help filter and infiltrate runoff generated from impervious areas. Surface disconnection spreads runoff from small parking lots, courtyards, driveways and sidewalks into adjacent pervious areas where it is filtered or infiltrated into the soil. When many small areas of impervious cover are disconnected from the storm drain system, the total volume and rate of stormwater runoff can be sharply reduced. Disconnections may be restricted based on the length, slope, and soil infiltration rate of the pervious area in order to prevent any reconnection of runoff with the storm drain system. In some cases, minor grading of the site may be needed to promote overland flow and vegetative filtering.

Urban Tree Canopy

Trees reduce the volume of stormwater runoff in neighbourhoods and ultimately community-wide. This function and benefit is especially important in developed settings with increased quantities of impervious surfaces (roads, driveways, homes, parking areas) and in areas in close proximity to surface waters. A tree's surface area, particularly leaf and trunk surfaces, intercept and store rainfall. The tree's root system absorbs soil infiltration, thereby decreasing runoff. Trees also reduce stormwater runoff by intercepting raindrops before they hit the ground, thus, reducing soil compaction rates and improving soil absorptive properties. Additionally, trees intercept suburban pollutants such as oils, solvents, pesticides, and fertilizers which are often part of stormwater runoff, reducing pollutant discharges into vital waterways.

3.6.2.2 Pre-treatment

Sump Catch Basin

A catch basin is a concrete underground container that performs stormwater pre-treatment and minimizes sewer clogging by trapping larger matter with an inlet grate. The sediment and other suspended material settle in a sump located below the inlet and outlet controls. Catch basins can achieve 50% removal of coarse sediment with regular maintenance of collected sediments. These BMPs are currently standard practice in Ontario as per City Standards and should be implemented if possible in some retrofit scenarios, in combination with more robust pre-treatment measures identified below.

Vegetated Filter Strips

Vegetated filter strips are bands of dense, perennial vegetation installed on a uniform slope and designed to provide pre-treatment of runoff prior to discharging into a BMP. These practices improve stormwater quality and reduce runoff flow velocity. As water sheet flows across the vegetated filter strip, the vegetation filters out and settles sediments and pollutants. Slope, length, gradient, underlying parent soil, and condition of the vegetation influence the pollutant removal efficiency of these practices. Vegetated filter strips also exhibit good removal of litter and other debris when the water depth flowing across the strip is below the vegetation height. Maintenance of vegetative cover is important to make sure that filter strips continue to remove pollutants and do not export sediment.[44]

Grass Swale

Grass swales are shallow, open vegetated channels designed to provide non-erosive conveyance with longer detention time than traditional curbs and gutters. These practices are effective for pre-treatment of concentrated flows before discharge to a downstream BMP. Although grass swales provide generally limited pollutant removal through gravity separation, they can be designed to enhance their stormwater pollutant removal effectiveness. In well-constructed swales high sediment load reductions have been observed. Properly designed grass swales are ideal when used adjacent to roadways or parking lots, where runoff from the impervious surfaces can be directed to the swale via sheet flow. As the vegetative cover is an integral component to the function of grass swales, flow depth should not exceed the height of the vegetation. As routing meltwater over a pervious surface will yield some reduction in flow and improved water quality, these practices have been shown to be very effective in cold climate conditions.

Proprietary Devices

There are many types of commercially-available proprietary stormwater controls for both water quality treatment and quantity control. These systems are utilized for pre-treatment applications within a treatment train, however, are often more costly than other BMPs and may have high maintenance requirements. There are several types of proprietary BMPs, including but not limited to: hydrodynamic separators, such as gravity and vortex separators (i.e. Oil-Grit Separators), filtering systems, prefabricated detention basins, and other floatable skimmers. Other applications are catch basin insert and chemical treatment. These types may be used for retrofits.

3.6.2.3 Lot-Level

Green roof

Green roofs effectively reduce runoff volume by intercepting rainfall through a layer of growing media and vegetation, planted on the rooftop. Rainwater captured in rooftop media then evaporates or is transpired by plants back into the atmosphere. Rainwater not captured by the growing media is detained in a drainage layer below and then flows to roof drains and downspouts. These systems are highly effective at reducing or eliminating rooftop runoff from small to medium storm events. Green roofs can be incorporated into new construction or added to existing buildings during renovation or re-roofing.

In addition to stormwater volume reduction, green roofs offer an array of benefits, including extended roof life span (due to additional sealing, liners, and insulation), improved building insulation and energy use, reduction of urban heat island effects, opportunities for recreation and rooftop gardening, noise attenuation, and aesthetics.[45][46] Green roofs can be designed as extensive, shallow-media systems or intensive, deep-media systems depending on the design goals, roof structural capacity, and available funding. As a result of the slower snow melt and reduced runoff volume, green roofs are very effective in colder climates.

Rainwater Harvesting (Cistern/Rain Barrel)

Rainwater harvesting is the use of containers that capture rooftop runoff and store it for landscaping and other non-potable uses. The captured stormwater can be effectively released for irrigation or alternative grey water uses with various control devices in between storm events. Rain barrels tend to be smaller systems that direct runoff through a downspout into a barrel that holds less than 200 litres. Cisterns are larger systems that often require a pump for water removal, can be self-contained above or belowground, and can collect water from one or more downspouts. Where site constraints limit the use of other BMPs, rainwater harvesting is a useful method of reducing stormwater runoff volumes in urban areas.

Because most rainwater harvesting systems collect rooftop runoff, which tends to have relatively low levels of physical and chemical pollutants, pollutant reduction mechanisms of rain tanks are not yet well understood. Rainwater harvesting systems can be equipped with filters to improve water quality and have also been shown to reduce pollutant loads when stored rainwater slowly infiltrates into surrounding soils using a low-flow drawdown configuration. The use of stored rainwater for alternative purposes, such as irrigation, has also been shown to reduce stormwater pollutants. This practice has been proven to be effective in cold climate conditions, however, barrels need to be drained each fall to avoid ice build-up unless collection occurs below frost line.

Infiltration Trench (Soakaway Pit)

Stormwater infiltration trenches are linear ditches, filled with a deep layer of aggregate and porous soil media that capture and temporarily store stormwater before allowing it to infiltrate into the soil below. Design variants include; the infiltration basin, the infiltration trench, the dry well and the soakaway pit. After the stormwater filters through the layer of aggregate and vegetation, it penetrates the underlying soil where chemical, biological and physical processes remove pollutants and delay peak stormwater flows.

These practices are most applicable to sites that have naturally permeable soils and are a suitable distance from the seasonally high groundwater table, bedrock or other impermeable layer. They are commonly used in residential and other urban settings where runoff volumes, pollutant loads, and runoff temperatures are a concern. In applications where the stormwater runoff has a particularly high pollutant load or where the soils have very high infiltration rates, a significant amount of pre-treatment should be provided to protect the groundwater quality. These practices are very effective in cold climate conditions when designed with enough available volume to accommodate meltwater in the spring and installed below the frost line to avoid ice build-up.

Pervious Pavement (Driveway/Parking/Street/Laneway)

Permeable pavement is a durable, load-bearing paved surface with small voids or aggregate-filled joints that allow water to drain through to an aggregate reservoir. Stormwater stored in the reservoir layer can then infiltrate underlying soils or drain at a controlled rate via underdrains to other downstream stormwater control systems. Permeable pavement allows streets, parking lots, sidewalks, and other impervious covers to retain the infiltration capacity of underlying soils while maintaining the structural and functional features of the materials they replace. Application of permeable pavements is more common in lower load-bearing settings, such as parking lanes and parking lots. Permeable pavement systems, when designed and installed properly, consistently reduce concentrations and loads of several stormwater pollutants, including heavy metals, oil and grease, sediment, and some nutrients.(47) The aggregate sub-base improves water quality through filtering, and chemical and biological processes, but the primary pollutant removal mechanism is typically load reduction by infiltration into subsoils.

Permeable pavement can be developed using modular paving systems (e.g., permeable interlocking concrete pavers, concrete grid pavers, or plastic grid systems) or poured in place solutions (e.g., pervious concrete or porous asphalt). In many cases, especially where space is limited, permeable pavement is a cost-effective solution relative to other practices because it doubles as both transportation infrastructure and a BMP. Extensive research has shown this practice is successful in cold climates when properly installed and maintained. To make sure permeable pavements function properly, it is particularly important to eliminate sand application to permeable roadways or when sand use cannot be eliminated, an expanded sweeping or vacuuming program may be required.

Bioretention

Bioretention areas are landscaped, shallow depressions filled with sandy soil, topped with a layer of mulch, and planted with suitable vegetation. Stormwater runoff flows into the cell and slowly percolates through the soil, or engineered filter media, (which acts as a filter) and into the groundwater; some of the water is also taken up by the plants. This important technique uses soil, plants, and microbes to treat stormwater before it is infiltrated or discharged. Bioretention areas are usually designed to allow ponded water 15-30 cm deep, with an overflow outlet to prevent flooding during heavy storms. Where soils are tight or infiltration is otherwise limited (which is the case in the City) a perforated underdrain, connected to storm sewer or alternative discharge should be utilized.

An alternative form of bioretention is the bioswale, a facility with similar properties and stormwater functions built for stormwater conveyance. This system utilizes slope and earthen dams to temporarily detain flows, which allows infiltration through the sandy soil layer.

Bioretention areas provide comprehensive pollutant load reduction through physical, chemical, and biological mechanisms. Infiltration provides the most effective mechanism for pollutant load reduction and should be encouraged where practical. Treatment performance can also be enhanced by installing deep media with slow infiltration rates (up to 5 cm per hour).[48][49][50] By definition, bioretention cells are designed for the growing season, but they do contain a sump area for storage and allow for infiltration during spring snowmelt. For proper function in colder climates, the surface of bioretention cells should be fully dry before freeze-up.

Tree Trench

Tree trenches are dug along the length of roads or pathways and filled highly permeable aggregate integrated with minimal soil. Impervious surfaces, or in some cases, permeable pavers overlie the infiltration media. Trees are planted in designed, usually square, openings of the top layer, which thrive in the well-watered, oxygenated environment. Runoff is directed from surrounding impervious surfaces through curb cuts and surface drains to the tree trench where it percolates through the soil media to the underlying ground or underdrain. If the runoff exceeds the design capacity, the underdrain directs the excess to a storm drain or additional BMPs. Ideal for redevelopment or in the ultra-urban setting, tree trenches have been implemented as pre-treatment devices around paved streets, parking lots, and buildings. Research shows that these practices are capable of consistent and high pollutant removal for sediment, metals, and organic pollutants.[50]

Planter Box

Stormwater planter boxes are containers placed on impervious surfaces that do not infiltrate into the ground. Placed at or above ground level and filled with gravel, soil, and vegetation, these facilities temporarily store stormwater runoff and filter sediment and pollutants as water slowly infiltrates. Excess water collects in a perforated pipe at the bottom of the planter and discharges to a conveyance system or other BMPs. Constructed of various materials, stormwater planter boxes can be built immediately next to buildings and are ideal for constrained sites with setback limitations, poorly draining soils, steep slopes, or contaminated areas.

3.6.2.4 Local & Regional

Infiltration Basin

An infiltration basin is typically a large facility constructed with highly permeable engineered filter media that provides temporary storage of stormwater runoff. These facilities do not typically contain structural outlets and instead outflow is primarily achieved through infiltration. Sometimes coupled with an overflow detention basin to provide additional runoff storage, infiltration basins provide an effective means of improving stormwater quality and quantity management. Dry wells are an alternative version of these facilities that are specialized to capture runoff from roofs or other small impervious areas.

Filtration Basin

Filtration basins are typically a large facilities constructed with engineered filter media amended with soil that detain stormwater runoff and filter pollutants. As stormwater infiltrates through the amended soil, sand, or engineered media, pollutants are filtered and adsorbed onto soil particles. An underdrain then captures and directs treated stormwater to additional BMPs or the drainage system. Filtration basins may be shaped like ponds or channels. Similar to bioretention basin, these facilities can be covered with grass, wetland species, or landscaped vegetation to improve pollutant removal. Although some designs may include spillways or outlet controls, all filtration basins have an underdrain system.

Underground Storage

Underground stormwater retention/detention involves vaults or large diameter, interconnected pipes that capture stormwater collected from surrounding impervious areas. Typically riser pipes or curb cuts lead surface stormwater to the subsurface system. These facilities effectively reduce peak flows during storms and may mimic pre-settlement conditions by slowly releasing stored stormwater back into the drainage system through outlet controls. Although minimal stormwater quality benefits are achieved, these facilities can advance the effectiveness of other BMPs by improving water quantity management.

Sand Filters

A sand filter is a flow-through system designed to improve stormwater quality by slowly filtering runoff through sedimentation and filtration chambers. Stormwater is first directed to the sedimentation chamber where larger particles settle with increased detention time. The removal of dissolved Phosphorous is significantly enhanced when the sand is amended with iron, calcium, aluminum, or magnesium.[51] Then the filtration chamber below removes pollutants and enhances water quality as the stormwater is strained through a layer of sand. The treated effluent is collected by underdrain piping and discharged to the existing stormwater collection system or another BMP. Sand filters can be used in areas with poor soil infiltration rates, where ground water concerns restrict the use of infiltration, or for high pollutant loading areas.

Sand filters are capable of removing a wide variety of pollutant concentrations in stormwater via settling, filtering, and adsorption processes. Sand filters have been a proven technology for drinking water treatment for many years and now have been demonstrated to be effective in removing urban stormwater pollutants including total suspended solids, particulate-bound nutrients, biochemical oxygen demand (BOD), fecal coliform, and metals.[52] Sand filters are volume-based and intended primarily for treating the water quality design volume. In most cases, sand filters are enclosed concrete or block structures with underdrains; therefore, only minimal volume reduction occurs via evaporation as stormwater percolates through the filter to the underdrain.

Constructed Wetland

Constructed stormwater wetlands are engineered, shallow-water ecosystems designed to treat stormwater runoff. These practices provide flood control benefits by storing water and slowly releasing it over 2 to 5 days. Commonly implemented in low-lying areas, stormwater wetlands are well suited to areas along river corridors where water tables are higher. Similar to natural wetlands, water quality improvement is effectively achieved through physical, chemical, and biological processes as water is temporarily stored. Sedimentation and uptake by wetland plants also facilitate many water quality improvements. High phosphorus removal rates have been observed in stormwater wetlands, which also perform well for nitrate removal because the anaerobic conditions and organic material in wetland sediment create an ideal environment for denitrification (converting nitrate into nitrogen gas).[48] Consequently, the flow path through the wetland should be maximized to increase residence time and contact with vegetation, soil, and microbes.

Wet pond

Wet ponds are depressions in the ground with elevated outlets, which allows water to pond and be stored between stormwater runoff events. Because the outlet structure opening is at a higher elevation than the pond bottom, the ponded water remains in the pond after the outlet is no longer discharging runoff. Wet ponds typically achieve greater total suspended solids removal rates than dry pond and although infiltration is possible, some wet pond designs include an impermeable liner or bedrock below and do not infiltrate. The sedimentation function of these facilities can be supplemented by a smaller, upstream pond designed to settle the first load of suspended particulates. This pre-treatment feature is called a sediment forebay.

Freezing and clogging of inlet and outlet pipes can pose challenges this type of BMP. To avoid these problems, there are a number of design recommendations for cold climates. To avoid upstream flooding, inlet pipes should not be submerged, however, pipes below the frost line often avoid frost heave and pipe freezing. Slopes greater than 1 percent often prevent standing water in the pipe, which reduces the potential for ice formation.

Dry pond

Dry ponds, sometimes called detention ponds or basins are unlined depressions in the ground surface. Fitted with inlets and outlets to manage the collection and release of stormwater, these facilities temporarily store stormwater runoff, which releases at a slower rate than if the dry pond were not present. Dry ponds are designed to drain completely and should not maintain a pool of water after draining a runoff event. Although not their primary function, dry ponds have been shown to provide some infiltration and evapotranspiration benefit. These facilities are most effective at sedimentation and reduction of suspended solids concentrations.

3.6.3 Methodology used to identify BMP retrofit opportunities

Through a multi-stage screening and analysis process, 552 stormwater BMP retrofit opportunities were identified throughout the eight watersheds of interest, varying in size – from several square metres up to several hectares. In order to prioritize the implementation of potential BMPs with a wide range of size and function, a methodology was developed that relies primarily on GIS analysis, field reconnaissance, and literature-derived estimates of BMP cost and performance. An outline of this methodology is described below.

3.6.3.1 Primary Screening

The purpose of the primary screening process is to provide a base list of sites potentially suitable for LID retrofit BMP implementation. Using GIS techniques and aerial photography, this process identified candidate locations on public lands based on suitability and feasibility. Implementation of BMPs involves identifying available land for stormwater treatment and thus assessing opportunities on publicly owned lands simplifies this process. Assuming that all publicly owned lots, parks, and buildings were available for BMP implementation, the emphasis for the primary screening was for public lands with the potential for increased stormwater benefit.

Additional information was incorporated into the primary screening process in order to identify limiting factors in BMP implementation. First, above- and under-ground utilities were located to identify where BMPs would not be feasible due to conflicts with other utilities. Second, road type and distance from right-of-way (ROW) were considered during primary screening.

3.6.3.2 Field Reconnaissance

Field reconnaissance allows for a verification, or ground-truthing, of the GIS analysis and provides an evaluation of a potential BMP location. The truthing process involved photo documentation and documentation of the visible site characteristics that can impact, prevent, or increase the cost of BMP design or construction. For example, the presence of bedrock does not necessarily disallow infiltration or underground practices, but may dramatically increase construction costs. The primary site characteristics observed during field reconnaissance included: slope, estimated drainage dynamics, proximity to water bodies, land use, and site condition. Impediments or benefits of a specific location were recorded and priority sites were identified based on design complexity and estimated costs-benefits.

Through field visits over the course of two weeks, two staff identified 552 BMP locations on public lands throughout Thunder Bay. Each location was categorized by BMP type and site characteristics.

3.6.3.3 Secondary Screening

Secondary screening involved a review of data collected. Reviewers used the data collected to identify potential BMP locations that would provide little to no stormwater management benefit. The locations which had a lack of ability to receive runoff from developed areas were eliminated from further analysis.

3.6.3.4 Cost-Benefit Analysis

A database tool was created to analyze all 552 BMP retrofit opportunities identified. For each BMP category, estimates of drainage area, pollutant loads and removals, runoff volume reduction, and present-day costs were computed. A set of cost-to-benefit ratios were computed by dividing the 20-year Total Present Cost (construction + design + operation & maintenance) by each of the three benefit estimates (total phosphorus reduction, total suspended sediment reduction, and runoff volume reduction). The database tool was constructed such that BMPs can be sorted by any of the three cost-benefit metrics in order to prioritize opportunities with low cost-to-benefit ratios. The range of BMP opportunities identified – both in terms of scale and treatment mechanism – necessitated a multi-faceted approach to estimating the various metrics used in the cost-benefit analysis.

One approach involved the use of a 2005 study by Weiss and Gulliver entitled "The Cost and Effectiveness of Stormwater Management Practices".[53] The analysis performed in this study facilitates the use of "Water Quality Volume" (WQV) as an estimator of 20-year Total Present Cost (TPC), total phosphorus (TP) removal, and total suspended sediment (TSS) removal for six categories of BMPs, including:

- Dry detention basins
- Wet basins
- Constructed wetlands
- Infiltration trenches
- Bioinfiltration filters
- Sand filters

The majority (~90%) of BMP retrofit opportunities could be categorized into one of the six BMP categories. For those BMPs, the WQV was first estimated using the site footprint to approximate the storage volume potential. The assumptions are shown in Table 57. The WQV for the remaining BMP opportunities was estimated on a case-by-case basis using typical design characteristics.

Table 57: Summary of BMP re-categorization to conform with Weiss and Gulliver and estimated per-unit-area depth.

BMP Opportunity Type	Weiss and Gulliver Category	Average Depth (m^3/m^2)	Total # of Opportunities
Biofiltration	Bioinfiltration filter	0.46	286
Ditch Maintenance	-	0.15	25
Impervious removal	-	-	5
Infrastructure - Check Dam with Iron Sand Filter	-	0.30	5
Infrastructure - Control Structure	-	-	2
Infrastructure - Curb Cut	-	-	11
Infrastructure - OGS	-	-	1
Parking Lot Retrofit	Infiltration trench	0.04	23
Parking Lot Retrofit - Islands	Infiltration trench	0.28	11
Pervious Pavement	Infiltration trench	0.24	11
Pond	Wet basin	1.22	82
Pond Retrofit	Wet basin	0.91	4
Sedimentation Basin	Wet basin	0.61	8
Stabilization - Ravine	-	-	7
Stabilization - Shoreline	-	-	2
Underground Storage	Wet basin	1.22	5
Tree Trench	Infiltration trench	0.28	46
Wetland	Constructed wetland	0.91	15
Wetland Protection	-	-	3
		Total	**552**

The contributing drainage area of each BMP was back-calculated for the runoff depth from the 90th percentile rain event (25 mm). For each site, the runoff depth was based on two site-specific indicators: (a) the soil texture as obtained from GIS data, which was used to approximate the hydrologic soil group (HSG) of the drainage area as shown in Table 58, and (b) the estimated % imperviousness of the drainage area, which was assumed to be 75% for sites within the urban boundary and 10% otherwise. These two indicators were combined into a Drainage Area Code. Each code was assigned a curve number for use in calculating the runoff depth resulting from the 25 mm rain event using the updated formulae recommended by Lin et al. [54] The runoff depths are summarized in Table 59.

Table 58. Hydrologic soil group classification using soil texture.

Soil Texture	Soil Texture Code	Hydrologic Soil Group*
Sand	S	A
Loamy Sand	LS	A
Sandy Loam	SL	A
Loam	L	B
Silt Loam	SIL	B
Sandy Clay Loam	SCL	C
Clay Loam	CL	D
Silty Clay Loam	SICL	D
Sandy Clay	SC	D
Silty Clay	SIC	D
Clay	C	D

*The hydrologic soil group of a soil is critical to determining the amount of runoff because certain soils allow rainwater to infiltrate easier than others. For example, type A soils allow more rainwater to infiltrate than type D.

Table 59. Drainage Area Code and corresponding SCS Curve Number, and the resulting runoff depth for a 25 mm storm event.

Drainage Area Code	Curve Number	Runoff Depth (mm)
A10	45	0.3
A75	83	6.9
B10	64	2.1
B75	89	10.1
C10	77	4.7
C75	92	12.6
D10	82	6.5
D75	94	14.3

Next, annual per-unit-area TP loads, TSS loads and runoff volumes were estimated using the Windows-based Source Loading and Management Model (WinSLAMM – version 10.0.2) for typical rural and urban land-use conditions (Table 60). The estimated values were multiplied by the estimated drainage area to obtain estimated annual loads and volumes.

Table 60: WinSLAMM-predicted Unit Area Loads (UAL) for total phosphorus (TP), total suspended solids (TSS), and runoff volume based on Drainage Area Code.

Drainage Area Code	WinSLAMM Site Characteristics		TP (kg/ha yr)	TSS (kg/ha yr)	Volume (m^3/ha yr)
	Soil	Land Use			
A10	Sandy	Rural	0.24	78	385
A75	Sandy	Urban	0.62	235	1382
B10	Silty	Rural	0.65	140	682
B75	Silty	Urban	0.90	286	1644
C10	Silty	Rural	0.65	140	682
C75	Silty	Urban	0.90	286	1644
D10	Clayey	Rural	0.77	163	787
D75	Clayey	Urban	1.12	325	2379

Finally, predicted loads for each BMP were compared with the removal potential as predicted by the Weiss and Gulliver study to estimate the annual removals. If the predicted loads were in excess of the potential removal, the actual estimated removal was set equal to the potential removal.

Runoff volume reductions were estimated using annual runoff volumes from WinSLAMM (Table 60), then by calculating a percentage-based reduction based on BMP category and soil type as summarized in Table 61. It was conservatively assumed that only BMPs located on “A” soils would facilitate infiltration practices. The capacity for infiltration is based on many site-specific factors, including field measurements, and will need to be determined on a case-by-case basis for each BMP.

Table 61: Estimated annual runoff volume reduction by BMP type and HSG

BMP Opportunity Type	Annual Runoff Volume Reduction	
	HSG A	HSG B, C or D
Biofiltration	90%	30%
Ditch Maintenance	15%	15%
Impervious removal	70%	70%
Infrastructure - Check Dam with Iron Sand Filter	30%	30%
Infrastructure - Control Structure	15%	15%
Infrastructure - Curb Cut	90%	30%
Infrastructure - OGS	0%	0%
Parking Lot Retrofit	90%	30%
Parking Lot Retrofit - Islands	90%	30%
Pervious Pavement	90%	30%
Pond	15%	15%
Pond Retrofit	15%	15%
Sedimentation Basin	15%	15%
Stabilization - Ravine	0%	0%
Stabilization - Shoreline	0%	0%
Underground Storage	90%	15%
Tree Trench	90%	30%
Wetland	30%	30%
Wetland Protection	30%	30%

3.6.3.5 Secondary Benefits

In addition to water quality improvement and runoff volume reduction, the database tool also catalogues other potential benefits to the implementation of particular BMP retrofit opportunities. The benefits can be used as additional factors in the prioritization process. Secondary benefits are catalogued in the database tool as "yes/no" questions, and include:

- Is the site located within a park?
- Is the site located on school property?
- Does the site provide a demonstration or education opportunity?
- Is the site in a Designated Growth Area?

3.6.4 Results of Investigation

A summary of the BMP retrofit opportunities, organized by watershed, is shown in Table 62. Within each watershed the BMPs, mapped in Volume 3 (Maps 76 to 82), are categorized by type and treatment function. The results of the analysis provides a useful means of prioritizing specific BMPs based on the relative costs, performance, and watershed-specific concerns. It is important to note that, due to the simplifying assumptions used in this analysis, the actual costs and performance associated with a particular design will almost certainly deviate from the values reported here. Larger (i.e. more costly) implementation projects should undergo a feasibility analysis to assess circumstances or site characteristics not considered in this analysis. Costs associated with feasibility analyses were estimated as 15% of total project costs for large potential projects, and are reported by watershed in Table 62.

Table 62. Summary of BMP costs and benefits by watershed, reported to four significant digits

Watershed	Total # of BMPs	Benefits			Costs	
		Total TP Removal (kg/yr)	Total TSS Removal (kg/yr)	Total Volume Reduction (m^3/yr)	Total Present Cost (CAD)	Total Feasibility Cost (CAD)
Current	83	233	81,780	260,100	$ 8,693,000	$ 556,600
Kaministiquia	62	716	803,700	691,700	$ 21,601,000	$ 2,120,000
McIntyre	136	968	647,400	656,000	$ 38,140,000	$ 2,754,000
McVicar	27	17	4,922	19,350	$ 1,560,000	$ 0
Mosquito	17	5	1,359	12,590	$ 649,200	$ 0
Neebing	161	513	338,400	779,000	$ 30,460,000	$ 1,355,000
Pennock	9	3	1,273	8,347	$ 1,365,000	$ 131,300
Waterfront	57	311	169,200	355,800	$ 13,760,000	$ 1,043,000
Total	**552**	**2,765**	**2,048,034**	**2,782,887**	**$ 116,228,200**	**$ 7,959,900**

While Table 62 indicates an average BMP cost of approximately $210,000 per facility, this is skewed due to the costs of large BMPs. The range in BMP cost is outlined in Table 63 and the detailed costs of each BMP are provided in Appendix F.

Table 63. Range in BMP Costs

Range in Total Present Cost (CAD)	Number of BMPs
$0 – 10,000	39
$10,000 - $50,000	117
$50,000 - $100,000	108
$100,000 - $500,000	236
$500,000 - $1,000,000	36
$1,000,000 - $3,000,000	16

3.6.5 Recommendations for BMP Retrofit/Opportunities Implementation

The BMP database tool can be used as a means of prioritizing BMP implementation projects within a watershed based on the priority needs. Using data from the preliminary screening and prioritization process, the City will need to collect and assess the following additional information on all priority sites during the initial stages of implementation:

- Drainage area boundary
- Drainage area soils and land uses
- Site soil borings including grain size and hydrometer analysis
- Existing stormwater infrastructure on site
- Existing utilities on site
- Existing easements/right-of-way
- Existing vegetation

Soil, land use, utility, and vegetation conditions can vary over short distances, so every individual site should be investigated to determine whether atypical site conditions make stormwater infiltration feasible or infeasible. The soils on public lands, for example, will affect the feasibility of infiltration BMPs. Generally, soils classified as gravel, sand, or silty sand are suitable for stormwater infiltration.

Several potential BMP retrofits identified in the field require further investigation because implementation could involve a significant change to infrastructure, such as day-lighting or diversion of storm sewer, major grading activities, and/or significant site specific design. A site needs to have sufficient soil above bedrock with fairly high permeability in order to infiltrate and convey stormwater away from the site. The bedrock units throughout the Plan area generally have very low permeability and may call for or require site specific designs at particular locations. Additional investigation is also required for larger, regional scale sites that could provide stormwater treatment for neighbourhoods or multiple commercial lots. Feasibility studies should be conducted in the future to further evaluate site constraints and cost-benefit. Potential BMP retrofit opportunities recommended for feasibility analysis are identified in Appendix F, and the associated costs are summarized by watershed in Table 62.

4 GOALS AND OBJECTIVES

In the last 20 years, the field of stormwater management has made a significant leap in terms of how stormwater runoff is managed. Stormwater management has evolved from a traditional conveyance system, intended to transport stormwater runoff safely and efficiently from one location to another, to a system designed to manage the rate, volume and water quality of stormwater runoff. Older design concepts for stormwater management system relied primarily on stormwater ponds (wet detention) to capture and slowly release stormwater runoff to downstream waterbodies. Modern systems rely on practices such as infiltration, sand filters, vegetated swales, constructed wetlands, Low Impact Development (LID) and Green Infrastructure.

While many of the stormwater management techniques rely on basic hydrologic processes to achieve a higher-level of performance (i.e. infiltration, evapotranspiration, filtration) they require design, implementation, operation and maintenance. Newer stormwater management techniques provide "stacked functions". Stacked functions are basically multiple benefits. For example, in an urban setting like the City, rain gardens provide not only rate control, volume control and improved water quality but they also include benefits such as recharge groundwater, enhance sidewalk appeal, provide traffic-calming, increased aesthetics of a neighbourhood, and habitat for animals and plants. While incorporating new stormwater management techniques requires taking a different approach to development practices, their ability to provide multiple benefits translates into cost-savings to the City, the development community and the public if done properly.

The City's SMP will serve to guide the City as it embarks on a new model for stormwater management. While the information presented in this Plan incorporates the latest in engineering design and management practices, it acknowledges that stormwater management is a constantly changing field. The City recognizes that the implementation of this Plan requires an adaptive management approach: as standard practices change or as new information is collected and evaluated, the City may change its course of action to achieve the goals and objectives laid out in this Plan. For example, there are many engineering design practices that are being re-evaluated today as a result of climate-induced changes in environmental factors.

This section of the SMP identifies the main elements of a sustainable and integrated stormwater management program. For each of the elements, a single goal is identified as well as a list of objectives or action items recommended to achieve the overall goals. Objectives and/or action items identified in this section of the SMP are the specific action that supports attainment of the goal. These objectives/action items are reiterated in the Implementation Plan which charts a course of action for the City's stormwater management efforts over the next 20 years.

The main elements of the City's integrated stormwater management program are:

1. Ecosystem Health
2. Water Quality
3. Water Quantity
4. Operations and Maintenance
5. Monitoring and Data Assessment
6. Regulation and Enforcement
7. Education and Outreach
8. Funding and Organization
9. Climate Change Adaptation

4.1 Ecosystem Health

Goal The City's surface water, groundwater and natural resources maintain their ecological integrity and provide their original level of function and value

While the primary focus of the SMP is to assess existing and future stormwater management needs, greening of the community and the health of the overall ecosystem has been recognized as a complementary need. The identification of the Lakehead Watershed as an Area of Concern in the Great Lakes region, as defined by Provincial Water Quality Standards, necessitates an evaluation of the impact of current and historic development and land use practices on the City's natural resources. In addition, a multi-million dollar tourism industry relies on high quality natural resources to attract the wide-range of visitors coming to Thunder Bay and its surrounding communities.

The City recognizes that there are various approaches to stormwater management that also promote healthy and viable natural ecosystems. Adopting development and land management strategies that recognize the value of ecosystem health create more sustainable communities and translate into long-term cost savings. For example, hydroelectric dams often impose a barrier to passage for fish, like salmon and trout. An alternative design that includes passage routes serves to maintain healthy fisheries. An example of the long-term cost savings realized by adopting an integrated stormwater management plan can be seen when evaluating the impacts of unmanaged timber harvesting and peat extraction on the landscape. Forests and wetlands, which maintain the stability of slopes, have high infiltration and interception capacity and reduce erosion but cannot provide these same ecological services when the forests and wetlands are clear cut or are significantly altered. Increases in surface water runoff associated with practices such as large-scale logging and mining negatively impact waterbodies downstream and the restoration activities required to re-establish the function and value of these resources after the fact are costly.

A consistent message heard throughout the Public Engagement Process was the need for ecological restoration within the City to restore the health of its resources. Stakeholders in the urban area of the City recognize the implications of paving the natural landscape.

Key items noted by the public during the engagement process were interpreted to be the following:

- Tributaries to the streams and rivers flowing through the City to Lake Superior have been buried, confined to concrete lined channels or subject to other alterations and manipulation (i.e. channel revetment, native vegetation removal, dredging and/or straightening).
- Undersized, shallow, and perched crossings and insufficient culvert design can impact a stream's functionality.
- Marshes and wetlands have been filled in for development.
- The City's fisheries have seen declining populations due to pollution, changes in habitat and are now experiencing additional stresses due to warmer water temperatures associated with climate change, eutrophication, and lower water levels.
- Many of these changes have direct impacts on recreation and tourism.

4.1.1 Objectives – Surface Water Resources

- Assess current health and ecological structure of the City's streams and rivers by performing geomorphic and biotic assessments (i.e. fish species, benthic, aquatic vegetation and terrestrial vegetation)
- Naturalize shoreline habitats and protect riparian zones to improve the resources ability to withstand higher storm flows and to provide additional stormwater treatment via filtration by restoring critical areas by:
  - *Addressing sections of the creek identified in McVicar Creek Plan*
  - *Prioritizing sections of the creek identified in geomorphic assessments*
  - *Conducting shoreline restoration projects*
  - *Developing cost share program to promote shoreline stabilization projects*
  - *Education campaign to teach homeowners about the value of natural shoreline*
- Inventory and assess the need to remove barriers to fish passage (from stormwater infrastructure)
- Identify locally significant wetlands based on MNRF Wetland Mapping updated in 2014 and consider for future environmental protection zoning.
- Collaborate with the LRCA as they coordinate the evaluation of wetlands in the City based on Ontario Wetlands Evaluation.
- Provide for the protection of wetlands by adopting standards regulating stormwater impacts from new development and redevelopment activity
- Inventory buried portions of the stream system and consider daylighting and naturalizing these reaches where appropriate to assist in improving water quality, addressing flash flooding concerns, and enhancing the livability of the built environment
- Work with upstream communities, the Lakehead Region Conservation Authority and others to address potential downstream impacts associated with clear cutting of trees

4.1.2 Objectives – Groundwater Resources

- Promote groundwater recharge, where appropriate, by evaluating the use of infiltration techniques to manage stormwater on public projects and by adopting volume control standards for new development and redevelopment activities
- Map groundwater recharge areas and consider adopting policies to protect these critical areas of the watershed. Inventory existing potential sources of groundwater contamination and develop protection strategies to protect the groundwater by minimizing activities that pose contamination risks in areas of known soil and/or groundwater contamination
- Protect groundwater dependent natural resources (i.e. cold water fisheries, fens, bogs, groundwater-dependent lakes, etc.) by conducting an inventory of these resources and developing strategies that address the land use activities in the contributing groundwater and surface watershed to the resource

4.1.3 Objectives – Natural Resources

- Increase the benefits afforded by green space by incorporating green design elements into new development, transportation corridors, brownfield redevelopment, and park enhancements
- Increase the ecological benefit of existing open space by creating and enhancing connections and green corridors
- Mitigate the loss of pervious areas by incorporating green infrastructure into the built environment by:
  - *Establishing targets for infiltration*
  - *Developing Green Infrastructure design guidelines for road reconstruction projects*
- Encouraging future waterfront development plans to incorporate habitat remediation to improve habitat value

4.2 Water Quality

Goal To improve and maintain the quality of the streams, rivers, lakes and wetlands in the Lakehead Watershed

Like many communities, a significant portion of the City is made up of impervious surfaces. These impervious surfaces intercept the rainfall, thereby increasing the volume of stormwater runoff and pollutants being discharged to resources like the Current River, the Kaministiquia River, McVicar Creek, the McIntyre River, Mosquito Creek, the Neebing River, Pennock Creek and Lake Superior.

Both water quality and water quantity impacts associated with urban stormwater combine to impact aquatic and riparian habitat in urban streams. Higher levels of pollutants, increased flow velocities and erosion, alteration of riparian corridors, and sedimentation associated with stormwater runoff negatively impact the integrity of aquatic ecosystems. The impacts include the degradation and loss of aquatic habitat and reduction in the numbers and diversity of fish and macroinvertebrates leading to effects such as beach closures, limits on fishing and limits on recreational contact.

The most comprehensive study of urban runoff was the Nationwide Urban Runoff Program (NURP), conducted by the US Environmental Protection Agency between 1978 and 1983. The NURP study was conducted to examine the characteristics of urban runoff and similarities or differences between various urban land uses, the extent to which urban runoff is a significant contributor to water quality problems, and the performance characteristics and effectiveness of management practices to control pollution loads from urban runoff. Subsequent research by the Environmental Protection Agency has determined that urban runoff is one of the leading causes of water quality impairment. Schuler[55] also suggest a direct relationship between watershed imperviousness and stream health. The Schuler study found that stream health impacts tend to begin in watersheds with as little as 10 to 20 percent imperviousness. This study demonstrated that sensitive streams can exist relatively unaffected by urban stormwater with good levels of stream quality where impervious cover is less than 10 percent. Some sensitive streams have been observed to experience water quality impacts as low as 5 percent imperviousness.

Given that a number of the City's resources are classified as cold water fisheries, a few of the watersheds have impervious coverage that is creeping up to the 10% threshold and some of the resources are showing signs of being impacted (i.e. monitoring data shows exceedances for Provincial Water Quality Objectives), the City has evaluated the need to develop water quality targets. The water quality targets estimate the portion of the total pollutant load coming from the City so that the City can take the appropriate steps to reduce the load. Two types of water quality targets have been developed for the SMP:

1. targets to address the pollutant loads from new development or redevelopment activity taking place in the City and
2. targets to address existing pollutant loads from the watersheds.

The water quality targets are summarized in Table 64. The supporting documentation for the establishment of these targets can be found in Section 3.3 *Establishment of Water Quality Targets and Ranking.*

Table 64. Water Quality Targets

Source of Pollutant Loads	Applicable Watershed	Water Quality Target
Pollutant loads from new development and/or re-development	All	No net increase in pollutant loads from new development and redevelopment activity in the City.
Existing pollutant loads	Kaministiquia	50% reduction in phosphorous loads and corresponding 80% reduction in total suspended solids

4.2.1 Objectives – Physical Pollutants

Note: In the case of Physical Pollutants, monitoring data supports the development of objectives/ action items on a watershed basis. As a result, this section of the Goals and Objectives are categorized by watershed.

Current River Watershed

- Maintain or improve the existing quality of the Current River by enforcing stormwater management standards for new development and re-development activity in the watershed
- Implement the BMP opportunities/retrofits identified in the Implementation Plan to address existing loads to the Current River
- Evaluate water quality reductions associated with other best management practices and pollutant load reduction plans, such as improved street sweeping practices, the installation of Goss Traps in catchbasins, and more frequent catch basin cleaning by conducting street sweeping optimization

Kaministiquia River Watershed

- Maintain or improve the existing quality of the Kaministiquia River by enforcing stormwater management standards for new development and re-development in the watershed
- Implement the BMP opportunities/retrofits identified in the Implementation Plan to address the water quality target established for the Kaministiquia River Watershed (Table 64)
- Evaluate water quality reductions associated with other best management practices such as improved street sweeping practices, the installation of Goss Traps in catchbasins and more frequent catch basin cleaning
- Eliminate the remaining Combined Sewer Overflows in the watershed

McIntyre River Watershed

- Maintain or improve the existing quality of the McIntyre River by enforcing stormwater management standards for new development and re-development activity in the watershed
- Implement the BMP opportunities/retrofits identified in the Implementation Plan to address existing loads to the McIntyre River
- Evaluate water quality reductions associated with other best management practices such as improved street sweeping practices, the installation of Goss Traps in catchbasins and more frequent catch basin cleaning

McVicar Creek Watershed

- Maintain or improve the existing quality of McVicar Creek by enforcing stormwater management standards for new development and re-development activity in the watershed
- Implement the BMP opportunities/retrofits identified in the Implementation Plan to address existing loads to McVicar Creek
- Evaluate water quality reductions associated with other best management practices such as improved street sweeping practices, the installation of Goss Traps in catchbasins and more frequent catch basin cleaning
- Identify sources for siltation in stream bed and assess the need for remedial activity by conducting a visual survey in the contributing drainage area

Neebing River Watershed

- Maintain or improve the existing quality of the Neebing River by enforcing stormwater management standards for new development and re-development activity in the watershed
- Implement the BMP opportunities/retrofits identified in the Implementation Plan to address existing loads to the Neebing River
- Evaluate water quality reductions associated with other best management practices such as improved street sweeping practices, the installation of Goss Traps in catchbasins and more frequent catch basin cleaning
- Eliminate the remaining Combined Sewer Overflows in the watershed
- Assess Thermal Property Classification of the Neebing River

Pennock Creek Watershed

- Maintain or improve the existing quality of Pennock Creek by enforcing stormwater management standards for new development and re-development activity in the watershed
- Implement the BMP opportunities/retrofits identified in the Implementation Plan to address existing loads to Pennock Creek
- Evaluate water quality reductions associated with other best management practices such as improved street sweeping practices, the installation of Goss Traps in catchbasins and more frequent catch basin cleaning
- Evaluate sources of high suspended sediment visible at 25th Side Road crossing by conducting a visual survey in the contributing drainage area
- Assess Thermal Property Classification of Pennock Creek

Waterfront Watershed

- Evaluate options for addressing existing pollutant loads to Whiskey Jack Creek

4.2.2 Objectives – Bacterial Pollutants

- Develop a reduction plan for the likely sources of E. coli including waterfowl and pet waste entering the City's streams, rivers, lakes, wetlands and Lake Superior focusing on education and outreach

4.2.3 Objectives – Chemical Pollutants

- Determine background levels of pollutants (i.e. Fe, Cd, Cu, Hg) at the City boundary to better define sources of exceedances for metal concentrations by collecting data at the municipal boundary (refer to Monitoring and Data Assessment objectives)
- Evaluate the need to develop a water quality target for resources that don't have monitoring data (i.e. Mosquito Creek and Pennock Creek) or for parameters that don't have standards
- Develop an illicit discharge inspection program to identify non-surface water connections to the storm sewer system
- Continue to implement pollution prevention programs (i.e. street sweeping, construction erosion control, emergency spill response procedures, and catchbasin cleaning)
- Evaluate ecological impacts of chemicals of emerging concern (e.g. pharmaceuticals, personal care products and flame retardants) generated from stormwater runoff, such as agricultural runoff, landfill leachate, etc., as these pollutants are being detected in Lake Superior

4.3 Water Quantity

Goal The City's stormwater system effectively manages the quantity and delivery of runoff in a manner that protects the environment, infrastructure, and the health and safety of the residents of Thunder Bay

The field of stormwater management, and how best to control the impacts of human activities on the landscape, has been changing. The focus has changed from the evaluation and management of the rate of runoff coming off the landscape under post-development conditions to the volume of runoff coming off the landscape.

The additional volume generated when land uses are converted, whether it be from forest to agriculture or agriculture to residential development, is significant. The increase in stormwater runoff carries increased loads of pollutants (i.e. nutrients, sediment and other pollutants). The pollutants either originate from the transition in land use (i.e. new impervious surfaces) or they result from the power (energy) the increase in runoff has which makes it more efficient at washing pollutants, otherwise trapped in the natural vegetation and porous soils, off the landscape. Many studies have documented the significant impacts increased runoff has on the stability of streams and rivers. Bank erosion impacts streams by adding more pollutants to the water (i.e. sediment and nutrients) and it makes the stream configuration less natural which results in loss of habitat. In addition, in-stream erosion can damage stream banks and nearby lands which can be an issue for structures located near the resource.

The increased volume of runoff also increases the likelihood of flooding, which threatens public safety and increases the potential for infrastructure damage. Both historic and current development practices have contributed to compacted soils, the placement of fill material, the underground disposal of waste materials, and the presence of contamination. These factors and others make Best Management Practices (BMPs) and other green infrastructure techniques more challenging to implement in the City.

4.3.1 Objectives – Stormwater Infrastructure

- Utilize structural and non-structural Best Management Practices (i.e. Green Infrastructure and Low Impact Development) to improve infrastructure capacity by retrofitting existing practices or implementing projects on public lands
- Continue to implement removal of Combined Sewer Overflows (CSO)
- Continue to implement the Residential Drainage Assistance Program to promote the installation of sump pumps, weeping tile and backflow preventers
- Develop a public cost share program (or expand the Residential Drainage Assistance Program) to assist landowners with the implementation of stormwater management practices on private residential properties.
- Address the stormwater system capacity issues identified in the Neighbourhood Master Stormwater Drainage Study (2014)(56)
- Develop a protocol for addressing localized flooding issues through the following sequence: identify existing constraints in the system by evaluating design events up to the 100-year event for the major and minor system, implement lot level control, regional stormwater management and relief sewer systems

4.3.2 Objectives – Floodplain Management

- Work with LRCA to maintain natural storage capacity (floodplain and wetlands) and in developing City policies to protect wetlands in the Lakehead Watershed
- Identify opportunities to re-establish lost floodplain areas

4.3.3 Objectives – Modeling

- Utilize the Comprehensive Watershed Management Models to identify existing and potential infrastructure capacity issues in partnership with LRCA modeling efforts
- Utilize the Comprehensive Watershed Management Models to evaluate the impact of climate change on infrastructure capacity in the future and identify potential flooding issues
- Assess cumulative impacts of future development expansion through Feasibility Level Models

4.3.4 Objectives – Stormwater Regulations

- Update City Site Plan Control By-Law, Zoning By-Law, Site Alteration By-Law, and Engineering and Development Standards with the latest planning, engineering, construction, and operation practices for sustainable stormwater management.
- Consider the development of regulations limiting construction of new buildings in hydric soils (i.e. wetlands, muskeg, marsh lands)
- Follow and build on the guidelines of the local roads and green streets performance standards in “City of Thunder Bay - Urban Design and Landscape Guidelines” (CTB-UDLG) including aspects such as:
  - *Consolidating and sharing driveways where possible to reduce impervious surfaces, maximize on-street parking, and promote street tree planting*
  - *Plant street trees in the boulevards on both sides of the road wherever possible recognizing that mature trees provide significant stormwater benefits*
  - *Provide barrier curbs to prevent parking on vegetated shoulders where appropriate*
  - *Define driveways with curb cuts for parking to address erosion associated with parking on vegetated surfaces*
  - *Encourage a reduction in residential driveway widths*
  - *Encourage the use of permeable surfaces for driveways*
- Integrate the following types of BMPs into the streetscape by developing standard road cross sections for new development and/or road redevelopment projects:
  - *Rain gardens*
  - *Tree trenches*
  - *Sediment capture devices – sumped manholes, grit chambers, etc.*
  - *Vegetated swales or other filtration facilities*

4.4 Operations and Maintenance

Goal The City's stormwater systems are maintained, managed and operated sustainably

All stormwater management systems require proper design, construction and maintenance to perform successfully. Historically, stormwater management systems were designed to transport stormwater runoff safely and efficiently from one location to another. Given that these systems were designed to transport or impound runoff from a relatively rare storm event (i.e. recurrence interval of 10, 25 to 100-years) they may experience maximum design conditions a few times in their lifetime. This resulted in lower maintenance requirements over the lifetime of the infrastructure.

However, in response to growing concerns over nonpoint source pollution, flooding and erosion, a new type of stormwater management system has evolved. Modern stormwater management system designs not only convey runoff but also manage runoff by deliberately modifying its flow rate, volume and/or water quality. Modern stormwater management systems thus address a wider range of concerns by utilizing a variety of techniques such as infiltration, extended dry or wet detention, sand filters, vegetated swales, and Green Infrastructure. Given the complexity of the issues stormwater systems are being designed to address, they have become more complex in nature. Not only are the number of tools in the toolbox expanding but the frequency with which they experience design conditions has increased as they are typically designed to capture smaller, more frequent rainfall events.

As stormwater management becomes an increasingly important part of the City's efforts to achieve clean water and a safe environment, so too does regular inspection and thorough stormwater system maintenance. Maintenance and its attendant costs will become an increasingly important feature of the designed infrastructure. While much of the inspection and maintenance roles and responsibilities for private development projects are addressed by the City's By-Laws there are operation and maintenance responsibilities for municipal infrastructure that the City is responsible for performing. The following objectives and implementation activities for these responsibilities are articulated below.

4.4.1 Objectives – Inspections

- Enhance inspection and maintenance procedures and schedules for City-owned stormwater BMPs

4.4.2 Objectives – Stormwater System Operation/Maintenance

- Review existing programs and identify where additional resources for inspection and maintenance of the storm sewer system are required (including urban runoff management practices), ditches, culverts, pumping stations and other facilities (BMPs) that takes the following into consideration:
  - *Scheduled inspections*
  - *Scheduled maintenance activities*
  - *Scheduled evaluations of operation and maintenance practices*
  - *Service needs to minimize life-cycle costs*
  - *Flow monitoring and CCTV inspection programs (in high risk areas)*

  - *Routine maintenance activities to restore facilities to design capacity while taking existing water quality treatment features of the facilities into consideration*
- Develop a maintenance program that minimizes impacts to stormwater BMPs and downstream resources and addresses capacity issues related to freezing temperatures
- Evaluate opportunities to modify existing ditches to provide stormwater treatment in addition to conveyance (i.e. filtration, retention and infiltration, settling)
- Continue to implement natural obstruction management programs (e.g. Beaver Management) while balancing environmental stewardship with protection of public health and property

4.4.3 Objectives – Storm Sewer and Culvert Replacement

- Assess and replace culverts via normal road upgrading program where necessary
- Replace wood stave pipes during road reconstruction projects or by in situ restoration methods
- Evaluate existing overland flow routes and determine if storm sewer systems need to be upgraded if an improper overland flow route exists

4.4.4 Objectives – Administration, Staffing

- Define maintenance responsibilities and accurately match staffing levels, expertise and equipment/materials availability with work requirements

4.4.5 Objectives – Program Evaluation

- Define acceptable levels of risk tolerance and levels of service for City and community (i.e. quality thresholds at which stormwater services should be provided to the community)
- Base/quantify level of service on the following factors (see Section 6.3.2.8):
  - *Strategic City goals*
  - *Legislative requirements and regulations*
  - *Expected asset performance*
  - *Community expectations (e.g. minimum response time to Operation and Maintenance emergencies)*
  - *Availability of finances*
- Use Table 89and Table 90 in Section 6 Framework for a Stormwater Asset Management Plan to evaluate Operation and Maintenance targets

4.4.6 Objectives – Compliance/Enforcement

- Develop assumptions protocol to make sure BMPs installed and performing per design prior to transfer of ownership to the City
- Obtain formal access to all stormwater management structures/facilities for inspection and maintenance purposes on public and private lands
- Define departmental roles and responsibilities as applied to development of Operation and Maintenance standards and enforcement

4.4.7 Objectives – Stormwater Asset Management Plan

- Conduct new inventories of all City-owned BMPs (including catchbasins with restrictors), the storm sewer system outfalls, culverts under 3 metres, ditch system, Oil Grit Separator and skimming devices to create the basis of a Stormwater Asset Management Plan
- Increase annual capital funding to meet the estimated costs noted in the Implementation Plan based on values presented in the AMP (2014) to make sure of the timely replacement of underground linear assets and the potential future replacement of facility infrastructure
- Develop more comprehensive rating systems, including a CCTV program for storm infrastructure, and physical inspections of pump house infrastructure, to better understand the condition of the existing infrastructure and better allocate future spending requirements
- Develop a financing strategy to fund the full cost of operating and maintaining the storm sewer system sustainably including:
  - *Maintenance and rehabilitation activities which extend the useful life of storm sewer assets (including Green Infrastructure)*
  - *Transfer of annual surpluses to reserves for future rehabilitation and replacement*
  - *Cost future planned network improvements, particularly those tied to the SMP recommendations, in the funding requirements/budgets*
- Update the replacement requirements for stormwater assets as infrastructure inventories and condition assessments are completed

4.5 Monitoring and Data Assessment

Goal Support a healthy watershed through effective monitoring and data management

Monitoring data is used to assess the existing quality of surface water resources which facilitates the development of stormwater management goals needed to either restore a resource which is already degraded or to protect a resource which has the potential to become degraded. This data is particularly important to the resources of the City where activity in the upper portions of the basin (i.e. timber harvesting, mining, hydropower development) have the potential to significantly impact the quality of the resources traveling through the City to Lake Superior. The stormwater management goals include: establishing pollutant load reductions, regulating development activity in the watershed and protecting critical groundwater recharge areas.

Collection of baseline monitoring data becomes a report card for the City. As Best Management Practices (BMPs) are implemented, it is important to collect data and monitor the effectiveness of BMPs in retaining and treating stormwater. The monitoring data will be used to guide future design and management decisions. It also can be utilized for hydrologic/hydraulic and water quality modeling to predict the system's performance. In addition, data collection and information management systems are necessary for the City to assess vulnerability to climate change and aid adaptive decision-making for infrastructure renewal.

While monitoring and data collection is primarily conducted by Environment Canada, Lakehead Region Conservation Authority and Water Survey Canada, the City should take a more active role in this activity.

4.5.1 Objectives – Multi-Jurisdictional Monitoring Activities

- Support the efforts of Environment Canada, Lakehead Region Conservation Authority and Water Survey Canada in the collection and evaluation of monitoring data by articulating the City's monitoring and data collection needs and exploring options to expand the existing monitoring network (to accomplish the goals and objectives of the SMP)
- Support the efforts of the North Shore Steelhead Association, the Ministry of Environment and Climate Change and others in the identification and monitoring of spawning habitat, assessment of stocking programs and monitoring of fish movement in the City's streams, rivers and lakes
- Coordinate monitoring and data collection efforts with the communities and Townships in the Lakehead Watershed

4.5.2 Objectives – Data Collection

- GIS Management:
  - *Obtain updated GIS layers listed in Table 65 to facilitate responses to concerns, model development and/or upgrades to existing models, development of feasibility studies, etc.*

Table 65. GIS Management

Monitoring Activity
Obtain updated aerial imagery every 5 years
Maintain the existing impervious surface dataset to remain relevant and useful for modeling and stormwater practice evaluation
Improve the current land use dataset in the draft Official Plan to identify more detailed land uses, including the following: - *in rural areas, identify the different types of crops and rural residential land uses that are currently identified in the rural land use category* - *in rural areas, identify the land cover present in areas zoned as industrial* - *in urban areas, separately identify the small commercial, park, and institutional areas that are currently included in the urban residential land use category* - *in urban areas, identify the different densities of urban residential developments (i.e. high, medium, and low)* - *create two separate land use datasets to represent existing and future conditions*
Maintain an up-to-date Geographic Information System (GIS) which accurately and comprehensively reflects the existing public stormwater management system, including storm sewers, culverts, bridges, ditches, other hydraulic control structures, and other stormwater management facilities. GIS as-built information should be provided by the developer for to include new private developments in the GIS system.
Create a higher resolution DEM (3D representation of a terrain's surface) as follows to provide the necessary details required to capture representative cross sections of watercourses and ditches and confirm drainage patterns in particularly flat areas of the City: - *Recommended horizontal resolution (i.e. grid spacing) ≤ 0.5 m* - *Recommended vertical resolution ≤ 0.25 m*

- Climatological Data:
  - *Make sure that existing climatological data is available in a compatible format for hydrologic & hydraulic modeling purposes*
  - *Collect local climatological data as shown in Table 66*

Table 66. Climatology Monitoring Plan

Monitoring Activity
Convert hourly dew point, humidity, and wind speed into daily averages from Environment Canada Station 6048262
Upgrade existing rain gauges to weather stations to collect additional climate parameters (i.e. relative humidity, air temp, precipitation, soil temperature, wind speed) for use in local modeling (H/H model and climate change assessment) efforts
Format regional precipitation records for comparison with other collected monitoring data and for use in future hydrologic/hydraulic and water quality models of the system
Install heated and wind-shielded tipping bucket precipitation gauges at the following locations to improve spatial resolution of precipitation monitoring: - *1 station in the McIntyre River Watershed (shown in Map 57)* - *1 station in upper McVicar Creek Watershed (shown in Map 58)* - *1 station in the Mosquito Creek Watershed (shown in Map 59)* - *1 station in the Neebing River Watershed (shown in Map 60)* - *1 station in the Pennock Creek Watershed (shown in Map 61)*
Snowpack depth and water equivalent should be monitored at multiple locations in each watershed (19 locations in total) in addition to the three locations monitored by the LRCA, as follows: - *4 locations in the Current River Watershed* - *4 locations in the McIntyre River Watershed* - *1 locations in the McVicar Creek Watershed* - *2 locations in the Mosquito Creek Watershed* - *4 locations in the Neebing River Watershed* - *1 locations in the Pennock Creek Watershed* - *3 locations in the Waterfront Watershed*

- Flow Monitoring:
  - *Expand flow monitoring activities as outlined in Table 67 to support future watershed modeling efforts and analysis of water quality data. To support water quality analysis, flow and water quality must be monitored at the same locations.*
  - *Establish flow and water quality monitoring stations at the upstream boundary of the City to characterize the water quality conditions at this point in the stream.*
  - *Compare water quality information at City limit with conditions at downstream monitoring stations to determine impact of the residents, industry, and land users in the City on stream water quality (flow gauges are already located at the city limits in the Kaministiquia River watershed (Station 02AB025) and the Current River Watershed (Station 02AB021) and so new water quality monitoring stations should be at the same locations).*

Table 67. Stream Flow Monitoring Plan

Monitoring Activity
Continue baseline monitoring activity
Develop a discharge rating curve for each flow monitoring location (listed below).
Install a monitoring station on Current River at Cumberland Street
Install 3 monitoring stations on McVicar Creek: - *City limits near Gorevale Road crossing* - *Wardrope Avenue (at development limit)* - *Onion Lake Road*
Install 3 monitoring stations on the McIntyre River: - *Upstream of confluence with Neebing-McIntyre Floodway* - *Island Drive* - *City limit near Dog Lake Road/ Highway 589 crossing 700 m northwest of Gorevale Road*
Install 4 monitoring stations on the Neebing River: - *Additional monitoring at existing John Street location (upstream of John Street Landfill site)* - *South of Kline Road/North of Hwy. 11 (downstream of John Street Landfill site)* - *Confluence with the Neebing-McIntyre Floodway* - *Tributary at the City limits*
Install 3 monitoring stations on Pennock Creek: - *Confluence with Neebing River* - *City limits near 25th Side Road crossing* - *Upper watershed*
Install a new flow monitoring station on the Kaministiquia River near the existing water quality monitoring site near McKellar Island
Install 2 monitoring stations on Mosquito Creek: - *Confluence with the Kaministiquia River* - *Loch Lomond Road crossing*
Obtain 3 additional flow gauges to collect data for future modeling efforts, such as the Waterfront Watershed and feasibility-level models (locations to be determined during model development)

Note: Assumes installation of Solinst Levelogger Edge + material cost to construct simple PVC security housing for logger. Conduct a minimum of 10 staff/discharge measurements per at each level logger location to develop a rating curve.

- <u>Water Quality Monitoring</u>:

Table 68. Water Quality Monitoring Plan

Monitoring Activity
Continue baseline monitoring activity (PWQMN – 1 sample/month Apr-Nov)
Make following changes to existing monitoring protocol: - *Collect at least 16 water quality samples, with at least 2 samples/month and most samples collected during peak flow events (snowmelt and rainfall events) which contribute the majority of pollutant loads to surface waters* - *Composite water quality samples during entire storm events* - *Include a minimum of two wet-weather sampling periods as well as two dry-weather sampling periods*
The following water quality indicators should be determined from samples collected using automated samplers or, if funding is not available, grab samples at the same locations as the flow monitoring stations: - *Suspended sediment concentration (SSC), rather than total suspended solids (TSS)* - *Total nitrogen (TN), using the total nitrogen method rather than the Kjeldahl method* - *TP, including particulate and soluble phosphorus* If automated samplers cannot be used, grab sample results can be processed with the flow data to create and estimated time series of pollutant loading.
Include E. coli bacteria as a PWQMN parameter
Add a water quality sampling site on the Current River at existing flow gauge 02AB021
Add 2 sampling sites on McVicar Creek: 1 at new flow gauge near Gorevale Road crossing, 1 at existing flow gauge 02AB019
Add a sampling site on McIntyre River at City limits near the Dog Lake Road/Highway 589 crossing 700 m northwest of Gorevale Road
Add 4 sampling sites on Neebing River: 1 near confluence with Neebing-McIntyre Floodway, 1 on a tributary near City Limits, 1 by john Street Road, and 1 at site south of Kline Road.
Add 2 sampling sites on Pennock Creek: 1 near confluence with Neebing River and 1 at City limits near 25th Side Road crossing
Add a sampling site on the Kaministiquia River at existing flow gauge 02AB025
Add 2 sampling sites on Mosquito Creek: 1 near the confluence with the Kaministiquia River and 1 near Lock Lomond Road crossing
Investigate ammonia levels being discharged from Castlegreen outfall.
Conduct water quality sampling on the Current River to identify the source of the oily sheen which has been observed on occasion
Conduct water quality sampling downstream of outfalls on the Kaministiquia to identify source(s) for foul odour and visible pollutants - *Establish continuous dissolved oxygen monitoring sites along the Kaministiquia River, including at the City boundary, and upstream and downstream of known industrial BOD sources* - *Conduct water quality sampling on the Neebing River to identify source of blue sheen/film which has been observed on occasion*

- <u>Groundwater</u>
  - *Evaluate the need to develop a groundwater monitoring network to collect groundwater level measurements for evaluation of trends, baseflow contributions, etc.*

- <u>Utilities (stormwater):</u>
  - *Update bridge and culvert inventory including:*
    - *Inventory of culverts and bridges along the main watercourses within the City's municipal boundaries and at other locations experiencing drainage issues (includes assessment of fish passage/barriers)*
    - *Upstream and downstream inverts, top of road elevation, span, rise, material, skew angle, shape of culvert, condition, catchbasin locations and grate types, manhole and junction locations and surveyed cross section of bridge openings*
    - *Submittal of information requests to the agencies with crossings on their property, including CN, CP, and the MTO*
  - *Survey critical ditch cross sections and develop profiles (note: if high resolution LiDAR data becomes available that measures ground elevation below water surfaces, the survey of critical ditch cross sections and profiles may not be needed)*
  - *Inventory and map trunk storm sewers (> 600 mm) including information available in as-built drawings, survey work to fill in missing information and information collected by consultants or on site investigations*
  - *Survey other hydraulic structures such as weirs on McVicar Creek and the Neebing River*
  - *Collect drainage system information from adjacent municipalities, townships, and Fort William First Nation (FWFN) to improve representation where watersheds also cross through Fort William First Nation, Municipality of Shuniah, Municipality of Oliver Paipoonge, Municipality of Neebing, Township of Conmee, Township of O'Connor, and Township of Gillies*

4.5.3 Objectives – Resource Assessments

- Coordinate with the LRCA to conduct annual inspections of watercourses to evaluate stream bank stability focusing primarily on existing problems and areas where meandering channels or erodible soils may present a problem

4.5.4 Objectives – Modeling Activities

- Develop a detailed Hydrologic/Hydraulic model of the entire drainage system to inform future stormwater and natural resource management decisions
- Develop Comprehensive Watershed Management Models for each of the watershed systems in Thunder Bay to facilitate:
  - *Assessment of existing conditions in the watersheds to better investigate causes of existing drainage issues at a higher resolution than the Base Models*
    - *Evaluate capacity of regional and local existing stormwater infrastructure, including trunk storm sewers and ditches*
    - *Evaluate functionality of both major and minor watercourse crossings*
    - *Resource evaluation at higher resolution than the Base Models*
  - *Assessment of existing conditions and the potential hydrological and hydraulic impacts associated with future development*
  - *Assessment of potential impacts of climate change*
  - *Scenario planning to improve stormwater quality at a more local scale*
  - *Assessment of standards*
- Incorporate downscaled climate change model projections as they become available

4.5.5 Objectives – Evaluation Activities

- Measure progress towards meeting goals by conducting annual evaluations of the monitoring data
- Establish partnerships to improve the City's ability to increase access and understanding of monitoring and research data
- Establish Quality Assurance/Quality Control procedures for the City's monitoring program to identify and fix anomalies and to process the data into a usable format for modeling purposes

4.6 Regulations and Enforcement

Goal Engineering Design Standards and By-Laws are in place and enforced to effectively manage the impact of new development and redevelopment activities in the City

The City has adopted Engineering and Development Standards (2015) which "outlines the requirements for the processing of applications for the development of land and especially the Engineering Division requirements for the Design, Construction and Acceptance into the City System for Roads and Services which are part of the Development".

While Engineering and Development Standards exist, a number of issues related to the need for improved compliance and inspections were identified during the public engagement process. In addition, there is the sense that current provincial and municipal regulations fall short of protecting the City's resources.

Under the existing Site Plan Control process the only types of development activity that are required to meet the Engineering and Development Standards are development sites that have been designated as an area of Site Plan Control based on a previous subject to a Planning Act approval, such as rezoning, severances, and variances. This has resulted in a minority of the total overall new developments being subject to site plan control, which resulted in very few of the developments meeting Engineering and Development Standards with respect to stormwater management; otherwise the remaining development proposals were processed through a building permit, which does not require an equivalent level of stormwater management to be met.

4.6.1 Objectives – Regulatory Language

- Establish a Site Plan Control By-Law that encompasses the entire City such that all development activity is subject to the City's Engineering and Development Standards.
- Evaluate the need to modify the Zoning By-Law to lessen potential barriers to implementation of Low Impact Development and to encourage and incentivize green infrastructure.
- Evaluate the need to modify other By-Laws (i.e. Site Alteration By-Law, Sewer Use By-Law) to improve protections for environmentally sensitive areas during interim conditions.
- Evaluate existing Engineering and Development Standards to:
  - *Provide clarity with respect to requirements for linear projects (i.e. street construction, rehabilitation and new road projects) and set a new standard for LID integration as part of road construction.*
  - *Incorporate recommendations made in the SMP (including recommendations for volume control).*
- Develop LID Design Guidelines
- Develop erosion and sediment control standards

- Develop standards to establish stream buffers and regulate stream bank alterations in coordination with LRCA
- Coordinate the development of wetland function and value management and wetland mitigation requirements with the appropriate provincial and federal government units
- Consider development charges under the Development Charges Act, to make sure that new development pays for itself, as dictated by the OP 22.19.
- Examine policies and regulations (i.e. Site Alteration By-Law, private tree planting program, etc.) that can aid in enhancing the natural environment and community greening beyond current policies, including policies that support:
  - *Enhanced forested areas, particularly types of forests that are at risk of being lost by inventorying the amount of forested cover and reviewing the establishment of a specified forest cover target*
  - *Establishment of community greening projects*

4.6.2 Objectives – Development Planning

- Require that stormwater and drainage assessments, including incorporation of LID approach, be incorporated and discussed from the beginning of the development planning to create more cost effective and environmentally sound developments

4.6.3 Objectives – Incentive Program

- Implement incentives to further promote the use of Low Impact Development and Green Infrastructure techniques in the City including:
  - *Reduce or waive the permit fees for green projects*
  - *Advertising or recognition for developers who use green/energy efficient design*
  - *Rebates and installation financing provides funding, tax credits or reimbursements to property owners who install specific practices*
  - *Consider tiered utility rates and smart meters to promote stormwater reuse (devices that have the ability to identify water use in near real-time)*

4.6.4 Objectives – Permitting Process

- Establish the a wider application of Site Plan Control – City wide
- Require that all new development and re-development activity not covered under SPC meet a minimum stormwater management standard (i.e. parking lot construction or expansions)
- Coordinate with the LRCA on floodplain regulations and enforcement
- Define enforcement responsibilities and accurately match staffing levels and funding sources

4.6.5 Objectives – Guidance Materials

- Recognizing the physical challenges to implementing innovative stormwater management techniques in Thunder Bay (i.e. shallow depth to bedrock and the groundwater table, historic land use practices, etc.), develop guidance materials to facilitate compliance with By-Laws and Engineering and Development Standards
- Map the most suitable areas (i.e. areas with permeable soils and adequate depth to bedrock and the water table) on both public and private lands for the application of alternative/innovative stormwater management techniques and consider how the City can promote the application of Green Infrastructure and/or LID in these areas
- Promote the use of Green Infrastructure on Brownfield sites by providing guidance on site characterization and design considerations (i.e. USEPA Implementing Stormwater Infiltration Practices at Vacant Parcels and Brownfield Sites)
- Develop and adopt stream crossing guidance to protect the City's stream systems, which are under development pressure, and to mitigate the impacts of existing crossing problems
- Adopt updated rainfall distributions to be used in stormwater calculations submitted to demonstrate compliance with Engineering and Development Standards

4.6.6 Objectives – Program Evaluation

- Enhance periodic assessment of Engineering and Development Standards to make sure that the current industry standard practices are being required by the City
- Enhance and review procedures for site inspections and enforcement of By-Laws

4.7 Education and Outreach

Goal The City's residents, businesses and institutions have a good understanding of stormwater management and are committed stewards of the Lakehead Watershed's resources

Although nonpoint source pollution has become more of a prominent issue in the last several years, the general public needs more information about the role of stormwater runoff in water pollution. Of the 85 surveys completed in November 2014, one-third (32%) of participants said they feel as though water quality is getting worse and about half (52%) think the primary sources of pollution are from city streets. Because water quality is a function of how people go about their everyday activities, educating the general public about how to modify those activities is an important goal for improving water quality.

Creating an informed community and empowering citizens to be stewards of the land and water resources where they live is the goal of watershed education. Individuals within the community can make a significant difference in protecting our water resources. The development of an effective education program will enhance public participation in stormwater management activities and increase public knowledge relative to water.

4.7.1 Objectives – Target Audience: Elected Official, City Staff

- Increase awareness about the role marshes and wetlands play in the hydrologic cycle, the functions and values they provide to watershed health and how they can be used to sustainably provide stormwater management by publishing articles in Corporate media and eNews, presenting at Division Meetings, and developing materials to educate the development and design community
- Continue to play a leadership role in setting up examples and pilot/demonstration projects by advertising the Low Impact Development/Green Infrastructure initiatives undertaken by the City
- Provide internal training by hosting semi-annual workshops on the following topics:
  - *Sources of stormwater contamination and ways to minimize the water quality impact of municipal activities, such as park and open space maintenance, fleet and building maintenance, construction and land disturbances, and storm drainage maintenance*
  - *Pollution prevention/good housekeeping measures*
  - *Spill Response and Prevention*
  - *Operation and Maintenance of structural Best Management Practices (BMPs)*
  - *Recognizing, tracking and reporting illicit discharges*
- Provide training and educational opportunities for management practice operators (i.e. contractors used to conduct inspections and maintenance)
- Provide continuing education credits for designers who attend city education functions

4.7.2 Objectives – Target Audience: Homeowners, Business Owners, Developers

- Educate the public about the SMP and the roles the City plays in stormwater management, Illicit Discharge Detection and Elimination and drainage issues by the development of public awareness programs that can be communicated via media outlets (i.e. TV, radio, newspaper and social media)
- Conduct workshops on stormwater management practices, such rain gardens fed by redirected downspouts, and engage public participation through cost-sharing and citizen science programs
- Provide reliable, community-oriented information regarding local watersheds and challenges to watershed protection on the City's web-site
- Increase public awareness of the Current River Greenway and its importance since the majority of the Core Greenway is privately owned by publishing articles in MyTBay
- Take measures to reduce water consumption and encourage water conservation by publishing articles in MyTBay
- Provide on-going training on Low Impact Development (LID) for the Thunder Bay community of designers, contractors, and related agency staff including cost-benefit information to the development community and provide continuing education credits
- Training in construction/post-construction runoff control measures and stormwater management for construction site operators and people who operate and maintain facilities and provide continuing education credits

4.7.3 Objectives – Coordination of Multi-Jurisdictional Efforts

- Create opportunities for sharing local knowledge and experience between designers, builders, and cultural groups through partnerships
- Actively seek partnerships with private developers and other levels of government to create a sustainable neighbourhood model in the City as a prototype for future development
- Develop a small scale homeowner education campaign in partnership with the EcoSuperior to educate residents on stormwater impacts in their community
- Work with EarthCare Community Partners, Aboriginal communities, cultural groups and the City to develop a strategy to protect, restore, and celebrate our rivers
- Collaborate with formal education systems in the delivery of programs, presentations, implementation of services and development of locally-based curricula

4.7.4 Objectives – Program Evaluation

- Measure the change in knowledge and behaviour as a result of the education and outreach efforts

4.8 Funding and Organization

Goal The City of Thunder Bay has the resources and capacity needed to adequately implement an effective Integrated Stormwater Management Program

Municipal stormwater management has evolved over time: from urban flood control, to water and resource management, to an environmental protection and regulatory function. This evolution has changed how stormwater management systems are planned, designed, constructed, operated and financed. What used to be a basic capital construction and maintenance program has shifted to an integrated water resource management program which has created overlapping roles and responsibilities within the various Divisions. Currently, there is no one single Division fully responsible for stormwater management within the City.

The City is sensitive to the economic status of its residents and is mindful of the importance of maintaining public support for expenditures on stormwater management and water quality improvement.

The City seeks to create funding partnerships with upstream and adjacent communities, Federal and Provincial Agencies, the Lakehead Conservation Authority, and other entities that have common goals and responsibilities for stormwater management and natural resource protection. These partnerships will be more cost effective than separate efforts and provide the additional benefit of creating ownership of resource protection programs by a broader constituent base.

4.8.1 Objectives – Administration

- Establish a single area responsible for stormwater management within the City that is responsible for stormwater management and coordinates stormwater-related efforts of other Divisions
- Clearly define internal roles and responsibilities related to the planning, design, construction, operation and maintenance of stormwater management activities

4.8.2 Objectives – Staffing

- Provide for adequate staff with the right expertise to meet the goals and objectives of the SMP
- Prepare a staff training strategy that identifies key areas for skill development; training priorities; the most appropriate vehicles for training; and resource requirements

4.8.3 Objectives – Funds

- Identify funding strategies (i.e. stormwater utility) and supplemental funding sources
- Evaluate opportunities to reduce existing costs and improve implementation of current programs and projects
- Utilize long-term planning and pursue cost effective solutions when carrying out stormwater management and resource protection programs and projects

- Commit resources to an annual fund to support an ongoing program of neighbourhood and community park upgrades and improvements in response to identified stormwater needs through consultation with the community
- Continue to support LRCA programs.

4.8.4 Objectives – Coordination of Multi-Jurisdictional Efforts

- Coordinate the stormwater and water resources management efforts that the City and its partners are currently undertaking
- Identify opportunities to incorporate water resource management and climate adaptation into capital improvement projects and large scale redevelopment projects
- Partner with neighbouring municipalities to promote the incorporation of watershed management into their Official Plans

4.8.5 Objectives – Program Evaluation

- Evaluate the results and costs for programs and projects to demonstrate their effectiveness
- Consider initial and life-cycle costs associated with programs and projects, as well as co-benefits of implementing items identified in other Strategic Plans, when evaluating their effectiveness
- Update the SAMP annually

4.9 Climate Change

Goal The City of Thunder Bay has evaluated the potential impacts related to climate change, built resiliency into its stormwater management system and incorporated adaptation strategies that will translate into long-term cost savings to the City and its inhabitants

The goal of the City's Climate Adaptation Strategy is to build community resilience to reduce the risks inherent in climate change and to take advantage of opportunities associated with current and future impacts of climate change.

During the development of the Climate Adaptation Strategy, the City held a series of workshops with various City staff and EarthCare stakeholders where 14 issues were identified (see the *Climate Adaptation Workshop March 24 2014 Report*).[57] While the issues identified through the workshops are currently being systematically reviewed to assess the actual risk they pose to the City as part of the development of the City's Climate Adaptation Strategy through the ICLEI – *Local Governments for Sustainability* Building Adaptive and Resilient Communities Framework, many of them have been repeatedly identified by communities throughout the middle and upper parts of North America. To facilitate the City's response to these issues, many of them have been folded into other components of the SMP. For example, the increased use of Green Infrastructure to address issues related to water quality and flood protection can also serve to increase community resilience to emerging climate change impacts. Similarly, practices such as green roofs, urban forestry, and water conservation are familiar to local governments as strategies to enhance sustainability and quality of life but they are also increasingly being seen as best practices in climate adaptation. Highlighting the multi-functional or stacked functions that stormwater management solutions provide increases the chances that these relatively simple adaptation strategies will become mainstream within the City.

Specific climate change objectives are included in this section of the SMP's Goals and Objectives.

4.9.1 Objectives

- Consider climate change adaptation strategies on all stormwater management projects implemented by or on behalf of the City
- Implement approaches to incorporate climate change into local stormwater management planning and alternative stormwater management practices such as green infrastructure options, to adapt to changing future conditions

5 CORRECTIVE ACTIONS AND IMPLEMENTATION PLAN

The implementation activities identified in this Section of the Plan were taken from previously conducted planning and/or resource management documents or they are new activities developed as a result of a gap analysis conducted as part of the planning process.

5.1 Organizational Structure and Responsibilities

Implementation of the SMP will rely on the organizational structure in place with the City to carry-through on recommendations. The following sections describe the current structure in place and proposed changes to the responsibilities related to stormwater management.

5.1.1 Existing Organizational Structure and Responsibilities

Responsibilities of the City related to stormwater management are currently shared by several divisions. The Development & Emergency Services Department includes the Realty Services Division, the Planning Services Division and Licensing & Enforcement Division, which oversees land development, planning, and By-Law enforcement, while other divisions within Infrastructure and Operations Department (Engineering, Roads, Environment, and Parks) hold all other responsibilities. The responsibilities of each division in the current organizational structure are described in the following subsections. EarthCare reports to Infrastructure and Operations as well and is responsible for implementing the City's Climate Adaptation Plan and promoting sustainable practices with the Earth Care sustainable development plan.

The City also plays a role in the LRCA through its annual funding and participation on the external board, although this is a responsibility of City Councillors or another designated person. The City and the LRCA are also jointly involved in the on-going inspection and maintenance of the Neebing-McIntyre Floodway.

The following sub-sections describe the general responsibilities of each division related to stormwater management.

5.1.1.1 Engineering Division

- Implement capital improvement projects for road and stormwater systems.
- Rehabilitate existing infrastructure, such as the stormwater collection system, and other infrastructure assets.
- Implement development approvals for new and re-development projects requiring Planning Services Division approval or already designated as Site Plan Control.
- Review lot grading and drainage plans submitted as part of development applications.
- Educate developers and consultants of the new ways of SWM and how it may be more cost effective.
- Assist residents with drainage issues on public and private property by directing them to the appropriate division, or provide general guidance on measures that can help mitigate issues on private property.
- Update the Engineering and Development Standards as needed, such as the quantity and quality standards for stormwater management and lot-specific grading

requirements for new houses to minimize the potential for flooding issues on property.

- Implement Site Alteration By-Law.
- Design and construct new municipal LID / BMP demonstration facilities.
- Define asset management priorities based on camera inspection of storm sewers and physical annual inspections of other assets.
- Manage and update the City's asset management plan.

5.1.1.2 Roads Division

- Maintain ditches, such as removing ice in the spring and minor or major cleaning.
- Thaw frozen infrastructure in the spring.
- Repair damaged infrastructure after the spring snowmelt.
- Inspect and replace culverts less than 3 m in diameter.
- Mitigate or address flooding issues by removing beaver dams, patrolling during rain events and removing blockages (i.e. beaver dams, debris, and screens).
- Respond to property drainage issues and forward to Environment Division if it is more applicable to their responsibilities, which include underground storm sewer infrastructure.
- Maintain open ditch systems, allowing runoff from the roads to enter the stormwater collection system, including thawing of infrastructure as needed.
- Address erosion issues at bridges with recommendations and approval from the LRCA.
- Implement street sweeping program to remove sediment prior to entering the stormwater collection infrastructure.

5.1.1.3 Environment Division

- Operate, repair and maintain linear collection systems, including cleaning catchbasins and storm sewer connections.
- On stand-by to respond to after-hours emergency situations.
- Inspect, monitor and maintain combined sewer overflows.
- Maintain publicly owned oil-grit separators (OGSs) (ongoing).
- Educate owners of private OGS's on how to inspect, clean, and maintain OGS's. New OGS's in subdivisions are subject to an Environmental Compliance Approval (ECA) from the MOECC and are required to have logbooks, sampling programs, inspections, and monitoring programs.[(58)] There are approximately 60 OGSs in the City that are privately owned although the number continues to increase.
- Maintain the stormwater management wet pond in River Terrace.
- Operate and maintain the stormwater pumping stations.
- Respond to complaints from public about discharge to the storm sewer system.
- Implement public education and outreach programs, such as the drainage assistance program.
- Boulevard Lake Dam operations.

- Mitigate or address flooding issues by removing sediment accumulation in catchbasins.
- Enforcement and compliance with City By-Laws relating to stormwater, such as the Sewer Use By-Law.
- Inspect stormwater outfalls and implement stormwater monitoring and sampling program.

5.1.1.4 Parks Division

- Operate and maintain park land, including grass cutting and responding to flooding issues on park land and especially on boundaries with private property owners.
- Landscaping for City properties, including landscape design and tree planting.
- Assist in the design and maintenance of new LID demonstration facilities.
- Urban Forest management including replacement and tree pruning programs for boulevard trees.

5.1.1.5 Planning Services Division

- Implement and administer the Official Plan and Zoning By-Law, which contain policies and regulations related to stormwater management.
- Facilitates the development process in Thunder Bay by working with other divisions to review development applications.
- Oversees and implements the Site Plan Control process.
- Administers plan of subdivision and lot creation processes.

5.1.1.5.1 Licensing & Enforcement

The Licensing and Enforcement Division enforces the Property Standards and Yard Maintenance By-Laws.

5.1.1.5.2 Realty Services Division

The Realty Services Division manages City owned lands, oversees the process for the acquisition of lands and easements, and reviews and processes requests for dispositions of City Lands (i.e. when the City sells land).

5.1.1.6 Financial Services Division

- Coordination and preparation of comprehensive asset management plan including financial strategy.
- Coordination and preparation of the City's budget and long term financial plans.

5.1.2 Proposed Organizational Structure and Responsibilities

5.1.2.1 Evolution of a Single Area Responsible for Stormwater Management

Federal and Provincial regulations establish water quality standards for pollutants that impact the Beneficial Use of a particular resource. Meeting the water quality standards requires a combination of point source control and non-point source control. According to an inventory conducted by the United States Environmental Protection Agency (USEPA), half of the impaired waterways in the United States are affected by urban/suburban and construction sources of stormwater runoff. As municipalities have completed addressing the point sources of pollution (i.e. sewage and wastewater treatment plan discharges) and begin to tackle the non-point sources of pollution (i.e. nutrient application, animal waste, oil and grease from automobiles, sediment from construction activities) it becomes apparent that addressing all these issues within the existing organizational structure may be cumbersome and inefficient. Over time, many municipalities in Canada and the U.S. have created stand-alone Stormwater Divisions or Stormwater Sections whose primary role is to address the stormwater and urban runoff containing pollutants being conveyed through their stormwater conveyance systems. Creating a stand-alone Stormwater Division allows a municipality to more easily address the multi-faceted nature of stormwater management.

In most cases, the creation of a stormwater section or a single area responsible for stormwater management is a long-term process whereby multiple divisions/departments relinquish roles and responsibilities as the framework is established and the need to avoid duplication becomes apparent. It is recommended the City of Thunder Bay implement a Stormwater Section. This single area responsible for stormwater management would be staffed through reorganization and maximizing the use of current City employees. New personnel would be added only when workloads and/or needs for specific expertise require it. It is also very common to perform this transition by first designating a stormwater administrator that would serve as a liaison to the different Divisions/Departments on stormwater-related issues. As the City implements the SMP it will need to explore the most effective organizational structure for achieving the goals and objectives presented in the Plan. This section identifies the role a single area could take in stormwater management, the types of responsibilities and services offered by this single area, and a comparison of what various municipal stormwater departments in Ontario and Minnesota offer their citizens.

5.1.2.2 Typical Role of a Single Area Responsible for Stormwater Management

The role of a single area for stormwater management could include:

- Works to help protect lands and property from flooding
- Assists with emergency response through the Flood Warning System
- Develops master plans for drainage basins/watersheds within the City
- Works to protect and maintain the quality of streams, rivers and other vital water resources
- Responsible for drainage improvement projects that are designed and prioritized to provide cost-effective flood protection

5.1.2.3 Typical Responsibilities of a Single Area Responsible for Stormwater Management

The typical responsibilities of a single area for stormwater management could include:

Watershed Management

The City has eight watershed planning areas: Current River, Kaministiquia River, McIntyre Creek, McVicar Creek, Mosquito Creek, Neebing River, Pennock Creek, and the Waterfront. These watershed plans are used to identify potential improvement projects to alleviate current and anticipated flooding problems; identify water quality problems; and index significant natural areas, storage areas and wetlands. Watershed models are used to analyze possible alternatives.

- *Best Management Practices Development/Implementation – Design and construction of low impact development and capital improvement projects that will provide long-term benefits to the storm drain system and mitigate flooding*
- *Pilot SWM Projects*
- *Public Education*

Floodplain Management *(currently the responsibility of LRCA[3])*

- *Riverine Flooding Concerns*
- *Designated Wetland Management (PSW's)*

Water Quality

- *Water Quality Monitoring and Analysis*

Regulatory Services

Stormwater Division enforces the City's Stormwater By-Law and Engineering and Development Standards and is responsible for updates to these documents.

- *Stormwater Regulations and Enforcement*
- *Stormwater Engineering and Development Standards*

Inventory, Operations and Maintenance

The City is responsible for the operation and maintenance of its stormwater management facilities and Best Management Practices (BMPs).

- *Inventories and Source Identification*
- *Replacement/rehabilitation of stormwater infrastructure*
- *Stormwater Inspection and Maintenance Program*
- *Illicit Discharge Detection and Elimination*
- *Stormwater Customer Service Requests*
- *Employee Training*

Asset Management

- *Inventories and determines condition of stormwater infrastructure*
- *Identifies and prioritizes capital stormwater renewal and expansion projects.*

Emergency Response

The City already has a number of stormwater emergency response components in place. The main emergency responsibility of a municipal Stormwater Department is to respond to flooding situations or unusual water levels due to temporary blocking or clogging of outlets, overflows and other relief structures.

[3] The LRCA is responsible for floodplain management related to riverine flooding. Local drainage, groundwater and surficial flooding not related to a riverine system, are not components regulated under O. Reg. 180/06.

5.1.2.4 Typical Staff Requirements of a Single Area Responsible for Stormwater Management

Stormwater Management is comprised of staff with a diverse background in engineering, natural sciences and environmental planning. The following types of specialists are typically used to perform the usual services provided by a single division responsible for stormwater management:

- Division Head/Program Manager
- GIS and Mapping Technician
- Inspection Supervisor and Inspection Staff
- Engineering Technician (also potentially part of the inspection team)
- Project Engineer
- Operations and Maintenance Staff
- Modeling Technician
- Landscape Architect

As mentioned in Section 5.1.2.1, it may not be necessary to add new personnel for these positions since the expertise may already exist within different departments and it just would be a matter of reorganizing and/or redefining staff's responsibilities.

5.1.2.5 Comparison to Other Municipal Stormwater Departments

While the recommendation to the City is to establish a single area responsible for stormwater management in stages, this section of the Plan reflects what other communities in Ontario and Minnesota have developed to more effectively manage stormwater runoff. Table 69 through Table 71 have been provided to illustrate what other comparable communities are doing to manage stormwater runoff. Information compared in these tables was not available for several northern Ontario communities similar to Thunder Bay in size and location, however, some information is available on the budget and funding structure for these communities. In general the budgets are mixed and funded through multiple sources, some of which include Development Charges. North Bay has implemented Development Charges for urban detached, semi-detached, and other land uses. Greater Sudbury also has Development Charges applicable to Residential, Multi-residential, Commercial, Institutional and Industrial Developments. The City of Sault Ste. Marie is currently completing a study for Development Charges and Timmins did not have a Development Charge as of 2015.[59]

Table 69. Representative Community Size and Level of Development Activity

Community	Current Population	Development and Redevelopment Activity
Calgary, AB	1,215,000	New development and very active redevelopment
Mississauga, ON	758,000	Active redevelopment and new development
Hamilton, ON	505,000	Active redevelopment
St. Paul, MN	295,000	Active redevelopment
Kitchener, ON	220,000	Active redevelopment and development
Richmond Hill, ON	186,000	New development and redevelopment
Sudbury, ON	161,000	New development and redevelopment
Waterloo, ON	99,000	New development and redevelopment
Sault Ste. Marie, ON	80,000	New development and redevelopment
St. Cloud, MN	67,000	Development and redevelopment
Woodbury, MN	66,000	Very active new development, active redevelopment, maintaining existing infrastructure
Eagan, MN	64,000	Active redevelopment
North Bay, ON	64,000	New and redevelopment primarily within urban limits
Blaine, MN	63,000	Active development and redevelopment (Blaine approves 300 to 350 building permits per year for new home construction as well as a fairly constant level of commercial and light industry development)
Burnsville, MN	63,000	Active redevelopment
Timmins, ON	43,000	New development and redevelopment
Stratford, ON	31,000	Active redevelopment and development

[1] Percentage of land within the municipality’s boundary that has been developed.

Table 70. Representative Community Budget and Funding Structure

Community	Annual Water Resources Budget*	Is Budget Independent?	Funding Sources**
Calgary, AB	$25M +	Mixed – Water Resources & Water Services Depts.	Flat Stormwater fee and minimal Provincial support
Mississauga, ON	$15M (with potential for $26M)	Mixed	Property Tax, Development Charges, Stormwater Fee
Hamilton, ON	$78M (+ $105M capital program)	Mixed	Development fees and SUF
St. Paul, MN	~$21M sewer	Mixed	General fund + stormwater utility fee (SUF) + grants for planning projects
Kitchener, ON	$13M	Mixed	Development fees and SUF
Richmond Hill, ON	-no data-	Mixed	Stormwater Management Rate
Waterloo, ON	$5.17M	Mixed	Stormwater Fee, Stormwater Credit Program, Tax base, and Development Charges
St. Cloud, MN	$1.1M	Independent	SUF
Woodbury, MN	$2.75M	Mixed – Distributed to Community Development (Planning), Engineering, & Public Works. City staff considers ineffective.	General fund= SUF + UF + Engineering + Public Works
Eagan, MN	$700,000 + $300,000 (capital improvements)	Independent	SUF paid to Public Works
Blaine, MN	$1.25M	Independent	SUF
Burnsville, MN	$400,000	Independent	SUF
Stratford, ON	$5.6M	Mixed	Development fees, SUF = 157.6% water use charge + $1.00/month

*The annual water resources budget generally includes operational and capital costs associated with stormwater management and water resource protection activities. Some municipalities grouped these costs with other activities, such as water and wastewater services.

**For more information related to stormwater utility fee and structure, see Table 86.
SUF – Stormwater Utility Fee
UF – Utility Fee

Table 71. Representative Community Organizational Structure

Community	Number of Staff (FTE)	Staff Growth in Past 10 yrs	# Residents /stormwater FTE	Organizational Structure	Tasks
Calgary, AB	15 stormwater professional	+10	80,000	Water Resources Department involves engineering and strategy. Water Services Department focuses on the implementation	storm sewer system maintenance and repair, capital projects, education, ESC construction oversight objectives/monitoring, wetland and riparian monitoring, site visits to meet with residents, Assumption protocols etc.
St. Paul, MN	~22 public works and engineering staff	-no data-	13,470	Divided: Public Works' Sewer Utility Div. handles drainage and conveyance. Planning and Parks depts. handles lakes within regional parks. Inter-departmental "WR Work Group" helps share information/ coordination activities across depts.	Public Works engineering staff responsible for preliminary engineering and overall program management. They designed/inspected 40% of the projects. Consultants designed/inspected 60%. Public Works utilizes consultants for heavy workload, timelines, and financing uncertainty.
Kitchener, ON	3 Engineering Design professionals 1 Technologist 1 Program Manager 1 Program Assistant 1 Stormwater Utility Manager (2 Students)	+8	27,500	Partnered with Waterloo for stormwater credit program. Design and technologist staff are housed within Engineering. Managers are field staff are within Operations.	storm sewer system maintenance and repair, capital projects, education, inspections, stormwater credit implementation, site visits to meet with residents, design review etc.
St. Cloud, MN	1 Stormwater Compliance Specialist 7 Stormwater professionals	+3	8,375	Stormwater Utility Div. within Public Works Dept. Water Resource mgmt. is multi-departmental: Utilities, Planning, Parks, Public Works, Health, and Engineering Depts.	-no data-
Woodbury, MN	1 wetland Specialist 1 surface water professional 1 groundwater professional 2.5 public works professionals	+3	10,200	Water Resources group coordinates efforts of multiple depts.: Community Development (Planning), Engineering, and Public Works.	Permitting, capital projects mgmt., education. Modeling is contracted

Community	Number of Staff (FTE)	Staff Growth in Past 10 yrs	# Residents /stormwater FTE	Organizational Structure	Tasks
Eagan, MN	1 stormwater manager 1 specialist 1 technician 1 storm drainage professional	+1	16,050	Originally, under Parks and Rec. and shifted to Public Works in 2006	Local water resources plan implementation, MS4 permit responsibilities coordination, technical review of stormwater mgmt. of development, water quality monitoring, aquatic plant harvesting, and fisheries mgmt. activities. public ed. and outreach.
Blaine, MN	1 stormwater manager 2 stormwater professionals 4 PTE (city engineer and field techs)	+3	20,700	Water Resources Group within Engineering Dept., in collaboration with Public works	Storm sewer system inspections, maintenance and repair, capital projects, education, construction oversight , plan review, project development/ mgmt., MS4 permit administration, SWPPP compliance, stormwater and Erosion & Sediment Control, site visits to meet with residents, etc.
Burnsville, MN	4 stormwater professionals	+0.5	15,750	Water Resources Department, within Public Works Division	Permitting, capital projects mgmt., education, modeling, stormwater maintenance, lake monitoring

No organizational structure data was available for following cities in Ontario included in Table 70: Mississauga, Richmond Hill, Waterloo, Hamilton, and Stratford.

5.2 Programs

The City will work towards achieving the Goals and Objectives of the SMP through implementing the programs in Table 72 focused on monitoring, improving, and maintaining the City's stormwater system, financing, and outreach.

Table 72. Activities within the SMP Programs

Program	Activities
Monitoring and Assessment Program	Stormwater Sampling Program* CSO Monitoring Program* Rainfall Collection Program (rain gauge network)* Heavy Rainfall Event Monitoring Program* See Monitoring and Data Assessment activities in Section 4.5
Inspections, Operations, Maintenance, and Rehabilitation Program	Storm Sewer Outfall Inspection Program* Oil-Grit Separator Maintenance Program* Pollution Prevention Control Program (PPCP) See additional activities in Section 4.4 (Operations and Maintenance), Section 5.5, & Section 6
Stormwater Retrofit Program	Implement BMP retrofit opportunities identified on public land
Capital Improvement Program	Implement capital projects outlined in Section 5.5
Cost-Share Program	Any opportunities for cost-sharing in implementation of retrofits Rain Garden Rebate Program* Residential Drainage Assistance Program* Rain Barrel Program*
Regulations and Enforcement Program	See Regulations and Enforcement activities in Section 4.6
Administration and Financing Program	See Funding and Organization activities in Section 4.8
Education and Outreach Program	Public Knowledge Assessments Homeowner Education Campaign Stormwater Retrofit and BMP demonstration tours School Outreach LID training for municipal staff, designers, contractors, & agency staff See Education and Outreach activities in Section 4.7

* Existing programs to be continued as activities within overarching stormwater programs

5.3 Recommendations for Standards and By-Laws

Historically, the goal of stormwater management was to move water off the landscape as quickly as possible and to reduce flooding concerns. Most of the urban areas within the City, with few exceptions, were developed under this paradigm. Stormwater management is ever evolving, and in the last 10-years, there has been a significant shift to lot-level controls on new development and retrofitting of existing development in order to mitigate the impacts of urbanization on the natural environment. Stormwater management design now focuses on keeping the raindrop where it falls and mimicking natural hydrology and hydrogeology in order to reduce flooding, minimize the amount of pollution reaching lakes, rivers, streams and wetlands, and to recharge groundwater.

5.3.1 By-Laws

One effective implementation strategy for stormwater management is through the use of regulations and enforcement. The City has a number of existing By-Laws that support stormwater management and provide a foundation to build on. Through amendments, revisions, and additions, the existing body of By-Laws could become a robust stormwater management framework.

5.3.1.1 Site Plan Control By-Law

Currently, the Site Plan Control (SPC) process is used by the Planning, Engineering, Parks, Building Services, and other Divisions for review of development / re-development applications, and to require conformance with the City's Engineering and Development Standards, including stormwater management. The SPC process also provides the opportunity to encourage the implementation of the Urban Design Guidelines and Image Route Guidelines through consultation with the applicants. The Site Plan Control process requires consideration of the following items related to stormwater management:

a. The need for easements and/or dedications for public services or facilities;
b. That the design and scale of buildings, structures, facilities, signage, and site works comply with the City's Urban Design Guidelines, Image Route Guidelines and any applicable standards or guidelines;
c. That all facilities and site works are designed in accordance with the City's Engineering and Development Standards, and the Parks Division Standards and Specifications, including stormwater management;
d. Any off-site works required as a result of the development, including road improvements, landscaping improvements including tree planting, transit stops, sidewalks or trails;
e. The provision of parkland dedication or cash-in-lieu of parkland; and
f. The protection of existing natural features, including individual trees.

The City does not currently have a Site Plan Control By-Law that requires all development within Municipal boundaries to be reviewed through the Site Plan Control process. The current framework requires the specific designation of lands on a site-by-site basis only when planning approvals such as variances of the Zoning By-Law, severances, re-zoning, Official Plan amendments, etc. are needed to facilitate the development. The wider application of Site Plan Control would remove the necessity to designate each development and would require that all development comply with the City’s Engineering and Development Standards, and would ensure that all developments of a similar size and scale addressed stormwater management in an equivalent manner.

5.3.1.1.1 Recommendations for Site Plan Control By-Law

1. Council should establish a Site Plan Control By-Law, which designates the entire City as the Site Plan Control Area, thereby establishing a wider application of Site Plan Control.

2. Thresholds should be established to identify the scale of development that would be subject to SPC. These thresholds should include, but not be limited to:

    a. *New non-residential developments or additions to existing non-residential developments which contain over 300 square metres of gross floor area;*
    b. *New or expanded parking lots and commercial parking structures;*
    c. *Any residential development containing four (4) or more dwelling units;*
    d. *Any development on or adjacent to lands designated Environmental Protection Zone or similar designation in the City’s Official Plan or Zoning By-Law; and*
    e. *Any development designated as "Waterfront" in the City’s Official Plan or Zoning By-Law.*

3. Exempt activities specified in the Site Plan Control By-Law could include, but not be limited to:

    a. *Minor modifications to existing development currently subject to a registered Site Plan with the City that do not have the effect of substantially increasing the size or usability of any building or structure, or alter grading or drainage at the discretion of the City Engineer;*
    b. *Works which result from an Order issued by the City's Fire Department;*
    c. *Where there is an approved Site Plan, any deviation from any dimension respecting the location of buildings and structures shown in the approved plans provided the deviation does not exceed 1 metre and, further, provided the deviation does not result in a violation of the requirements of any By-Law enacted by the City or other applicable law;*
    d. *Signs and temporary construction buildings placed in accordance with any applicable By-Law; and*
    e. *Agricultural buildings used for "a farm", or "riding stable", but not including "a specialized farm” as defined in the applicable Zoning By-Law.*

4. The City should establish an ongoing and regular inspection program that promotes compliance with applicable standards and guidelines related to design, construction, and maintenance for private works.

5.3.1.2 Zoning By-Law

Section 34 of the Planning Act authorizes councils of municipalities to pass Zoning By-Laws, which standardize the use of land in a community and specify the permitted type, use and locations of permitted buildings and structures. Zoning By-Laws also determine how land may be used, lot sizes and dimensions, building heights and sizes, and parking requirements. Zoning By-Laws implement land-use policies specified in the Official Plan. The Zoning By-Laws contain specific requirements that are legally enforceable. In general, no person shall use any land, building, or structure within a Zone for a use that is not permitted within that Zone, unless a variance is approved by Council or it's designate.

The City's current Zoning By-Law is applicable to all land and all buildings or structures erected, altered, enlarged, or used within the City. The first four sections of the Zoning By-Law describe administrative processes, outline enforcement measures, and provide definitions of terms. Section 5 sets forth the General Regulations for all development and land management within the City.

Zoning By-Law Sections 6-35 define each Zone and their subsequent rules and regulations. The majority of these sections contain requirements regulating such things as lot size, road width, and landscaped open space etc. specific to each Zone.

5.3.1.2.1 Recommendations for Zoning By-Law

1. There are three primary opportunities to revise the General Regulations to remove potential barriers to LID or to improve current stormwater management infrastructure:
   a. *A reduction in maximum impervious surface area and width;*
   b. *An increase in minimum requirement for landscaped and pervious surfaces; and*
   c. *Language which requires functional and well-maintained stormwater management facilities.*
2. The City should examine the entire Zoning By-Law for additional opportunities to remove potential barriers to LID and to encourage and incentivize green infrastructure;
3. Section 5.11 Rules for non-complying land should require redevelopment to implement an equivalent LID standard. While specific LID standards are not proposed, current MOECC standards should be observed;
4. The City should decrease the minimum number of parking spaces required for developments and revise Sections 5.13-5.15 to reduce the area required for impervious surfaces. Examples of this include but are not limited to: reduced minimum driveway width, reduced loading space requirements, and an increase in required landscaped areas within parking lots. In general, all parking lot space requirements should be examined and revised to minimize impervious surfaces;
5. The City should re-evaluate all lands within the municipal boundaries for opportunities to designate additional environmentally sensitive areas such as locally significant wetlands and unevaluated wetlands as Environmental Protection Zones; and

6. The City should consider enhanced standards for lands that are adjacent to Environmental Protection Zones. Example enhanced standards for lands near Environmental Protection Zones include, but are not be limited to:
    a. *Individual lots, buildings and streets should be designed and located to minimize impact on the protected lands and to maximize opportunities for uses consistent with the City natural resource protection goals;*
    b. *The design should protect floodplains, wetlands, steep slopes, and shoreline and bluff impact zones from clearing, grading, and filling and construction impacts;*
    c. *The design should avoid siting new construction on prominent hilltops or ridges; and*
    d. *The design should protect, to the extent possible, rural roadside character through retaining existing trees or native vegetation between housing and roads, setting back development from roads, or designating new landscaping as a buffer.*

5.3.1.3 Site Alteration By-Law

In general, Site Alteration By-Law regulates the dumping of fill and the alteration of the grade of land. In most municipalities throughout Ontario the alteration of land topography, greater than a specified size, requires that property owners obtain a Site Alteration Permit.

The intent of the current Site Alteration By-Law in Thunder Bay is to protect the land of property owners from significant disturbance, or alteration, as a result of development on adjacent properties and to establish regulatory requirements for land development and land disturbing activities. The Site Alteration By-Law is generally used as a tool to establish an inspection program that promotes compliance with applicable standards and guidelines related to design, construction, and maintenance for both public and private works.

While the City currently has a Site Alteration By-Law, site alteration permits have historically not been required or issued. The following recommendations for amendments and implementation of the Site Alteration By-Law are modified from the Lake Simcoe Watershed Model By-Law for Municipalities (2015)[60] and the Minimal Impact Design Standards (MIDS) Community Assistance Package by the Minnesota Pollution Control Agency (2014).[61]

5.3.1.3.1 Recommendations for Site Alteration By-Law

1. The City should require an assessment of stormwater management measures prior to any site alteration.
2. Section 858.1.3, the definition of Site Alteration, should be amended to include the clear cutting of trees which reduces canopy cover greater than a specified area. This amendment is intended to regulate and control the increases in stormwater runoff that results from tree removal. The definition should also be amended to include the removal of vegetative cover, the compaction of fill, the creation of impervious surfaces, or any combination of these activities.

3. The City should establish exemptions to the Site Alteration By-Law that may include, but not be limited to:
   a. *Emergency work necessary to protect life, limb, or property; and*
   b. *Routine agricultural activity such as tilling, planting, harvesting, and associated activities.*
4. The City should utilize the authority to establish an inspection program that guarantees compliance with the Site Alteration Permit.

5.3.1.3.2 Recommendations for Site Alteration Permit Process

1. Site Alteration Permits should be enforced and required for all qualifying development activities as specified in the Site Alteration By-Law;
2. Activities which increase drainage received by or decrease drainage away from lands undergoing site alteration should no longer be exempt from the Site Alteration By-Law as stated in Article 2 General Provisions 858.2.3. While these drainage alterations may not adversely impact or exasperate off drainage issues with respect to flooding, they may inadvertently impact the hydrology to a water resource such as a wetland;
3. Permit conditions should require the consideration of LID practices as the preferred method and include requirements that provide a justification for any less preferred methods of treatment selected;
4. Permit holders should comply with the Engineering Development Design Standards and, as a result, any proposed land development activity that meets any of the criteria below should submit a Stormwater Management Design Brief:
   a. *Site Alteration exceeds an area as defined in the Site Alteration By-Law;*
   b. *Site Alteration is within 120 metres of Lake Superior Shoreline or a key natural heritage feature, as defined in the Site Alteration By-Law;*
   c. *Construction of any new public or private road or parking lot; and*
   d. *Any land development activity, regardless of size, that the City determines is likely to cause an adverse impact to an environmentally sensitive area or other property.*
5. The City should consider subdividing Site Alteration Permits into major and minor development categories, with Minor Site Alteration including all development less than 1,000 square metres. The City should issue a Minor Site Alteration or a Site Alteration Notification, rather than a Permit that describes the conditions of the Site Alteration By-Law. Minor Site Alteration may not necessitate a full Design Brief, according to Design Brief, which should be coordinated with the City Engineer;
6. The City should establish a Performance and Maintenance Guarantee rate per hectare of Site Alteration Area, which would be required for the duration of the permit to cover the total estimated cost of Erosion and Sediment Control measures;
7. Permit conditions should require the implementation of erosion and sediment control measures before site alteration commences;

8. For stormwater management facilities that are not publicly owned and maintained the City should require a separate maintenance agreement with the developer for private stormwater management facilities; and

9. The City should establish a Site Alteration Permit Inspection Program for Minor and Major Site Alteration, which includes the following:
   a. *Regular site visits that record construction progress through photographs and field notes;*
   b. *Regular inspection reports submitted to permittee after each site visit which communicate the compliant and non-compliant conditions of permit and, if site is non-compliant, recommendations for restoration into permit compliance; and*
   c. *Upon closure of permit, communication to permittee and documentation of compliant conditions.*

5.3.2 Engineering and Development Standards

Municipal Engineering and Development Standards provide requirements for the design of buildings, streets, parking lots, and lands within the public right of way and on private property, when applicable. With respect to stormwater, these requirements are intended to prevent harm to people or adjacent properties and to promote sustainable development practices. In general, design standards also include provisions such as: erosion and sediment control; shoreline protections; wetland protections; and floodplain protections. The City's existing Engineering and Development Standards provide guidance for development, erosion and sediment control, and stormwater management. Through amendments, revisions, and additions, the existing body of standards will become an effective tool within a robust stormwater management framework.

The recommendations listed below are revisions, amendments, and additions to existing sections of the Engineering and Development Standards. These recommendations are limited to sections of the current standards that contain the greatest number of opportunities to remove barriers to LID and improve stormwater management.

5.3.2.1 Storm Sewers Outfall into Lake Superior and the Neebing McIntyre Floodway

Although this Standards Section 2.2.17 is an effective standard, it should be included within Section 2.3 Stormwater Management, rather than 2.2 Design Standards.

The following paragraph should be added within Standards Section 2.2.17:

Storm sewers outfalling into the Neebing-McIntyre Floodway shall not impinge upon the integrity of the Floodway to act as a flood control device, per the Neebing/McIntyre Floodway Agreement (By-Law Number 251-2003) between the LRCA and the City of Thunder Bay.

The following section should be added immediately after Standards Section 2.2.18:

2.2.18 – Storm Sewer Works located within the Regulated Area of the LRCA

Storm sewers, outfall structures and any required site grading located within the approximate regulated area of the LRCA will require a permit from the LRCA under the *Conservation Authorities Act*. It is noted that the approximate regulated area will include: all watercourses and adjacent lands; all Provincially Significant Wetlands and 120 metre adjacent areas; 15 metres landward and one kilometre lakeward from the 100 year Lake Superior flood level; ravines, valleys, steep slopes and talus slopes; hazardous lands including unstable soil and bedrock; and all land zoned Environmental Protection.

Any development on land owned by the LRCA will require the approval of the Board of Directors, in addition to any issued permits.

5.3.2.2 Objectives

The last paragraph of this Standards Section 2.3.1 should be amended to read:

The goals of Stormwater Management are:

a. To preserve groundwater and baseflow characteristics;
b. To protect water quality;

c. To protect downstream watercourses from undesirable geomorphic change;
d. To minimize the risk of injury and property damage resulting from floods exceeding the capacity of the piped (minor) storm sewer system and the capacity of the overland (major) storm flow routes;
e. To protect wetlands, lakes, and rivers;
f. To protect natural topography, bluffs, and biologically significant areas;
g. To protect wooded areas, native trees, shrubs, and grasses;
h. To develop in sustainable fashion; mimicking natural hydrology of the site; and
i. To reduce nutrient, sediment, metals and other pollutant loading to the AOC.

The following paragraph should be added to this section:

New development projects shall be designed using Low Impact Development techniques, which are applied early in the design process to preserve natural areas, reduce impervious cover, distribute runoff and use pervious areas to more effectively treat stormwater runoff. Site design shall address and consider open space protection, impervious cover minimization, runoff distribution and minimization, and runoff utilization, as outlined below:

1. Open space protection and restoration
   a. Conserve and protect existing natural areas (upland and wetland);
   b. Implement reforestation efforts;
   c. Re-establish dominant forest type;
   d. Restore wetlands;
   e. Establish or protect stream, shoreline and wetland buffers; and
   f. Re-establish native vegetation into the landscape.
2. Reduction of impervious cover
   a. Reduce new impervious cover through redevelopment of existing sites and use of existing roadways, trails etc.;
   b. Minimize street width, parking space size, driveway length, and sidewalk width; and
   c. Reduce impervious surface footprint (e.g. two story buildings, parking structures)
3. Distribution and minimization of runoff
   a. Utilize vegetated areas for stormwater treatment (e.g. parking lot islands, vegetated areas along property boundaries, front and rear yards, building landscaping);
   b. Direct impervious surface runoff to vegetated areas or to designed treatment areas (roofs, parking, driveways drain to pervious areas, not directly to storm sewer or other conveyances); and
   c. Encourage infiltration and soil storage of runoff through grass channels, soil compost amendment, vegetated swales, rain gardens, etc.
4. LID treatment train
   a. Utilize a connected network of pre-treatment practices and proprietary devices.
5. Runoff utilization
   a. Capture and store runoff for use for irrigation in areas where irrigation as necessary.

5.3.2.3 Stormwater Quantity Control

This Standards Section 2.3.1.1 should be re-named Stormwater Rate and Volume Control and should be amended to read:

Stormwater rate and volume control is required where increased storm runoff volume and peak discharge rate, due to development, will cause detrimental impacts downstream of the development site via flooding and erosion. A site-specific stormwater management assessment will identify the detailed SWM methods required to comply with the City's policies.

Site-specific controls are required where post development peak discharge rates for the 2-year through 100-year events exceed the pre-settlement rates for the development lands. Pre-settlement conditions, based on historic land cover typical for the development site, are generally defined for the City as land use of mixed forest with soils as currently mapped. For new development, the minimum volume control required is to maintain post-development volume at pre-settlement levels for the 2-year event. In developments with high percentages of impervious surfaces pre-settlement levels can be attained through site storage and infiltration methods, as detailed in Section 3.6.2 of the SMP. Additional rate and/or volume controls may be required where the receiving storm sewer and/or watercourse are at capacity, or where existing flooding or erosion problems have been identified.

Re-development that proposes to disturb more than 50% of existing impervious surfaces must meet the stormwater rate and volume criteria for the entire site. Otherwise, the stormwater rate and volume criteria will apply only to net increase in impervious surfaces. Notwithstanding, for road and other linear projects, only the net increase in impervious surfaces will be considered. The stormwater rate and volume criteria are summarized in Table 73.

Table 73. Stormwater Rate and Volume Criteria

Development Scenario	Trigger	Rate Criteria	Volume Criteria	Other Criteria
New Development	All development. Modified submittal requirements for Site area < 1,000 m^2	Match Post-Development peak rate to Pre-Settlement peak rate for 2-year through 100-year events	Match Post-Development runoff volume to Pre-Settlement runoff volume for the 2-year event	Do not cause erosion or flooding damage downstream of site. Do not exceed capacity of downstream infrastructure.
Re-Development	Disturbs > 50% existing impervious (criteria apply to entire site) OR Net increase in impervious surfaces	Match Post-Development peak rate to existing peak rate for 2-year through 100-year events	Match Post-Development runoff volume to Pre-Settlement runoff volume for the 25 mm event	

5.3.2.4 Stormwater Quality Control

The following recommendations should be incorporated into the existing structure of this Standards Section 2.3.1.2:

In addition to the existing stormwater quality control standards, explicit standards should be implemented for redevelopment and public linear projects. Emphasis should be placed on LID practices rather than Oil and Grit Separators and language should indicate that LID is given priority. Specification of pre-treatment measures for infiltration or filtration facilities (e.g. long-term removal of at least 50 percent of sediment loads) should be incorporated into these standards. Compliance with these stormwater quality control standards must be demonstrated in the design brief.

All sites should generally include quality controls such as Best Management Practices and LID's; however, at the discretion of the City Engineer, conventional methods of stormwater quality control, such as oil/grit separators, may be used in place of LID, when it can be sufficiently proven that the implementation of LID and BMP's are not practical due to site specific constraints.

The Operation and Maintenance Manual should be extended to encompass all LID practices and stormwater management facilities and should be intended specifically for use by developers.

5.3.2.5 Wetland Inundation and Source Control

The following should be added to Section 2.3.1.3 of the Engineering and Development Standards:

The development shall not increase the bounce (fluctuation) in water level or duration of inundation beyond the specified limit, for a 24-hour precipitation event with a return frequency of 2-, 10-, and 100-years, for any downstream wetland as outlined in Table 74.(62)

Table 74. Bounce and Inundation Period Standards

Wetland Susceptibility Class	Permitted Storm Bounce	Inundation Period for Two Yr event	Inundation Period for 10 and 100 Yr Event
1. Highly susceptible	Existing	Existing	Existing
2. Moderately susceptible	Existing plus 0.15 metres	Existing plus 1 day	Existing plus 7 days
3. Slightly susceptible	Existing plus 0.3 metres	Existing plus 2 days	Existing plus 14 days
4. Least susceptible	No limit	Existing plus 7 days	Existing plus 21 days

Note: Wetland susceptibility classification is determined based on wetland type:

- Highly susceptible wetland types include: sedge meadows, bogs, coniferous bogs, open bogs, fens, coniferous swamps, lowland hardwood forests, and seasonally flooded basins.
- Moderately susceptible wetland types include: shrub-carrs, alder thickets, fresh (wet) meadows, and shallow & deep marshes.
- Slightly susceptible wetland types include: floodplain forests and fresh wet meadows or shallow marshes dominated by invasive species.
- Least susceptible wetland includes severely degraded wetlands. Examples of this condition include cultivated hydric soils, dredge/fill disposal sites and some gravel pits.

5.3.2.6 *Dedication for Watercourses*

The following should be added to Section 2.3.1.4 of the Engineering and Development Standards:

Where a subdivision is traversed by a watercourse, drainage way, channel or stream, a stormwater separation, utility rights-of-way or park dedication, whichever the Planning Services Division may deem the most appropriate, a buffer or separation conforming substantially to the lines of such water courses should be provided.

1. Vegetative Buffers: The purposes served for vegetative buffers include bank and shoreline stabilization; erosion prevention; filtration of nutrients, sediments, and other pollutants from storm flows; protection of stream beds and banks and mitigation of downstream flooding through moderation of peak flows both into and within the resource; regulation of in-stream temperatures; preservation of aquatic and terrestrial habitat; protection of scenic resources; and maintenance of property values.
    a. Protected stream buffer minimum width of 15 metres as measured from the top of bank is required;
    b. Before any disturbance of ground vegetation or contour, or placement of any structure on the ground, a declaration, separation, or other instrument acceptable to the City must be implemented; and
    c. The buffer should be indicated by either permanent, flush to the ground markers or permanent, post markers at the buffer's upland edge, with a design and text approved by the City.
2. The following activities are prohibited within a stream buffer:
    a. Creating impervious cover;
    b. Excavation or placing fill or debris; and
    c. Altering vegetation, such as mowing, landscaping, and applying fertilizer except for as approved in writing by the City and the removal of invasive exotic species or trees for disease control or re-vegetation.

5.3.2.7 *BMP Assumption protocol*

The following language is a recommendation for the new section recommended for Section 2.3.1.5 of the Engineering and Development Standards:

In addition to the existing subdivision level development requirements for stormwater management, such as detention ponds, it is imperative to implement a protocol that certifies performance. An assumption protocol, or BMP certification program, will standardize the inspections and maintenance and confirm stormwater management facilities perform according to design standards before the City assumes ownership and responsibility of these practices.

Developers are required to maintain and monitor the operation of detention ponds and all SWM facilities to confirm the facility conforms to current MOECC Environmental Compliance Approval (ECA) process prior to the City assuming the facility. To assist with this process the City should develop an assumption protocol, which will require as-built surveys, minimum performance monitoring and testing, and additional reporting requirements. In addition to this assumption protocol, the City should also develop a general LID Operations and Maintenance Manual template intended for Developers to use.

5.3.2.8 Wetland Impacts

The following section should be added to Section 2.3.1.6 of the Engineering and Development Standards:

1. Applicants must adequately explain and justify each individual area of wetland alteration in terms of impact avoidance and minimization alternatives considered.
2. Wetland replacement: Wetland Replacement must be located within the watershed and as close as possible to the site of impact. Qualifying City or Provincial impacts may be mitigated outside the watershed. However, the balance of replacement, required below, must be located within the watershed.
3. Wetland Replacement Ratios: Full replacement of all wetland functions is required at the following ratios (new wetland area : impacted wetland area):
   a. 6:1 for impacts to wetlands in Class 1 Highly Susceptible;
   b. 4:1 for impacts to wetlands in Class 2 Moderately Susceptible;
   c. 3:1 for impacts to wetlands in Class 3 Slightly Susceptible; and
   d. 2:1 or minimum required by City, whichever is greater for impacts to wetlands in Class 4 Least Susceptible.
4. Eligible Replacement Activities & Priorities: The following activities, listed in order of priority, are eligible for replacement credit. Applicant must first consider replacement of unavoidable impacts by restoring or, if wetland restoration opportunities are not reasonably available, creating replacement wetland areas having equal or greater function. Restoration and creation activities eligible for replacement credit include:
   e. Restoration of completely drained or filled wetland areas;
   f. Restoration of partially drained or filled wetland areas;
   g. Upland buffer areas (established or preserved);
   h. Vegetative restoration of farmed wetlands;
   i. Wetland creations.
5. If the above activities are not reasonably available to satisfy the entire replacement required, the following additional activities, where they protect or improve the functions of wetlands, should be considered for replacement:
   j. Protection of high quality upland;
   k. Protection of landlocked basins;
   l. Protection and restoration of corridor connections; and

Those activities preserving wetland functions are eligible for 25% replacement credit on an area basis. Those activities restoring and preserving wetland functions are eligible for 50% replacement credit on an area basis.

5.3.2.9 Coldwater Streams

The following section should be added as a new section (Section 2.3.1.3) of the Engineering and Development Standards:

When a stormwater management facility discharges to a cold water stream, either via a directly connected (i.e. storm sewer) system or within 30 metres via grassed or naturally vegetated conveyance path, the stormwater management facility should be designed such that the discharge from the project will minimize any increase in the temperature of cold water stream receiving waters resulting from the 2-year, 24-hour precipitation event . Projects that discharge to cold water streams must minimize the impact using one or more of the following measures, in order of preference:

1. Minimize new impervious surfaces;
2. Minimize the discharge from connected impervious surfaces by discharging to vegetated areas, or grass swales, and through the use of other non-structural controls;
3. Infiltration or other volume reduction practices to reduce runoff in excess of pre-settlement conditions (up to the two (2) year 24 hour precipitation event);
4. If ponding is used, the design must include an appropriate combination of measures such as shading, filtered bottom withdrawal, vegetated swale discharges or constructed wetland treatment cells that will limit temperature increases. The pond should be designed to draw down in 24-hours or less; and
5. Other methods, as approved by the City, which will minimize any increase in the temperature of the coldwater stream.

5.3.2.10 Requirements

This Standards Section 2.3.3 should be amended to include the following items:

Roof Water: The requirement for roof water to be discharged onto splash pads should be amended to require roof leader disconnection. Roof water should be discharged to LID facilities and overflow should be directed towards the street, as a last alternative.

Parking Areas: Requirements for all paved parking areas larger than 250 metres^2 should be amended to encourage the use of depressed islands with rain gardens, tree trenches, perimeter swales, and other LID practices. Catch basins, oil/grit separators, and other proprietary devices should be required as an alternative to LID where site-specific conditions do not allow for LID.

5.3.2.11 Design Brief

The Standards Section 2.3.4 Stormwater Management Design Brief will address both temporary construction and permanent post-construction stormwater management and must be submitted prior to development. All development, whether designated as either Major or Minor Site Alteration, is required to comply with the Stormwater Quantity Control Standards and must submit a Stormwater Management Design Brief. The requirements and scope of the Design Brief will be determined by the City Engineer or a qualified person identified by the City Engineer and will vary based on the scope and designation as Major or Minor Site Alteration. Below is an outline of the contents to be included in a typical Stormwater Management Design Brief for new development designated as Major Site Alteration:

1. Overview

a. A description of the site alteration activities;
b. A key map showing the location of the site, site boundaries, number of hectares of the site, the site address or legal description, the nearest major intersection, a legend, scale, and a north arrow; and
c. A list of all required and/or obtained permits from other regulatory agencies (i.e. LRCA, MNRF, DFO, etc.).

2. Existing Conditions

a. A field survey of the existing site topography at a contour interval not to exceed one half of one metre determined in accordance with the Canadian Geodetic Datum and with spot elevations along the property to clearly show the existing drainage patterns on the site and the adjacent sites and for all development designated as major site alteration, to extend into adjacent lands to understand the potential impacts of drainage both from and to adjacent lands, i.e. a minimum of thirty (30) metres beyond the site boundary for large development such as subdivisions;
b. The location of lakes, streams, wetlands, channels, ditches, other water courses, Environmental Protection Zones, and all other water bodies that will receive stormwater from the construction site, during or after construction, on and within three hundred (300) metres beyond the site boundary;
c. The location of the regulatory storm flood line and fill regulation lines;
d. The location and identification of predominant soil types;
e. The location and species types of existing vegetative cover , including the species and size of all trees and shrubs;
f. The location and dimensions of any existing and proposed stormwater drainage systems and natural drainage patterns on and within thirty (30) metres beyond the site boundary; and
g. The location and dimensions of utilities, structures, roads, highways and paving on the site within thirty (30) metres beyond the site boundary.

3. Proposed Conditions

a. The location and dimensions of all proposed site alteration activities;
b. The location, dimensions and use of the buildings and other structures existing or proposed to be erected on the site;
c. The location of driveways on each site and all easements and right-of-way over, under, across or through each site;
d. The identification of the proposed finished grade elevations of the site;
e. The location and dimensions of all proposed temporary stockpiles for fill, soil and other materials;
f. The location and dimension of all proposed access routes from highways;
g. The location and dimensions of all proposed staging areas for equipment; and
h. An indication on the drawing of the directions of overland flow and overland flow routes.

4. Erosion and Sediment Control

a. In conformance with Erosion Protection and Sediment Control, the Erosion and Sediment Control (ESC) Plan should propose BMPs to control the discharge of sediment and/or other potential pollutants from the site. A provision should instruct the installation of ESC measures before initiation of site alteration;

b. Narrative regarding the potential for discharge of sediment and/or other potential pollutants from the site;

c. Identification of a person knowledgeable and experienced in the application of erosion prevention and sediment control BMPs who will oversee the implementation of the ESC Plan;

d. A schedule of the anticipated start and completion dates of each land disturbing or land developing activity including the installation of erosion control measures needed at the site to meet the requirements of these standards;

e. Any specific chemicals and the chemical treatment systems that may be used for enhancing the sedimentation process on the site and how compliance will be achieved must be described;

f. Estimated preliminary quantities anticipated for the life of the project must be included for all erosion prevention and sediment control BMPs (e.g., linear metres of silt fence or square metres of erosion control blanket, mud mats, etc.);

g. The nature of stormwater runoff and run-on at the site, including factors such as expected flow from impervious surfaces, slopes, and site drainage features.

   If any stormwater flow will be channelized at the site, the applicant must design BMPs to control both peak flow rates and total stormwater volume to minimize erosion at outlets and to minimize downstream channel and stream bank erosion; and

h. Provisions for the maintenance of the site and control measures and a schedule for monitoring procedures during construction including a mud tracking prevention program which describes the procedure for mud tracking prevention and road clean up and designating a contact person for such a program throughout each land disturbing and land developing activity.

5. Stormwater Management – Rate and Volume Control

In conformance with Stormwater Quantity Control, the Stormwater Management Design Brief should include the following narrative on Rate and Volume Control:

a. The expected amount, frequency, intensity, and duration of precipitation;

b. Calculations showing development will not increase the bounce in water level or duration of inundation beyond the specified limit in immediately downstream receiving wetlands;

c. The number of hectares of impervious surface for both pre- and post-construction must be specified;

d. Methods used to minimize soil compaction and preserve topsoil must be described. Minimizing soil compaction is not required where the function of a specific area of the site dictates that it be compacted;

e. The location, dimensions, design details and design calculations of all site control measures, including plan and profile drawings of stormwater management, rate control devices, and erosion control devices necessary to meet the requirements of these standards; and

f. Standard details and/or specifications for the BMPs used on the project must be included in the final plans and specifications for the project.

6. Operation and Maintenance Plan

a. A maintenance plan that includes, but is not limited to, who will conduct the maintenance, type of maintenance needed, maintenance intervals and demonstrating that at the time of final stabilization that the stormwater facilities conform to design specifications.

7. Site Completion

Methods to be used for final stabilization of all exposed soil areas must be described. Final stabilization is not complete until all requirements outlined below are complete:

a. All soil disturbing activities at the site have been completed and all soils are stabilized by a uniform perennial vegetative cover with a density of 70 percent of its expected final growth density over the entire pervious surface area, or other equivalent means necessary to prevent soil failure under erosive conditions;
b. The permanent stormwater management system is constructed and is operating as designed. Temporary or permanent sedimentation basins that are to be used as permanent water quality management basins have been cleaned of accumulated sediment. All sediment has been removed from conveyance systems and ditches are stabilized with permanent cover;
c. All temporary synthetic and structural erosion prevention and sediment control BMPs (such as silt fence) have been removed. BMPs designed to decompose on site (such as some compost logs) may be left in place;
d. For residential construction only, individual lots are considered finally stabilized if the structure(s) are finished and temporary erosion protection and down-gradient perimeter control has been completed; and
e. For construction projects on agricultural land (e.g., pipelines across crop, field pasture or range land) the disturbed land has been returned to its preconstruction agricultural use.

8. As-Built

a. Site map submitted for the Stormwater Management Plan with existing and final grades, including dividing lines and direction of flow for all pre- and post- construction stormwater runoff drainage areas located within the project limits must be included. The site map must indicate the areas of slopes steeper than grade specified by the City. Buffer zones must be described and identified on plan sheets or project maps.

9. List of Appendices

a. Existing and Proposed Runoff Calculations;
b. Storage Calculations and Stage-Storage Discharge;
c. Storm Sewer Design Sheet;
d. Stormwater Management Facility Operation and Maintenance Manual; and
e. Existing and Proposed Storm Catchment Drawings

5.3.2.12 Calculating Runoff Flows

The following amendments should be incorporated into the existing structure of this Standards Section 2.3.12:

Four updates are recommended to the standard approach to using runoff parameters and precipitation data in calculating runoff. The updates include representing soil compaction with modified curve numbers, updating the City's IDF curves with the most recent precipitation data, increasing the rainfall intensity used for SWM design by 15%, and setting a standard rainfall distribution to be used in generating synthetic design storms. The following paragraphs describe each recommendation in more detail.

The City should implement modelling requirements to account for the impacts of grading on soil structure, such as modified curve numbers that are representative of compaction, unless project specifications incorporate soil amendments to preserve infiltration and retention capacity of in-situ soils. For instance, a common approach to account for the impacts of grading on soil structure is modeling of the post-development condition with the Hydrologic Soil Group (HSG) and corresponding CN-value of areas within the construction limits shifted down one classification (or ½ classification for HSG A).

It is recommended per Volume II, Appendix E, that the City's current IDF data (Drawing M-108) be updated based on the latest Thunder Bay Airport rainfall gauge data (up to year 2014) with event durations extended beyond the current IDF curves. The updated IDF curves and data tables are provided in Volume II, Appendix E in Figure 24, Table 55 and Table 56 along with further details of the approach used to update the curves.

Runoff flow calculations for review of existing City CIP program infrastructure should use the updated IDF curves with an additional 15% increase in rainfall depth and intensity. Runoff flow calculations for review of development applications should use the updated IDF curves for pre-development conditions and use the updated IDF curves with an additional 15% increase in rainfall depth and intensity for post-development conditions. This proactive measure plans for the uncertainty associated with intensity and frequency of storms due to climate change. The approach is consistent with the policies of other municipalities in Ontario, as discussed in Section 3.4.(38)

For areas incorporating one or more hectares of impervious surfaces, a unit hydrograph program such as PCSWMM, Visual OTTHYMO or other suitable technique should be used to calculate the flows. As the use of hydrologic and hydraulic models becomes a more common design tool for stormwater management facilities in Thunder Bay, the City should consider defining a standard rainfall distribution for use in developing synthetic design storms, such as the 24-hour SCS Type II, Chicago Storm, or the most recently developed MSE 4 and 5 distributions by the National Resources Soil Conservation Service.(39)

5.3.2.13 Culverts

The following amendments should be incorporated into the existing structure of this Standards Section 2.3.17 as they specifically relate to stream crossings:

The City should address three primary opportunities for improving stream crossings to prevent barriers to fish and wildlife and lead to several common consequences: undersized crossings, shallow crossings, and crossings that are perched. All new installations should utilize the stream crossing guidance outlined in the McVicar Creek Protection and Rehabilitation Plan (2014).[(11)] In order to address issues commonly associated with culverts, all stream crossings should:

1. Retain adequate hydraulic capacity;
2. Retain adequate navigational capacity;
3. Not adversely affect downstream channel and crossing stability or water quality;
4. Represent the "minimal impact" solution to a specific need with respect to reasonable alternatives;
5. Allow for future erosion, scour, and sedimentation considerations; and
6. Require new road construction to meet Provincial and Federal Guidelines for freeboard and overtopping by flood events.

In addition to addressing the opportunities for improvement listed above, new installations at stream crossings will integrate the following[(63)]:

1. Crossing Type: Spans (bridges, 3-sided box culverts, open- bottom culverts or arches) are strongly preferred and use of bridges is encouraged and prioritized;
2. Stream Channel Embedment: All stream crossing culverts should be embedded (sunk into stream) a minimum of 0.6 metres and, for round pipe culverts, at least 25% of the diameter. If pipe culverts cannot be embedded this deep, then they will not be used. When embedment material includes elements > 38 cm in diameter, embedment depths should be at least twice the D84 (particle width larger than 84% of particles) of the embedment material.
3. Stream Crossing Span: Span must include the stream bed and banks (at least 1.2 times bankfull width) with sufficient headroom to provide dry passage for wildlife ;
4. Channel Openness: Openness ratio (cross-sectional area/crossing length) of at least 0.25 metres. The stream crossing should be wide and high relative to its length. Openness ratio of at least 0.5 metres will be prioritized with and minimum height of 2 metres. If conditions significantly reduce wildlife passage near a crossing (e.g., steep embankments, high traffic volumes, and physical barriers), maintain a minimum height of 2.4 metres, and an openness ratio of 0.75 metres;
5. Stream Channel Substrate: Natural bottom substrate should be used within the crossing and it should match the upstream and downstream substrates. The substrate and design should resist displacement during floods and maintain an appropriate bottom during normal flows; and
6. Stream Water Depth and Velocity: Water depths and velocities must be comparable to those found in the natural channel at a variety of flows.

5.3.2.14 Erosion Protection and Sediment Control

This Standards Section 2.3.19 should be amended to read:

An Erosion and Sediment Control (ESC) Plan should be completed and submitted as part of Site Plan Control prior to site alteration activities, when applicable and should address construction and post-construction conditions. An ESC Plan should include but may not be limited to the following requirements:

1. Protection of receiving water bodies, wetlands, and storm sewer inlets;
2. Significant effort shown to minimize the following:
   a. Disturbance of natural soil cover and vegetation;
   b. Exposed soil and unstable soil conditions;
   c. Off-site sediment transport on trucks and equipment;
   d. Work in and adjacent to water bodies and wetlands; and
   e. Compaction of site soils.
3. Description of areas within the site that have potential for serious erosion or sediment transportation problems;
4. A delineation and description of the measures to be undertaken to prevent erosion and to retain sediment on the Site, including but not limited to, the designs and specifications for swales, dikes, drains, sediment control ponds, and a schedule for their maintenance and upkeep;
5. A delineation and description of the vegetative measures to be used, including, but not limited to, mulches, types of seeds and fertilizers and their application rates, the type, location and extent of pre-existing and undisturbed vegetation types and a schedule for maintenance and upkeep;
6. Description of any new ESC techniques and effective measures provided such techniques are proven to be as or more effective than the equivalent ESC;
7. Record keeping procedure including sample inspection and maintenance forms. Maintenance record-keeping procedure including name of the person who will keep the inspection and maintenance records;
8. An estimate of the cost of implementing and maintaining all interim ESC measures as per standards acceptable to the Municipality; and
9. The ESC Plan must be dated and signed by the City Engineer or a qualified person identified by the City Engineer.

5.3.2.15 Master Project Specifications

The following recommendations should be incorporated into the existing structure of this Standards Section 10.4:

1. Update the design template M-108 per the IDF analysis from the SMP, including the provided tables that accompany the updated curves in Appendix E of the SMP; and
2. Develop a suite of design templates for erosion and sediment control practices per recommendations from the SMP.

5.4 Partnerships

The Lakehead Region is home to many stakeholders working with the City towards sustainable watershed management through public outreach, research, and regulatory initiatives. The City should leverage these existing partnerships as it implements the SMP through the EarthCare Water Working Group and foster new partnerships .

The Water Working Group consists of volunteers representing stakeholders of the Lakehead Watershed that meet regularly to develop strategies to protect the local watershed through community engagement and planning activities. The group played a key role in driving the development of the SMP and has updated its goals and objectives in the EarthCare Sustainability Plan for 2014-2020[15] with strong correlations to those in the SMP. As such, the Water Working Group is well positioned to help realize partnerships in implementing the SMP. It is anticipated that these organizations will partner with the City in achieving specific goals of the SMP that are tied to each organization's past efforts and strengths in stormwater management. A description of each organization and SMP goal are highlighted in Table 75.

Table 75. Partnerships through the Water Working Group

Organization	Efforts Relating to SMP	Partnership to Achieve SMP Goal
EcoSuperior	A non-profit supported entirely through fee-for service projects related to stormwater infrastructure inspection and public education delivered for corporate sponsors and municipal, provincial, and federal government.	Education & Outreach Operations & Maintenance
Confederation College	Confederation College has a significant student population interested in hydroelectricity and water resources.	Monitoring & Data Assessment
LRCA	The conservation authority monitors water quality, flow, and precipitation throughout the Lakehead Watershed and regulates the impact of land development on floodplain management.	Regulations & Enforcement Monitoring & Data Assessment
Lakehead University	An educational institution partnering to complete local research on stormwater impact assessments and remediation options.	Monitoring & Data Assessment
MOECC	The MOECC develops provincial standards for stormwater management and water quality criteria.	Regulations & Enforcement
MNRF	The MNRF identifies wetlands through remote sensing and develops guidelines for evaluating the significance of those wetlands and management of natural hazards. The MNRF has reported in the past on fisheries in the Current River Watershed and worked with OPG in developing the Kaministiquia Water Management Plan (2004).	Water Quantity Water Quality Ecosystem Health Regulations & Enforcement Monitoring & Data Assessment
North Shore Remedial Action Plans	Supported by Environment Canada, MOECC, and MNRF in efforts towards delisting the Bay as an Area of Concern, such as plans to address north harbour mercury contamination, stream restoration projects, and stormwater impacts assessments through partnerships with Lakehead University.	Water Quality Funding & Organization Monitoring & Data Assessment
North Shore Steelhead Association	A non-profit organization committed to the protection and restoration of habitat for coldwater fisheries throughout the Lakehead Watershed. The Association recently completed several restoration projects within the watershed.	Funding & Organization Monitoring & Data Assessment

Additional partners identified beyond those in the Water Working Group are listed in Table 76 and should be engaged by the City.

Table 76. Additional Partnerships for Implementation

Organization	Efforts Relating to SMP	Partnership to Achieve SMP Goal
Adjacent Municipalities, Townships, and First Nation	These municipalities, townships, and the Fort William First Nation manage development and stormwater management within the Lakehead Watershed outside of the City's jurisdiction.	Monitoring & Data Assessment Water Quantity Water Quality Ecosystem Health
Great Lakes and St. Lawrence Cities Initiative	A binational coalition of U.S. and Canadian mayors and other local officials working to advance the protection and restoration of the Great Lakes and St. Lawrence River. This network of cities that are often similar in size, demographics, and geography will provide useful connections for information sharing and municipal partnerships.	Education & Outreach
Ontario Power Generation	Operates the multiple dams and generating stations upstream of the City in the Kaministiquia River Watershed and was a partner in developing the Kaministiquia Water Management Plan (2004) with the MNRF.	Water Quantity
Thunder Bay Field Naturalists	A non-profit organization dedicated to environmental education, the study of natural history, and the advocacy of natural resource protection.	Education & Outreach Monitoring & Data Assessment
Aboriginal Stakeholders	Métis Nation of Ontario and Red Sky Métis Independent Nation	Education & Outreach

5.5 Capital Improvement Plan / Implementation Plan

The SMP Implementation Plan includes annual estimated costs and a schedule for Programs, Projects and Studies/Inventories. The Implementation Plan identifies the Activities the City needs to undertake to meet the goals and objectives of the SMP. To facilitate implementation, budgeting, leveraging partnerships and applying for grants, the Implementation Plan includes the specific element(s) of the SMP that the activity addresses, the estimated cost to implement the activity, and when the activity should be conducted.

As the City continues to expand its stormwater management program and collect more information about the watersheds located within the City's municipal boundary, it will need to periodically review and revise the Implementation Plan so that it reflects the needs and priorities of the City and its constituents at that point in time.

In general, consideration of the following funding approaches is recommended through the implementation of this Plan:

1. Implementing existing stormwater management activities in Year 1, adding preparatory training and administrative programs in Year 2, and phasing in the remaining recommendations to match the annual funding in Years 3 to 20;
2. Developing and initiating a Stormwater Utility in Year 2 which is anticipated to annually increase by approximately $1 million to fund the implementation of additional activities while tax funding is decreased;
3. Supplementing these funds during Years 3 to 20 when needed to fully fund the implementation plan by securing grants, leveraging partnerships (Section 5.4) and considering the adoption of other funding strategies presented in the SMP; and
4. Funding all stormwater management programs and activities through the Stormwater Utility by Year 20.

Funding needs for the first two years are based on information contained in the Capital Forecast and more recent cost estimates provided by City Staff, with only some new programs requiring funding in Year 2. According to the current AMP, an annual budget of $5.8 million is required for renewal and rehabilitation of the existing linear storm sewer network. Estimated cost provided in Table 82 for *Storm Sewer Replacement and Enhanced Infrastructure Renewal Program* is proposed to increase each year to reach the $5.8 million of annual funding recommended AMP in Year 16, however the $5.8 million may need to increase as new infrastructure is added to the AMP. Assumptions made for new Programs, Projects and/or Studies/Inventories are included in the Implementation Plan tables.

A more detailed explanation of the City's implementation plan by category is provided below.

Operations and Programs

- Administration Activities
- Monitoring Program
- Inspection and Maintenance Program
- Regulation and Enforcement
- Public Education, Outreach, and Rebate Programs

Many of the activities identified in this section of the Implementation Plan are expected to be funded by the City. A number of these activities are currently being performed by the City and others are coordinated with the LRCA. A timeline for the general approach to accomplishing the activities within the CIP Operations and Programs is described in Table 77. The average annual cost for Operations and Programs is $3,698,950 (equates to 33% of the total average annual cost of the Implementation Plan).

Table 77. Approach to Accomplishing CIP Operations and Programs

Time Period	General Approach for Accomplishing Activities
Years 1-2	In Year 1, the City will continue implementing existing activities related to the inspection and maintenance of storm sewer infrastructure, on-going contributions to monitoring efforts, existing support of LRCA programs, and public education and outreach. In Year 2, the City will start to develop a Stormwater Utility which will generate funds to supplement stormwater management activities starting in Year 3. The cost of inspecting and maintaining the City's stormwater infrastructure will continue to increase each year due to an expanding system. In addition, the City will begin developing inventory procedures, a maintenance and rehabilitation plan, and assumption protocol for infrastructure. Also in Year 2, the City will initiate education and outreach programs to prepare local City staff, consultants, contractors, and residents to implement the recommended approaches to stormwater management.
Years 3-5	In addition to the activities identified in Years 1 to 2, it is anticipated that the City will establish human resources over this three year time period beginning with an Administrator (of a Stormwater Section if needed), followed by two additional staff in Years 4 to 5. In addition, the City will expand its monitoring program by collecting information in two watersheds: Neebing and Pennock. This information will be used to develop Comprehensive Watershed Management Models in Year 5 (see Studies and Inventories). The City will begin to expand its inspection program to include all stormwater infrastructure, including the expanding number of LIDs throughout the City. The City will begin funding an on-going BMP Cost-Share Program in addition to developing an incentive program. Guidance Materials will also be developed to facilitate compliance with standards and by-laws. Enforcement of the City's illicit discharge By-Law will be expanded to protect storm sewers, ditches, and watercourses. Education programs regarding wetland protection and modeling training for City staff will be implemented. In Year 5, it is assumed that the City will assess the need to amend the SMP to incorporate information collected and developed for the Neebing and Pennock Creek Watersheds.
Years 6-10	In addition to the activities identified in previous years, it is assumed that the City will dedicate additional staff resources for this five year time period. The monitoring program will be expanded to collect information in two additional watersheds: McIntyre and McVicar. This information will be used to develop Comprehensive Watershed Management Models for these same watersheds (see Studies and Inventories). Again, it is assumed that the City will assess the need to amend the SMP at the end of this five year time period to incorporate information collected and developed for the McIntyre River and McVicar Creek Watersheds.
Years 11-15	In addition to the activities identified in previous years, the monitoring program will be expanded to collect information in two additional watersheds: Current and Mosquito. This information will be used to develop Comprehensive Watershed Management Models for these same watersheds (see Studies and Inventories). Again, it is assumed that the City will assess the need to amend the SMP at the end of this five year time period to incorporate information collected and developed for the Current River and Mosquito Creek Watersheds.
Years 16-20	In addition to the activities identified in previous years, the monitoring program will be expanded to collect information in two additional watersheds: Kaministiquia and Waterfront. This information will be used to develop Comprehensive Watershed Management Models for these same watersheds (see Studies and Inventories). Again, it is assumed that the City will assess the need to amend the SMP at the end of this five year time period to incorporate information collected and developed for the Kaministiquia River and Waterfront Watersheds.

5.5.1 Capital Projects

A number of the storm sewer upgrades identified in this portion of the Implementation Plan were previously identified by the City. Estimated costs for these activities included in the Capital Forecast Component Details are reflected in the Implementation Plan. The cost of other projects, such as the separation of storm and sanitary sewers, was estimated more recently by City staff. New projects identified during the development of the SMP are included as described in the following table. A timeline for the general approach to accomplishing the activities within the CIP Projects is described in Table 78. The average annual cost for Capital Projects is $6,996,750 (equates to 63% of the total average cost for Implementation Plan).

Table 78. Approach to Accomplishing CIP Capital Projects

Time Period	General Approach for Accomplishing Activities
Years 1-2	City will implement projects already identified in the Capital Forecast Component Details, such as replacement of storm sewer infrastructure, the Pollution Prevention Control Plan, outfall repairs, and culvert replacement. The City will also design and construct the BMPs recommended in past studies and will continue to support the LRCA's programs.
Years 3-5	The City will begin designing and constructing stormwater BMPs recommended in the SMP. Of the 550 stormwater BMPs identified during the development of the SMP, it is assumed that the City can implement 96 of these practices over the remaining 18 years in the time frame of the Plan. The annual cost of BMP design and construction included in the Implementation Plan for the remainder of the years reflects this assumption. The cost of replacing storm sewer infrastructure will continue to increase each year. The City will begin to address riparian erosion and sediment control issues by implementing shoreline restoration projects. Improvements to address the quantity and quality of stormwater generated on rear lanes will be initiated in Year 4.
Years 6-10	The same approach applied to Years 3-5 are applied to this five year time frame. The Pollution Prevention Control Plan is expected to be completed within the time frame.
Years 11-15	The same approach applied to Years 3-5 are applied to this five year time frame.
Years 16-20	The same approach applied to Years 3-5 are applied to this five year time frame. The annual funding for storm sewer replacement will reach the $5.8 million recommended by the AMP during this period. This target may need to increase as additional stormwater infrastructure is added to the network.

5.5.2 Studies and Inventories

- Feasibility Studies
- Natural Resource Inventories
- Stormwater Infrastructure Inventories & Data Collection
- Modeling Efforts

All activities identified under Studies and Inventories are new costs that were not previously identified and budgeted for by the City. A timeline for the general approach to accomplishing the activities within the CIP Studies and Inventories is described in Table 79. Coordination with the LRCA will greatly assist the City in implementing these activities and reducing duplication of efforts. In addition to their ongoing monitoring programs, the LRCA has begun updating floodplain mapping of the major watersheds in the City, including McIntyre River (2015), Neebing River (2016), McVicar Creek (2018), Current River (2020), Kaministiquia River (2021), Pennock Creek (2023), and Mosquito Creek (2024). The data collected in these studies will provide some of the data, models and inventories outlined in the CIP.

Table 79. Approach to Accomplishing CIP Studies and Inventories

Time Period	General Approach for Accomplishing Activities
Years 1-2	No activities recommended for implementation by the City in this time frame. The City will continue to contribute annually to the LRCA's watershed studies and floodplain mapping.
Years 3-5	Of the 550 stormwater Best Management Practices (BMPs) identified during the development of the SMP, it is assumed that 70 of these BMPs require analysis prior to the development of construction plans. Of the 70 projects identified for feasibility studies, it is assumed that the City can implement 33 over the time frame of the Plan. The annual cost included in the Implementation Plan for the remainder of the years reflects this assumption, with one feasibility study completed annually in Years 3 to 5. Natural resource inventories, stormwater infrastructure inventories, and modeling efforts for the Neebing River and Pennock Creek Watersheds are recommended during this three year time frame as well.
Years 6-10	In addition to the development of two feasibility studies per year for stormwater BMPs, natural resource inventories, stormwater infrastructure inventories and modeling efforts for the McIntyre River and McVicar Creek Watersheds are recommended in this five year time frame.
Years 11-15	In addition to the development of two feasibility studies per year for stormwater BMPs, natural resource inventories, stormwater infrastructure inventories and modeling efforts for the Current River and Mosquito Creek Watersheds are recommended in this five year time frame.
Years 16-20	In addition to the development of two feasibility studies per year for stormwater BMPs, natural resource inventories, stormwater infrastructure inventories and modeling efforts for the Kaministiquia and Waterfront Watersheds are recommended in this five year time frame.

The average annual cost for Studies and Inventories is $466,250 (equates to 4% of the total average cost for Implementation Plan).

The following Table 80 summarizes the total expenditures for the Implementation Plan by category. Specific costs of the individual Implementation Activities are included in the Implementation Plan Table 81, Table 82, and Table 83.

Table 80. Capital Improvement Plan Summary

Plan Components	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 10	Years 11 15	Years 16 20	Annual Average
Studies and Inventories									
Feasibility Studies	$ -	$ -	$ 114,000	$ 114,000	$ 114,000	$ 1,137,000	$ 1,137,000	$ 1,137,000	$ 187,650
Natural Resources Inventories	$ 46,000	$ 46,000	$ 61,000	$ 61,000	$ 333,000	$ 486,000	$ 596,000	$ 648,000	$ 113,850
Stormwater Infrastructure Inventories & Data Collection	$ -	$ -	$ -	$ 127,000	$ 20,000	$ 147,000	$ 147,000	$ 153,000	$ 29,700
Modeling Efforts	$ 100,000	$ 100,000	$ 100,000	$ 103,000	$ 228,000	$ 740,000	$ 715,000	$ 615,000	$ 135,050
Sub-Total	**$ 146,000**	**$ 146,000**	**$ 275,000**	**$ 405,000**	**$ 695,000**	**$ 2,510,000**	**$ 2,595,000**	**$ 2,553,000**	**$ 466,250**
Estimated Annual Cost	$ 146,000	$ 146,000	$ 275,000	$ 405,000	$ 695,000	$ 502,000	$ 519,000	$ 510,600	
Capital Projects									
Sub-Total	**$ 4,341,000**	**$ 5,149,000**	**$ 5,617,000**	**$ 6,383,000**	**$ 6,270,000**	**$ 35,947,000**	**$ 36,114,000**	**$ 40,114,000**	**$ 6,996,750**
Estimated Annual Cost	$ 4,341,000	$ 5,149,000	$ 5,617,000	$ 6,383,000	$ 6,270,000	$ 7,189,400	$ 7,222,800	$ 8,022,800	
Operations and Programs									
Administration	$ -	$ 100,000	$ 200,000	$ 460,000	$ 660,000	$ 3,980,000	$ 3,980,000	$ 3,980,000	$ 668,000
Monitoring Program	$ 113,000	$ 113,000	$ 113,000	$ 214,000	$ 134,000	$ 588,000	$ 565,000	$ 549,000	$ 119,450
Inspection & Maintenance Program	$ 2,261,000	$ 2,307,000	$ 2,362,000	$ 2,400,000	$ 2,449,000	$ 12,819,000	$ 13,179,000	$ 13,539,000	$ 2,565,800
Regulations & Enforcement	$ 53,000	$ 83,000	$ 159,000	$ 130,000	$ 81,000	$ 412,000	$ 419,000	$ 427,000	$ 88,200
Public Education, Outreach, and Rebate Programs	$ 181,000	$ 216,000	$ 219,000	$ 269,000	$ 266,000	$ 1,333,000	$ 1,333,000	$ 1,333,000	$ 257,500
Sub-Total	**$ 2,608,000**	**$ 2,819,000**	**$ 3,053,000**	**$ 3,473,000**	**$ 3,590,000**	**$ 19,132,000**	**$ 19,476,000**	**$ 19,828,000**	**$ 3,698,950**
Estimated Annual Cost	$ 2,608,000	$ 2,819,000	$ 3,053,000	$ 3,473,000	$ 3,590,000	$ 3,826,400	$ 3,895,200	$ 3,965,600	
TOTAL	**$ 7,095,000**	**$ 8,114,000**	**$ 8,945,000**	**$ 10,261,000**	**$ 10,555,000**	**$ 57,589,000**	**$ 58,185,000**	**$ 62,495,000**	**$ 11,161,950**
Estimated Annual Cost	$ 7,095,000	$ 8,114,000	$ 8,945,000	$ 10,321,000	$ 10,555,000	$ 11,517,800	$ 11,637,000	$ 12,499,000	

Table 81. Capital Improvement Plan Studies and Inventories

Study/Inventory Name	SMP Element*	Estimated Cost							
		Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 10	Years 11 15	Years 16 20
Feasibility Studies									
BMP Retrofit Feasibility Studies	WQN & WQL	$ -	$ -	$ 114,000	$ 114,000	$ 114,000	$ 1,137,000	$ 1,137,000	$ 1,137,000
Subtotal Feasibility Studies		**$ -**	**$ -**	**$ 114,000**	**$ 114,000**	**$ 114,000**	**$ 1,137,000**	**$ 1,137,000**	**$ 1,137,000**
Natural Resources Inventories									
Stream Assessments	MDA	$ -	$ -	$ -	$ -	$ 148,000	$ 158,000	$ 190,000	$ 230,000
Floodplain Encroachment Remediation Feasibility Study	ESH	$ -	$ -	$ -	$ -	$ 50,000	$ 50,000	$ 50,000	$ 50,000
Biotic Assessment (Macroinvertebrate and Fish Surveys)	ESH	$ -	$ -	$ -	$ -	$ 89,000	$ 48,000	$ 114,000	$ 138,000
Inventory existing potential sources of groundwater contamination	ESH	$ -	$ -	$ 15,000	$ 15,000	$ -	$ -	$ -	$ -
Inventory groundwater dependent natural resources	ESH	$ -	$ -	$ -	$ -	$ -	$ -	$ 12,000	$ -
Assess Thermal Property Classification of the Neebing River and Pennock Creek	WQL	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA
Aerial Imagery	MDA	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA
LRCA Watershed Studies	WQL	$ 46,000	$ 46,000	$ 46,000	$ 46,000	$ 46,000	$ 230,000	$ 230,000	$ 230,000
Subtotal Natural Resources Inventories		**$ 46,000**	**$ 46,000**	**$ 61,000**	**$ 61,000**	**$ 333,000**	**$ 486,000**	**$ 596,000**	**$ 648,000**
Stormwater Infrastructure Inventories & Data Collection									
Inventory and Create GIS Layer of Existing Ditch System	O&M	$ -	$ -	$ -	$ 20,000	$ 20,000	$ 40,000	$ 40,000	$ 40,000
Bridge and Culvert Inventory	MDA	$ -	$ -	$ -	$ 24,000	$ -	$ 24,000	$ 24,000	$ 24,000
Critical River and Ditch Cross Sections and Profiles	MDA	$ -	$ -	$ -	$ 48,000	$ -	$ 48,000	$ 48,000	$ 48,000
Trunk Storm Sewer Gap Analysis, Survey, and Information Management	MDA	$ -	$ -	$ -	$ 28,000	$ -	$ 28,000	$ 28,000	$ 28,000
Survey of Other Hydraulic Structures	MDA	$ -	$ -	$ -	$ 4,000	$ -	$ 4,000	$ 4,000	$ 4,000
Coordinate additional data collection efforts with adjacent Municipalities, Townships, and Fort William First Nation	MDA	$ -	$ -	$ -	$ 3,000	$ -	$ 3,000	$ 3,000	$ 9,000
Subtotal Stormwater Infrastructure Inventories & Data Collection		**$ -**	**$ -**	**$ -**	**$ 127,000**	**$ 20,000**	**$ 147,000**	**$ 147,000**	**$ 153,000**
Modeling Efforts									
PCSWMM License	WQN	$ -	$ -	$ -	$ 3,000	$ 3,000	$ 15,000	15,000	$ 15,000
Comprehensive Watershed Management Model Development and Application	WQN	$ -	$ -	$ -	$ -	$ 125,000	$ 225,000	200,000	$ 100,000
LRCA Floodplain Mapping	WQN	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 500,000	$ 500,000	$ 500,000
Subtotal Modeling Efforts		**$ 100,000**	**$ 100,000**	**$ 100,000**	**$ 103,000**	**$ 228,000**	**$ 740,000**	**$ 715,000**	**$ 615,000**
TOTAL - STORMWATER MANAGEMENT STUDY & INVENTORY COSTS		**$ 146,000**	**$ 146,000**	**$ 275,000**	**$ 405,000**	**$ 695,000**	**$ 2,510,000**	**$ 2,595,000**	**$ 2,553,000**

*SMP Elements:
ESH – Section 4.1 Ecosystem Health
WQL – Section 4.2 Water Quality
WQN – Section 4.3 Water Quantity
O&M – Section 4.4 Operations & Maintenance
MDA – Section 4.5 Monitoring & Data Assessment
R&E – Section 4.6 Regulations and Enforcement
E&O – Section 4.7 Education & Outreach
F&O – Section 4.8 Funding & Organization

Table 82. Capital Improvement Plan Capital Projects

Capital Project Name	SMP Element	Estimated Cost							
		Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 10	Years 11 15	Years 16 20
BMP Retrofit Engineering & Design [1]	WQN & WQL	$ 25,000	$ 50,000	$ 100,000	$ 133,000	$ 167,000	$ 1,001,000	$ 1,001,000	$ 1,001,000
BMP Retrofit Construction [1]	WQN & WQL	$ 25,000	$ 100,000	$ 100,000	$ 500,000	$ 667,000	$ 4,834,000	$ 5,001,000	$ 5,001,000
Pollution Prevention Control Plan (PPCP)	WQN	$ 1,350,000	$ 1,376,000	$ 1,402,000	$ 1,428,000	$ 414,000	$ 2,500,000	$ -	$ -
Storm Sewer Replacement and Enhanced Infrastructure Renewal Program [2]	O&M	$ 2,419,000	$ 3,101,000	$ 3,093,000	$ 3,500,000	$ 4,000,000	$ 22,500,000	$ 25,000,000	$ 29,000,000
Stormwater Network Expansion	O&M	$ -	$ -	$ 400,000	$ 200,000	$ 400,000	$ 2,000,000	$ 2,000,000	$ 2,000,000
Outfall Repairs	O&M	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 125,000	$ 125,000	$ 125,000
Culvert Replacement (less than 3 m diameter)	O&M	$ 204,000	$ 204,000	$ 204,000	$ 204,000	$ 204,000	$ 1,022,000	$ 1,022,000	$ 1,022,000
Naturalize Shoreline Habitat and Protect Riparian Zone [3]	ESH	$ -	$ -	$ -	$ 100,000	$ 100,000	$ 500,000	$ 500,000	$ 500,000
Conservation Area & Authority Site Developments	O&M	$ 293,000	$ 293,000	$ 293,000	$ 293,000	$ 293,000	$ 1,465,000	$ 1,465,000	$ 1,465,000
TOTAL - STORMWATER MANAGEMENT CAPITAL PROJECT COSTS		**$ 4,341,000**	**$ 5,149,000**	**$ 5,617,000**	**$ 6,383,000**	**$ 6,270,000**	**$ 35,947,000**	**$ 36,114,000**	**$ 40,114,000**

[1] The annual cost of designing and constructing BMP Retrofits identified in the SMP is an estimated average cost per BMP. The total cost for all 550 BMPs was estimated based on BMP footprint and other factors and was averaged in this line item. The actual cost year by year may vary based on implementing large or small scale retrofits.
[2] Assumes Boulevard Lake Dam will be reconstructed under Bridges and Culverts structural funding.
[3] The cost of riparian zone naturalization could be shared with the LRCA.

Table 83. Capital Improvement Plan Operations & Programs

Operation and Program Name	SMP Element	Estimated Cost							
		Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 10	Years 11 15	Years 16 20
Administration									
Develop Stormwater Utility	F&O	$ -	$ 100,000	$ 50,000	$ -	$ -	$ -	$ -	$ -
Establishing Human Resources of Stormwater Division	F&O	$ -	$ -	$ 150,000	$ 230,000	$ 310,000	$ 1,950,000	$ 1,950,000	$ 1,950,000
Administration of Stormwater Division	F&O	$ -	$ -	$ -	$ 230,000	$ 310,000	$ 1,950,000	$ 1,950,000	$ 1,950,000
SMP Program Evaluation Every 5 Years	F&O	$ -	$ -	$ -	$ -	$ -	$ 40,000	$ 40,000	$ 40,000
SMP Amendment Every 5 Years	F&O	$ -	$ -	$ -	$ -	$ 40,000	$ 40,000	$ 40,000	$ 40,000
Subtotal - Administration		**$ -**	**$ 100,000**	**$ 200,000**	**$ 460,000**	**$ 660,000**	**$ 3,980,000**	**$ 3,980,000**	**$ 3,980,000**
Monitoring Program									
Weather and Precipitation Monitoring	MDA	$ 6,000	$ 6,000	$ 6,000	$ 16,000	$ 7,000	$ 43,000	$ 40,000	$ 32,000
Flow and Level Monitoring	MDA	$ 107,000	$ 107,000	$ 107,000	$ 127,000	$ 109,000	$ 509,000	$ 508,000	$ 504,000
Water Quality Monitoring	MDA	$ -	$ -	$ -	$ 71,000	$ 18,000	$ 36,000	$ 17,000	$ 13,000
Subtotal – Monitoring Program		**$ 113,000**	**$ 113,000**	**$ 113,000**	**$ 214,000**	**$ 134,000**	**$ 588,000**	**$ 565,000**	**$ 549,000**
Inspection & Maintenance Program									
Incorporate Inventory Procedures	O&M	$ -	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 50,000	$ 50,000	$ 50,000
Develop a Maintenance and Rehabilitation Plan	O&M	$ -	$ 20,000	$ -	$ -	$ -	$ -	$ -	$ -
Stormwater Infrastructure Inspection	O&M	$ 15,000	$ 15,000	$ 75,000	$ 79,000	$ 83,000	$ 435,000	$ 457,000	$ 480,000
Stormwater Management Facility Maintenance	O&M	$ 621,000	$ 637,000	$ 652,000	$ 686,000	$ 731,000	$ 4,209,000	$ 4,547,000	$ 4,884,000
Storm Sewer (linear system) CCTV Inspection	O&M	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 1,000,000	$ 1,000,000	$ 1,000,000
Storm Sewer Outfall Inspection Program	O&M	$ 26,000	$ 26,000	$ 26,000	$ 26,000	$ 26,000	$ 130,000	$ 130,000	$ 130,000
Oil Grit Separator Maintenance Program	O&M	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 50,000	$ 50,000	$ 50,000
Operation and Maintenance of Erosion Control Structures	O&M	$ 109,000	$ 109,000	$ 109,000	$ 109,000	$ 109,000	$ 545,000	$ 545,000	$ 545,000
Catchbasin Cleaning	O&M	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 900,000	$ 900,000	$ 900,000
Street Sweeping Operations	O&M	$ 660,000	$ 660,000	$ 660,000	$ 660,000	$ 660,000	$ 3,302,000	$ 3,302,000	$ 3,302,000
Trunk Ditching Rural Wards	O&M	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 500,000	$ 500,000	$ 500,000
Other Ditching	O&M	$ 173,000	$ 173,000	$ 173,000	$ 173,000	$ 173,000	$ 863,000	$ 863,000	$ 863,000
Conservation Land Management	O&M	$ 167,000	$ 167,000	$ 167,000	$ 167,000	$ 167,000	$ 835,000	$ 835,000	$ 835,000
Subtotal - Inspection & Maintenance Program		**$ 2,261,000**	**$ 2,307,000**	**$ 2,362,000**	**$ 2,400,000**	**$ 2,449,000**	**$ 12,819,000**	**$ 13,179,000**	**$ 13,539,000**
Regulations & Enforcement									
Develop Site Plan Control By-Law with Wider Application Across City	R&E	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA
Modifications to Site Alteration and Zoning By-Laws	R&E	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA
Revise Engineering and Development Standards per recommendations of the SMP	R&E	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA
Develop guidance materials to facilitate compliance with By-Laws and Engineering and Development Standards	R&E	$ -	$ -	$ 50,000	$ 50,000	$ -	$ -	$ -	$ -
Develop incentive program	R&E	$ -	$ -	$ 30,000	$ -	$ -	$ -	$ -	$ -
Develop assumptions protocol	O&M	$ -	$ 30,000	$ -	$ -	$ -	$ -	$ -	$ -
Illicit Discharge and Pollution Prevention/Sewer Use Control	O&M	$ -	$ -	$ 26,000	$ 27,000	$ 28,000	$ 147,000	$ 154,000	$ 162,000
Assessment of Engineering and Development Standards	R&E	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA
LRCA Development Plan Review Input	R&E	$ 53,000	$ 53,000	$ 53,000	$ 53,000	$ 53,000	$ 265,000	$ 265,000	$ 265,000
Subtotal – Regulations & Enforcement		**$ 53,000**	**$ 83,000**	**$ 159,000**	**$ 130,000**	**$ 81,000**	**$ 412,000**	**$ 419,000**	**$ 427,000**
Public Education, Outreach, & Rebate Programs									
Municipal Staff and Contractor Education	E&O	$ -	$ 7,000	$ 7,000	$ 7,000	$ 7,000	$ 35,000	$ 35,000	$ 35,000
Residential education on SMP and Stormwater BMPs	E&O	$ -	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 125,000	$ 125,000	$ 125,000
Wetland Education	E&O	$ -	$ -	$ 3,000	$ -	$ -	$ 3,000	$ 3,000	$ 3,000
Training for construction site operators and people who operate and maintain facilities	E&O	$ -	$ 3,000	$ 3,000	$ 3,000	$ 3,000	$ 15,000	$ 15,000	$ 15,000
Partner Coordination	E&O	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA	$ NA
Continue to implement Residential Drainage Assistance Program, Rain Barrel Program, & Raingarden Rebate Program	WQN	$ 160,000	$ 160,000	$ 160,000	$ 160,000	$ 160,000	$ 800,000	$ 800,000	$ 800,000
Develop BMP Cost-Share Program	WQN	$ -	$ -	$ -	$ 50,000	$ 50,000	$ 250,000	$ 250,000	$ 250,000
PCSWMM Training for Municipal Staff	E&O	$ -	$ -	$ -	$ 3,000	$ -	$ -	$ -	$ -
LRCA Stewardship Programs	E&O	$ 21,000	$ 21,000	$ 21,000	$ 21,000	$ 21,000	$ 105,000	$ 105,000	$ 105,000
Subtotal - Public Education, Outreach, & Rebate Programs		**$ 181,000**	**$ 216,000**	**$ 219,000**	**$ 269,000**	**$ 266,000**	**$ 1,333,000**	**$ 1,333,000**	**$ 1,333,000**
TOTAL - STORMWATER MANAGEMENT OPERATIONS & PROGRAM COSTS		**$ 2,608,000**	**$ 2,819,000**	**$ 3,053,000**	**$ 3,473,000**	**$ 3,590,000**	**$ 19,132,000**	**$ 19,476,000**	**$ 19,828,000**

5.6 Funding Strategies

The estimated costs for the City to implement the actions included in this implementation plan as defined in Section 5 *Corrective Actions / Implementation Plan* are summarized in Table 82, Table 81, and Table 83. These actions are broken down into 3 project types; 1) Capital Improvement Projects (CIP), 2) Programs, and 3) Studies/Inventories. Capital Improvement Projects include but are not limited to new stormwater capacity, quality or volume control improvements as well as restoration activities. Programs include on-going education, inspection, maintenance, and pollution prevention activities that are necessary to maintain the existing system. The Studies/Inventories category includes projects necessary to evaluate the City's system including detailed modeling analyses and feasibility studies.

As the City evaluates the feasibility studies, projects and programs it needs to accomplish to meet the goals and objectives of the SMP, it also needs to determine how best to fund these activities. Currently the City of Thunder Bay finances existing programs, projects and operation and maintenance activities through taxes and the sewer surcharge rate. According to the City's 2014 AMP, the City is currently operating at a deficit for future replacement of existing storm sewer infrastructure. To provide financial security for existing and future stormwater management functions and support the implementation of a successful stormwater management program, the City needs to explore means of generating sustainable funds.

The funding sources available to the City for stormwater management are varied and the most cost-effective approach would likely be a combination of strategies. Below is a description of the most common funding sources other organizations and municipalities use to finance stormwater programs. Advantages and disadvantages associated with each alternative are also discussed, as well as an indication of the activity (e.g. administration, feasibility studies, design, operation, maintenance, renewal/replacement, capital improvements, monitoring, data collection, etc.) for which the funding source is best suited.

5.6.1 Funding Sources

This section describes some of the various funding sources that could be used by the City to finance the implementation of the SMP.

5.6.1.1 Tax Levy

Many communities the size of Thunder Bay fund stormwater management programs and projects using the city's tax levy. This is how Thunder Bay currently finances a significant portion of its stormwater management activities in addition to sewer surcharge rate and grants. Property tax revenue typically contributes the greatest amount to municipal funds which can best be described as a "bank" into which revenues are placed and from which most programs are funded. While these funds are appropriated for specific purposes, they remain relatively consistent from year to year. It has been our experience that competition for funding results in a lower priority being given to stormwater management over other public services. Nevertheless, general tax revenue can be used for partially or totally funding components of the stormwater management program including; administration, design, renewal/replacement, maintenance, and monitoring (see Table 85).

5.6.1.2 Fees and Development Charges

Fees may be obtained from permit reviews, plan reviews, and other fees associated to planning and development. Currently in Thunder Bay, development review fees do not go towards funding engineering or stormwater management works. Fees collected for permit and plan reviews are typically used for carrying out specific regulatory functions. For example, permit fees and sureties can be used to confirm that development plans are in compliance with By-Laws and Engineering and Development Standards as well as conduct permit inspections to make sure proper BMP installation and maintenance. Using permit fees to conduct regulatory functions is generally perceived as a more equitable use of funds than conducting these activities using the tax levy or utility rates.

The Development Charges Act, 1997 provides sufficient flexibility for municipalities to apply development charges in a manner that meets local needs and goals. Typically a one-time development fee can be charged either by number of units built, impervious surface being created, or by area as a function of land use and associated run off (e.g. a single family development would pay less per hectare than a commercial/industrial development).

5.6.1.3 Stormwater Utility

To generate funds to manage stormwater and its impacts, most of the communities the size of Thunder Bay or bigger have created stormwater utilities that charge a fee to residential, industrial and commercial stormwater customers. A stormwater utility is a mechanism designed to fund the cost of services directly related to the implementation of stormwater programs. Similar to a water or sewer utility, a stormwater utility is a stand-alone service unit that generates revenues through user fees for services related to the control and treatment of stormwater, separate from the tax levy.

A stormwater utility fee payer is assigned an equitable share of the cost of the stormwater management program, based on the relative contribution to the storm sewer system. This share is determined by the amount of runoff contributed by the property. The basic premise of the utility is: the greater the amount of runoff generated the greater the contribution to the system and the greater the cost to control, convey and treat the stormwater.

There are three common methods for collecting stormwater utility fees: (1) flat fee, (2) equivalent residential unit (ERU), and (3) tiered rate structure (typically based on the size/value of the residential unit). Flat fees and tiered rate structures are used more frequently for residential customers in cities where the vast majority of development is residential. ERU fees are more common for non-residential customers (e.g. commercial, industrial, institutional, etc.) and the most widely used (and fair) method of establishing stormwater rates.

There are several factors that should be considered when developing a stormwater utility including population size, poverty rate, median household income, geographical/site characteristics and other factors. In addition, a sustainable stormwater utility should include a credit program for customers that implement mitigation steps (e.g. rain gardens, rain barrels) on their own properties.

The establishment of a stormwater utility provides funding for the five significant elements of an integrated stormwater management plan: administration and design, operation and maintenance, renewal/replacement, capital improvements and monitoring. This income can also be used to pay the debt service for a stormwater capital improvement program, thereby leveraging the utility's annual revenue into a major program.

5.6.1.3.1 Establishment of Stormwater Utility in Kitchener, Ontario

The City of Kitchener was the first municipality in Canada to implement a stormwater utility fee based on impervious area.

Beginning in 2004, residents of Kitchener expressed growing concerns that Victoria Park Lake, a 26 hectare water body centrally located between the City of Kitchener and the City of Waterloo, had experienced high nutrient concentrations and was rapidly filling with sediment. The political environment that ensued motivated an Environmental Assessment (EA) by the MOECC in 2009. During the two years that followed the EA completion, the City of Kitchener developed a financial strategy for a capital improvement project on Victoria Park Lake; funded one-third from the Water budget, one-third from Wastewater budget, and one-third from a proposed stormwater utility fee. Although the stormwater utility was initially slow to gain political momentum within City Council, Kitchener transferred stormwater management funding from property taxes to a user-fee program, effective Jan. 1, 2011. A series of rate tiers were established, calculated based on property type and size of impervious area, to account for the varying degrees of water runoff generated. This approach was considered to be more fair and equitable than charges based exclusively on property values.

The City of Kitchener stormwater program financed by the stormwater utility initially consisted of one Stormwater Program Manager, one Engineering Project Manager, one Financial Analyst, and one Operations Supervisor. In addition to these four dedicated staff, approximately 40 personnel from the Engineering and Operations Departments provided technical support during the implementation and billing process. This additional support was critical as the City received an average of 300 phone calls per week from residents during the initial years of implementation. For the first two years the entire stormwater program budget of $13M was appropriated to the Victoria Park Lake capital improvement.

In March 2012, the City of Kitchener approved the stormwater credit policies, providing incentives to property owners who use best management practices to reduce the quantity and improve the quality of stormwater runoff entering the municipal stormwater system. Property owners are now able to apply for stormwater credits of up to 45% of the stormwater portion of their utility bill. The stormwater credit program required hiring two additional staff; one Technologist and one Program Assistant.

The current organizational structure of the stormwater program is not an independent department and instead is split between Operations and Engineering. The three engineering design professionals within the stormwater program are also involved in the beginning stages of development review. Regular inspections of stormwater infrastructure are performed by the stormwater Technologist and a field staff person. The subsequent operations and maintenance are largely performed by 10-15 staff from the Sanitary Sewer Department, with moderate assistance from the two stormwater inspections staff. The City has plans to eventually transition the 8 current FTEs of the stormwater program into a new and independent section of the Operations Department.

For more information related to organizational structure see Table 69 to Table 71 and for information on stormwater utility fees of other municipalities see Table 86.

5.6.1.4 Grants

Grants are available through various programs to help local communities implement nonpoint source pollution control programs. The requirements and funding for these programs vary a lot. At a minimum the City should consider the following grant sources:

Federal

- **Climate Change Adaptation Program (CCAP)**[64]
  Aboriginal Affairs and Northern Development Canada (AANDC) has developed CCAP, which is designed to support communities in their preparation for the challenges created by a changing climate. This program funds projects that specifically involve members of the community. Projects funded through CCAP in FY2014 did not exceed $500,000 and were centred on developing management strategies and identifying the appropriate actions to reduce risks associated with climate change impacts. In addition to funding resources, CCAP offers guidance and information in climate change resilience for the design of upgrades and new infrastructure.

- **Gas Tax Fund** ($6,588,917 allocated in Ontario for 2016)[65]
  As part of the New Building Canada Plan, the renewed federal Gas Tax Fund (GTF) provides predictable, long-term, stable funding for Canadian municipalities to help them build and revitalize their local public infrastructure while creating jobs and long term prosperity. Originally designed to provide municipalities with $5 billion in predictable funding over five years, the GTF has been extended, doubled from $1 billion to $2 billion annually, and legislated as a permanent source of federal infrastructure funding for municipalities. Communities are using federal GTF for the following types of projects: local roads and bridges, capacity building, disaster mitigation, and brownfield redevelopment. As a result of the wide range of projects that qualify, stormwater programs often compete with other infrastructure development projects of equal or greater priority.

- **New Building Canada Fund – Provincial-Territorial Infrastructure Component**[66]
  The Provincial – Territorial Infrastructure Component of the New Building Canada Fund provides $10 billion in support for projects of national, regional, and local significance. The majority of this dedicated fund is allocated to projects that involve larger communities. Through this program most qualifying projects will be federally cost-shared by one-third and additional funding through the GTF (mentioned above) can supplement additional portions of project costs. In Ontario the primary contact agency for this fund is the Ministry of Economic Development, Employment and Infrastructure.

- **Recreational Fisheries Conservation Partnerships Program**[67]
  Legislative amendments to the Fisheries Act of Canada were put in place to allow the Minister of Fisheries and Oceans to partner with third parties and undertake activities which restore recreational fisheries habitat. This Recreational Fisheries Conservation Partnerships Program provides project-based funding for many different types of habitat restoration. Some examples include, but are not limited to stream channel and bank erosion control, construction of in-stream habitat, and fish passage improvement.

- **Federation of Canadian Municipalities (FCM) – Green Municipal Fund**[68]

  The Canadian government has allocated $550 million to FCM to create a perpetual endowment called the Green Municipal Fund, a long-term sustainable source of information and funding for municipal governments and their partners. The fund is divided into two different types of grants. The first type involves approximately $6 million in grants is approved each year to fund up to 50% of plans, feasibility studies, and field tests. Examples of eligible plans are neighbourhood action plans and community brownfield action plans. Feasibility plans revolve around environmental, social, and economic impacts of a potential environmental project. The second type involves $30 million in below-market loans and $5 million in grants for funding capital projects. The below-market loans fund up to 80% of project costs, however, the grant component of this program has typically been about 10% of the approved loan amount. With a competitive loan and funding approval process for capital projects, this program has eligibility criteria for water conservation and stormwater management projects. Rainwater collection, bio-retention facilities, and other infiltration practices are examples of projects encouraged through this fund.

Provincial

- **Ontario Community Infrastructure Fund (OCIF)**[69]

  This permanent source of funding, launched in August 2014, provides predictable and long-term support for infrastructure projects in small, rural, and northern communities. Half of the annual $100 million of funding will be allocated annually using a fair and transparent formula, which recognizes that municipalities have different infrastructure needs. The remaining $50 million will be distributed through an application-based process. The formula component is $1,416,800 annually for 2015-2017.

- **Showcasing Water Innovation (SWI) Program**[70]

  In April 2011 the MOECC introduced the Showcasing Water Innovation (SWI) program as a complement to the 2010 Ontario Water Opportunities and Conservation Act. The SWI program was created to encourage the early adoption of innovative and cost effective approaches and technologies for advancing integrated sustainable water management. The objective of SWI was to fund up to 50% of eligible project costs (maximum of $1 million) for a small number of projects in a representative set of Ontario communities. In total, the program invested $17 million in provincial funding over a several years to assist communities across Ontario to use innovative practices and new water technologies to manage their water. Thirty-two projects were chosen to receive funding and each is now well under way. There are plans to call for new funding applications in the future and specific dates have not yet been announced.

- **Ontario Trillium Foundation (OTF)**[71]

  The Ontario Trillium Foundation (OTF) is an agency of the Ontario government that awards more than $110 million annually. The Collective Impact Grants program requires co-design of solutions through partnerships across multiple agencies and organizations. Grants amount up to $500,000 per year for a maximum of 5 years and provide a sustainable source of funding for projects that include multiple phases. OTF offers a number of other grant programs that would be more amenable to community groups and organizations interested in initiating water management projects of their own.

- **Rural Water Quality Program**[72]

  In collaboration with Conservation Authorities and municipalities, MOECC provides cost-sharing grants to landowners of rural properties and farms for practices that improve ground and surface water quality.

- **Ontario Drinking Water Stewardship Program (ODWSP)**[73]

  The MOECC provides funding towards implementing practices that improve municipal drinking water sources. This program namely has revolved around municipal wellheads and municipal surface water intakes, however, other related projects have included septic system upgrades, runoff and erosion control, and pollution prevention.

Private Funding Sources

- There a number of non-profit organizations and philanthropic foundations that provide grants of smaller amounts for water conservation, wildlife habitat restoration, and shoreline naturalization. These programs may prove to be valuable resources for landowners and members of the community whom express interest in water resources management. Some of these programs include:
  - RBC Blue Water Community Action Grants
  - Evergreen Canada's Green Grants and Take Root Grants
  - Watersheds Canada's Natural Edge cost-share
  - CN Econnexions
  - Great Lakes and St. Lawrence Cities Initiative (GLSLCI)

5.6.1.5 Local Improvement Charges

The Local Improvement Charges regulation under the 2001 Ontario Municipal Act authorizes municipalities in Ontario to recover all or part of the cost of capital improvement projects by imposing local improvement charges on properties that benefit from the work. The Local Improvement Charges regulation does not specifically limit the types of capital projects municipalities can undertake. Local improvement charges enable local government units to raise revenue for the construction or expansion of capital facilities necessitated by new development. These fees can be generally spread over several years to minimize the annual payment property owners have to make. Local improvement charges are typically used in situations in which the benefit and impact of new development or redevelopment on existing City's stormwater infrastructure is:

1. Measurable and certain;
2. Quantifiable in terms of the incremental capital investment that will be required to maintain an adequate service level in the face of the added runoff flows and volumes attributable to the development.

For stormwater management, these Local Improvement Charges are most suitable for small-scale retrofit applications (e.g. green infrastructure projects that improve drainage at a neighbourhood-scale or for few properties). For example, if stormwater management practices are constructed along a road with no or inadequate stormwater system, then the flooding control increases the value of properties along the road. Therefore, the capital cost of those improvements could be apportioned to the property owner. In our experience Local Improvement Charges are not typically used as the only funding source for stormwater projects.

5.6.1.6 Subdivision Agreement

As a condition of approval for development, municipalities typically require the developer of a subdivision or large parcel to construct stormwater management facilities and dedicate them to the City upon completion. This is the approach currently used by the City for new subdivision developments. In addition, developers are required to dedicate drainage easements or other types of partial rights to the City for stormwater management purposes. Thus, the developer would be responsible for funding the initial capital program while the City would be responsible for funding the operation and maintenance after Final Acceptance is granted by the City. The City is ultimately responsible for the long-term capital replacement of the infrastructure.

5.6.1.7 Penalties and Fines

Some municipalities have a set fee / fine system for permits and infractions relating to stormwater management. Currently in Thunder Bay, there is no permit fee or set fines for stormwater or erosion control related permits or infractions. Similar to permit fees, penalties and fines are limited in scope and, in most cases, are intended to cover only the cost of administration and enforcement. Thunder Bay does have a Site Alteration By-Law, which is used to establish an inspection program that promotes compliance with applicable standards and guidelines related to design, construction, and maintenance for both public and private works. A number of cities place this permit fee income in the tax levy or to complement the stormwater fund, however, it is more beneficial to use the fines to correct stormwater violations. Penalties and fines alone are not sufficient to fund either capital improvements or operation and maintenance programs.

5.6.2 Financing Capital Strategies

5.6.2.1 Debentures

Debentures are means of borrowing money and are most commonly used by cities to pay for large stormwater capital improvement projects, however, municipalities are not allowed to borrow for operation and maintenance purposes. Repayment (including interest and loan principal) is normally done through the city's tax levy or rate generated funds. Debentures allow large-scale stormwater capital improvement projects to be initiated when the stormwater facilities are needed or opportunities arise, rather than waiting until the funds are accumulated.

"Green" bonds are a newer source of funding dedicated to environmentally-friendly projects. Like normal bonds, green bonds can be issued by governments, multi-national banks or corporations. In Ontario, the Federation of Canadian Municipalities Green Municipal Fund and the Province of Ontario Green Bonds are examples of issuing entities. Hamilton and Toronto have been able to secure debentures for environmentally friendly capital projects at preferential financial terms.

5.6.2.2 Public-Private Partnerships

Public-Private Partnerships is a yet uncommon but growing stormwater financing source for municipalities in the U.S.A. Although no such partnerships have yet been formed in Canada, this is an emergent idea that may affect the implementation of this plan for the next 20 years.

This approach engages the private sector more deeply in funding stormwater infrastructure projects to meet public needs. There is a contractual agreement between the city and the private sector that allows for the private sector involvement in financing, planning, design, construction, operation, maintenance and rehabilitation of urban stormwater facilities and Best Management Practices.

5.6.2.3 Credits and Incentive Programs

Although not a direct funding mechanism, stormwater credits and incentive programs are often used by cities to promote and reward developments that go beyond the minimum stormwater permitting requirements established by the city. The most commonly used credit system is fee discounts (e.g. reduction in stormwater area charges or stormwater utility charges). Other credit/incentive programs like stormwater credit exchange, water quality trading or installation financing, are not as common. The Lake Simcoe Conservation Authority is currently exploring the development of a Phosphorous Off-Set Program which would require the developer pay for the phosphorous that can't be removed with the stormwater management plan. Funds from the Phosphorous Off-Set Program would be used to retrofit existing infrastructure to remove phosphorous and other pollutants from the system. Credits and incentive programs can be applied to both new development and retrofit projects.

5.6.3 Comparison of Funding Sources (Advantages and Disadvantages)

Table 84 summarizes the individual funding sources described in the previous section and presents the advantages and disadvantages of each strategy for funding stormwater management programs and activities. The information presented in Table 84 forms the basis of the recommendations made in the next section of the Plan.

Table 84. Comparison of Funding Sources

Funding Source	Description	Advantages	Disadvantages
Tax Levy	Funds raised through property taxes that are paid into a general fund.	- Consistent from year-to-year - Utilizes an existing funding system (i.e. administrative structure for collection in place) - Allows for a larger revenue base - Simple and accepted source of revenue	- Competition for funds - May be unclear to residents how/why tax funds are allocated to stormwater projects - Tax-exempt properties do not contribute - Tax levy is based on the property value for all households, and may not be an equitable system (i.e. does not fully reflect contribution of stormwater runoff)
Fees and Development Charges	Funds raised through charges for services related to regulatory functions (i.e. permit review and inspections). Funds raised through developer impact fees are one-time charges linked with new development.	- Specific permit and inspection fees allow for more direct allocation of costs for services provided - Directly addresses stormwater impacts related to new construction (i.e. new development generating runoff pays for runoff management) - Makes the development community more accountable for impacts - More equitable use of taxpayer dollars - Avoids competing with other programs and needs covered by the tax levy	- Public projects may be exempt - Addresses enforcement of new issues, not correction of major problems - Requires administrative framework and time to manage - Limited life as a financial mechanism - Unreliable source of funding (related to health of housing market) - Addition of Development Charges may be inferred to increase housing costs.
Stormwater Utility	A stormwater utility generates funds through user fees and the revenue from the stormwater charges into a separate fund dedicated to stormwater management.	- Dedicated funding source - More fair and equitable: link fee levels to the service benefits that payers receive. - Reflect the cost of the services being provided - Easy, sustainable, stable and frequent source of revenue - Shared cost - Provide incentives for payers to reduce their fees - Addresses existing stormwater management issues - Can be designed to include tax-exempt properties - Better capacity of response to the demands of new Provincial and Federal regulations and new development	- Some analysis required for implementation, fee and administrative structures - Perception by the public of a “tax on rain” - Potential impact on churches, schools and other tax exempt property not currently paying for stormwater management services - User charges based on the cost of providing customer service and not on their ability to pay for those services

Funding Source	Description	Advantages	Disadvantages
Grants	Provincial and Federal grants provide additional funding for stormwater management improvements	- Reduce cost burden to city residents - Existing sources available for stormwater-related funding - Does not require repayment	- Competitive - Typically one-time, project-specific, or time-constrained funds - Undependable source of revenue - Often requires a funding match
Debentures	A loan secured by a specific physical asset. A debt service secured by the issuer's promise to pay the interest and the loan principal. Debentures are not a true revenue source, but are means of borrowing money. "Green" bonds are a newer source of funding dedicated to environmentally friendly projects, including clean water projects.	- Allow large-scale capital improvement, construction-ready projects and programs to be initiated when needed - Existing sources available for stormwater-related funding - Steady repayment over the period of the debenture, and spreads the cost over the life of the infrastructure.	- One-time source of funds - Requires individual approval for issuance - Requires full repayment and long-term commitment of annual revenues to pay for the debt service - Possible high interest and transaction charges - Generally requires dedicated repayment revenue stream that can't be used for continued maintenance of systems - May require significant administrative preparation
Local Improvement Charges	Unique, one-time fees a city assesses against specific benefited properties to fund stormwater projects. The capital cost of the improvements is apportioned to the property owner based on benefit.	- Only benefited properties pay - Funds for facilities or operation and maintenance are used in the area where the money is collected - Flexible to allow assessment based on different parameters (e.g. property value, lot size, etc.) - Assessment can be deferred in hardship cases - Easy use in conjunction with a Stormwater Utility	- Rigid procedural requirements - Sometimes is difficult to determine and prove stormwater or water quality benefit - May place an unfair burden on some segments of the population - The assessed area may not be capable of generating the required revenues - Pays for initial capital cost but not on-going maintenance and future replacement.
Subdivision Agreements	As a permit condition, the City could require the developer of a subdivision or large parcel to construct stormwater management facilities and dedicate them to the City upon completion.	- Developer responsible for partially funding the capital program - City only responsible for funding operation and maintenance and future capital replacement	- Stormwater facilities transferred to City may not have been properly designed which then would require updating of design standards and acceptance protocols - Discharge may aggravate downstream flooding issues - Intensive design review by City and MOECC is required
Penalties and Fines	Funds typically raised due to construction mismanagement or downstream impact.	- Can be used to support the tax levy or to complement the stormwater fund - It covers the cost of administration and enforcement and can be used to correct stormwater violations	- Very limited in scope and not sufficient to fund either capital improvements or operation and maintenance programs

Funding Source	Description	Advantages	Disadvantages
Public-Private Partnerships	Contractual agreement between the city and the private sector that allows for the private sector involvement in financing, planning, designing, constructing, operating, maintaining and rehabilitating urban stormwater facilities and Best Management Practices.	- Can reduce costs to government - Significant leverages public funding and government resources - Provides for adequate, dedicated funding - Improved O & M - Shared financial risk	- Perceived loss of public control - Private financing could be more expensive. Contract negotiations could be difficult
Credits and Incentive Programs	It is not a direct funding source, but stormwater credits and incentive programs are often used to promote and reward developments that go beyond the minimum stormwater requirements.	- Incentivizes the development community to go beyond minimum stormwater requirements	- Not a source of revenue

Source: Expanded from *Paying for Green Infrastructure, Financing Options and Resources for Local Decision-Makers*. Environmental Protection Agency, December 2014. EPA 842-R-14-005.

5.6.3.1 *Funding Stormwater Management Activities*

The following table identifies how the various funding sources presented in this Section of the Plan can be used to fund the main components of the SMP including: Stormwater Management Administration and Design; Modeling and Feasibility Studies; Capital Improvement Program; Operations & Maintenance; and Monitoring Activities.

Table 85. Linking Funding Sources to Functional Program Elements

Funding Source	Functional Program Elements				
	Stormwater Management Administration and Design	Modeling and Feasibility Studies	Capital Improvement Program	Operations and Maintenance	Monitoring Activities
Tax Levy	√	√	√	√	√
Fees and Development Charges	√	√	√		
Stormwater Utility	√	√	√	√	√
Grants	√	√	√		
Debentures			√		
Local Improvement Charges			√		
Subdivision Agreements			√		
Penalties and Fines	√			√	√
Public-Private Partnerships	√	√	√		
Credits and Incentive Programs			√		
√ *indicates source could fund the stormwater management activity*					

Since many of the funding sources are variable depending upon the activities being undertaken, the easiest cost to estimate is the Stormwater Utility. Table 86 shows the Stormwater Utility charged by other municipalities of comparable size.

Area Charges is the main funding mechanism used by municipalities to finance the stormwater infrastructure needed to serve new developments. They fluctuate significantly from about $4,000 - $20,000/acre for single family residential developments, to about $15,000 - $200,000/acre for commercial, industrial and institutional.

Table 86. Examples of Typical Annual Stormwater Utility Fees Charged in Minnesota and Canada

Community	2013 Population *	Date of Inception	Current Annual Stormwater Fees				
			Single Family Properties			Multi Family Residential	Other (Commercial, Industrial, Institutional)
			High Impervious	Medium Impervious	Low Impervious		
Edmonton, AB	877,926 (2014)	2002	Lot size in m^2 x Runoff Coefficient (typical is 0 .35 - 0.65 for single family) x monthly rate ($.0330 per m^2). Rates for an 700 m^2 property			Runoff Coefficient of 0.65 - 0.80 and 400 m^2 per household	Runoff Coefficient of 0.8. For a 4,000 m^2 property the fee is:
			$180	$138	$95	$103 - $127	$1,270
Calgary, AB	1,195,194 (2014)	1994	$132			$132	$132
St. Albert, AB	63,400	2003	$137			$137	$374
Strathcona Cnty, AB	93,000	2007	$24 - $108			$108	N/A
Richmond Hill, ON	185,541 (2011)	2013	$48			$138	
[!]Hamilton, ON	505,000	2006	$.30/day + ($0.71 x m^3 metered water consumption/ month)	$.30/day + ($1.41 x m^3 metered water consumption/ month)		$903	Mid-Size (2,272 m^2) = $5,993 Large (22,727 m^2) = $60,541
[!]Stratford, ON	31,000		157.6% of water use charge + $1.00/month fixed charge				
Kitchener, ON	219, 153 (2011)	2011	$160	$122	$73	$98 – $244	$234 – $24,851
Waterloo, ON	98,780 (2011)	2011	$143	$65	$43	$124 - $2,793	$166 - $6,332
London, ON	384,400	1996	$140			$140	Commercial = $170 Institutional = $135 Industrial = $995/ha/yr to $1,170/ha/yr
Aurora, ON	56,000	1998	$169			$169	Commercial and Industrial only = $692
St. Thomas, ON	41,700	2000	$88			$88	$88 for areas less than 1,800 m^2 and $1,213/ha/yr for areas more than 1,800 m^2
Mississauga, ON	757,200	2016	$170	$100	$50	(Total impervious area / 267 m^2) x $100	

Community	2013 Population *	Date of Inception	Current Annual Stormwater Fees				
			Single Family Properties			Multi Family Residential	Other (Commercial, Industrial, Institutional)
			High Impervious	Medium Impervious	Low Impervious		
Guelph, ON	132,000	Being Studied in 2016	Stormwater user fee approved February 2016 with plans to develop fee schedule by 2017.				
Toronto, ON	2.7 million	-	Stormwater management activities are financed as a part of a general User Fee that covers water, sanitary and stormwater				
Saskatoon, SK	257,300 (2014)	2012	$53 per Equivalent Stormwater Unit (ESU) of 265 m^2 on average. High Impervious = 3 ESU, medium impervious = 2 ESU, low impervious = 1 ESU			2 - 3 ESU equivalent (estimated)	4 ESU equivalent (estimated)
			$159	$106	$53	$106 - $159	$1,270
Regina, SK	220,000	2001	Residential lots up to 1,000 m^2 = $175			Lots from 1,000 m^2 to 30,000 m^2 $350 - $5,260	
Surrey, BC	468,300	-	$161 per parcel tax used only for flood control, regardless of zoning and size				
West Vancouver, BC	43,000	-	$121 residential parcel tax used only for flood control			-	-
White Rock, BC	20,200	-	$276			-	-
Minneapolis, MN	400,070	2005	1.25 ESU $172	1.00 ESU $137	0.75 ESU $102	Gross lot size (ft^2) x Runoff Coefficient divided by 1,530 ft^2 = # ESUs	
Rochester, MN	110,742	2003	(Residential Charge applied equally to all parcels) $80/parcel			$117 - $199	
Woodbury, MN	65,656	1990	(Residential Charge applied equally to all parcels) $69/parcel			$208 - $417	
Inver Grove Heights, MN	34,344	2007	$32 - $96	$21 - $62	$15 - $46	$50 - $206	$96 - $399
Roseville, MN	34,934	2000	(Residential Charge applied equally to all parcels) $47/parcel			$362/acre	$181 – $724/acre

*All rates were from the period of 2012-2013 rates (on average) unless otherwise indicated in parentheses.

ESU= Equivalent Stormwater Unit

[!] The User Fee collected is used for both stormwater and wastewater

5.6.4 Recommendations

As this Section demonstrates, the funding sources available to the City for stormwater management are diverse. The most cost-effective approach for funding the SMP will likely be a combination of these strategies. As the City restructures its Divisions to more effectively administer and implement its stormwater management program, the range of options presented in this Section of the Plan should be explored.

Based on our experience with other cities with similar stormwater management goals and challenges, we recommend that the City establishes a stormwater Utility Fee and a Development Area Charge. Thunder Bay should also continue to actively seek grant funding. The pioneering SMP and the Great Lakes Area of Concern classification by the Federal Government, should position Thunder Bay on the front line to receive those grant funds.

6 FRAMEWORK FOR A STORMWATER ASSET MANAGEMENT PLAN

6.1 Purpose, Documentation and Components

The purpose of this section is to set the framework for an SAMP that incorporates all existing and future stormwater infrastructure. For this purpose, the framework for the SAMP builds upon the City's past asset management efforts regarding stormwater infrastructure. It is recommended that the additional considerations outlined for the SAMP be used to initiate a departmental asset management plan (the SAMP) for operational purposes while only certain considerations be incorporated into the stormwater section of the existing comprehensive AMP, where they are deemed applicable by the City's staff. The stormwater component of the City's financial AMP produced by the City's staff in December 2014, was used as a template for this framework.

The guide developed by the Ministry of Infrastructure of Ontario titled: "BUILDING TOGETHER: Guide for Municipal Asset Management Plans (2012)" was also used as a reference for content and structure. Other key documents utilized to develop this section are:

- City of Cambridge, ON AMP, 2013
- Town of Caledon, ON AMP, 2013
- City of Brampton, ON Stormwater Management/Low Impact Development Operations, Maintenance, and Monitoring Report, 2012
- City of Grand Rapids, MI AMP, 2014
- Ontario Structure Inspection Manual, 2014
- Canada's National Water and Wastewater Benchmarking Initiative (NWWBI), 2013
- Credit Valley Conservation Authority - Stormwater Management Certification Protocols for the City of Toronto, 2014
- Thunder Bay Enhanced Infrastructure Renewal Program (EIRP), 2012
- Minnesota Urban BMP Manual
  - Stormwater Best Management Practices for Cold Climates, 2012
- Inver Grove Heights, MN - Stormwater Management Manual, 2013
- Minnesota Pollution Control Agency - Stormwater Manual, 2014
- Optimizing Stormwater Treatment Practices:
  A Handbook of Assessment and Maintenance, 2013
- EPA website:
  http://water.epa.gov/polwaste/npdes/swbmp/BMP-Inspection-and-Maintenance.cfm
- Various EOR reports and studies

This section also presents recommendations for the following components of the SAMP:

- **State of Local Infrastructure**

  Existing stormwater data base was assessed and used in consultation with various City Divisions. Recommendations were developed based upon the following elements:
  - Asset types and quantity/extent of the assets
  - Valuation and replacement cost estimation of stormwater assets
  - Age distribution and expected useful life
  - Asset condition

- **Levels of Service**

  Recommendations to establish quality thresholds at which municipal services should be supplied to the community were included throughout this section. Recommendations were developed for the following elements:
  - Performance measures and expected levels of service for the stormwater system
  - Current performance of infrastructure relative to the desired performance targets
  - Which performance targets should be associated with which assets

- **Asset Management Strategy**

  Recommendations for the construction and long-term maintenance of a Comprehensive Watershed Management Models to allow a better definition of Thunder Bay's Asset Management Strategy were developed as part of the Modeling Section in this report. Recommendations were developed for the following elements:
  - Maintenance, renewal/rehabilitation and replacement activities
  - Risks associated with the SAMP strategy

- **Financing Strategy**

  Potential stormwater infrastructure financing strategies were developed as part of the SMP's Financial Section and are discussed later on in this section.

6.2 Stormwater Assets and Framework Organization

The specific existing and future stormwater assets for which recommendations are developed include:

- Gravity pipes (including culverts greater than 3 metres), pumping stations and force mains (already incorporated in the City's AMP)
- Culverts less than 3 metres
- Manholes and catchbasins (indirectly accounted for in the City's AMP; specific recommendations are included in this section)
- Outfalls (indirectly accounted for in the City's AMP; specific recommendations are included in this section)
- Ditches/open channels, including concrete lined channels and excluding standard, roadside grassed ditches
- Dry and wet ponds
- Infiltration basins
- Infiltration trenches
- Bioretention and rain gardens
- Sand filters
- Filter strips
- Dry swales
- Tree trenches/boxes
- Pervious Pavers (i.e. porous asphalt or interlock concrete)
- Oil-Grit Separators (OGSs)
- Skimmers
- Fish ladders
- Lake dams
- Soil nailing to stabilize failed streambanks

The following recommendations for the SAMP framework have been organized following the sections of the City's AMP and the 2012 guide by the Ministry of Infrastructure of Ontario titled: "BUILDING TOGETHER: Guide for Municipal Asset Management Plans."

6.3 Framework Recommendations for the SAMP

The following sections include general and specific recommendations to be considered when incorporating the SAMP into the City's comprehensive AMP or when creating a separate departmental SAMP document. These recommendations are to be considered in addition to stormwater sections already developed in the City's AMP.

6.3.1 Inventory of Stormwater Assets

A detailed inventory of all public owned stormwater management assets mentioned in Section 6.2 above is key to develop a useful and effective SAMP.

All already inventoried, partially inventoried and not yet inventoried stormwater assets, should follow the format outlined in the Ontario Structure Inspection Manual. Electronic data is preferred, but paper form would also be appropriate.

The existing and future assets to be inventoried are:

- Gravity pipes; all sizes
- Pumping stations and force mains; all
- Culverts less than 3 metres; from 450 mm to 3000 mm (excludes driveway culverts)
- Manholes, catchbasins, and outfalls; all (current estimate includes about 11,000 catchbasins, 4,200 manholes and 380 outfalls)
- Ditches/open channels; more than 1 metre bottom width
- Ponds, OGS, LID/BMPs, skimmers, fish ladders, lake dams; all

At a minimum, the following inventory entries are recommended:

- Type and identification of asset
  (e.g. pipe # A35, manhole # A35-1, ditch # golf links 3, pond # Terrace 1, etc.)
- Material (e.g. CSP, RCP, PVC, etc.)
- Location
- Dimensions (incorporate picture in the data base)
- Construction year and condition
- Last inspection
- Probability of failure as defined on page 78 of the AMP
  (excellent condition = score of 1, critical condition = score of 5)
- Invert elevation and depth
- Consequence of failure using the ranking in page 80 of the City's 2014 AMP modified as follows:

– Culverts < 3m	450 mm - 1050 mm = score of 1 1,051 mm - 2000 mm = score of 2 2,001 mm - 3000 mm = score of 3
– Manholes and catchbasins	≤ 2 m deep = score of 1 > 2 m deep = score of 2
– Ditches	1 m – 2 m bottom width = score of 1 > 2 m bottom width = score of 2
– Wet Ponds	< 4,000 m3 = score of 3 4,000 m^3 - 8,000 m^3 = score of 4 > 8,000 m^3 = score of 5
– OGS, LID/BMPs & skimmers	Score 1 to 5 depending upon the quality of the downstream resources impacted by the failure or defective operation
– Fish ladder	To be determined at a later date
– Lake dams	Score 5

Regarding culverts less than 3 metres, the City has already developed a GIS shapefile identifying the location of 390 culverts. This shapefile keeps track of the culvert's latest inspection, including the date, inspector, condition of the pipe, other conditions around the culvert, and other comments. The shapefile also has the diameter, length, and material of most of the culverts (only missing diameter of 9 culverts and material of 8 culverts). It is recommended that all of the entries/attributes listed above are added into the culvert's GIS shapefile. Regarding other culverts, it is recommended that any future inventory concentrate first on the priority watersheds identified in this plan.

6.3.2 Changes and Additions Compared to the City's AMP

As the City develops the SAMP with the AMP as a starting point, it is recommended that elements are modified as shown below and organized based on the sections of the AMP. These recommendations are based on all the information and reports listed in Section 6.1 and on other communities' experience. Also, all recommendations should be considered for potential future incorporation into the AMP.

For example, the expanded inventory of small culverts could assist the department in estimating how the operational costs of replacing those structures may fluctuate annually depending on factors such as material and age. , Such information may not be needed in the AMP because it is not a direct capital cost. It is recommended that the City consider other types of infrastructure, such as BMPs, in their AMP to incorporate the long term capital cost of replacing such infrastructure at the end of their lifespan.

6.3.2.1 AMP Section 3.8.1 What do we own?

Culverts:

- The City has already developed a GIS shapefile identifying about 390 culverts under 3,000 mm. The rest still need to be inventoried.
- Based upon the most up-to-date inventory, incorporate total number of culverts 450 mm to 3,000 mm.
- Identify number of culverts by size: 3,000 mm - 2,000 mm
2,001 mm - 1,050 mm
1,051 mm - 450 mm
- If enough information is available, separate by materials.
- It is recommended that this separation by material is also done for the pipe storm sewer network already included in the AMP. Many of these pipes may be wooden, clay, asbestos, cement, etc., with the corresponding service lives.

Manholes and Catchbasins

- The City has inventoried about 4,200 public manholes and 11,000 public catchbasins so far. The rest still need to be inventoried.
- Categorize by depth and diameter: = < 1,200 mm
≤ 2 m in depth
> 2 m in depth
> 1,200 mm
≤ 2 m in depth
> 2 m in depth

Outfalls

- There are about 373 outfalls identified in the City inventory.
- Categorize by material and diameter: ≤ 900 mm
> 900 mm

Ditches

- No readily available ditch inventory has been found. An inventory for ditches above 1 metre bottom width (excluding standard, roadside grassed ditches) need to be developed.
- Categorize by bottom width: > 2 m
1 m – 2 m

Ponds

- There are 2 wet detention ponds identified in the stormwater inventory. Any future ponds will need to be added to this inventory.
- Categorize by size: < 4 Ml
4 Ml – 8 Ml
> 8 Ml

LID/BMPs

- There are 7 surface infiltration facilities identified in the stormwater inventory. Any future BMPs will need to be added to this inventory.
- Replacement value and maintenance/repair costs vary largely based on the type, size and location of the BMP. As a first cut, it is recommend to categorize the BMPs by:
  - Infiltration BMPs: use of mostly natural soils and no drain tile (less expensive, lower maintenance)
  - Filtration BMPs: use engineered soils/media and drain tile (more expensive, higher maintenance)

OGS

- The existing stormwater inventory identifies approximately 88 OGS with 68 privately owned OGS of which 15 are sand filters. There are another 10 owned by the City with 10 more in subdivisions which will be turned over to the City upon completion. Any future OGS will need to be included in this inventory.
- Replacement value and maintenance/repair costs vary based upon size and manufacturer.
- Categorize by manufacturer (e.g. Stormceptor, Echelon, etc.) and by flow capacity at full separation efficiency: < 60 L/sec.
> 60 L/sec.

Skimmers/Debris barrier

- Any debris barriers different than OGSs.
- No need to categorize further.

Fish ladders

- There is one fish ladder identified in the inventory.

Lake Dams

- Boulevard Lake Dam
- Carp River Dam

6.3.2.2 AMP Section 3.8.2 AMP What is it worth?

All numbers proposed below are in 2014 dollars. Unit costs were derived from information from the City when available and industry standards. The costs will need to be validated and modified as needed at the time of SAMP preparation.

Culverts:

- Add estimation of replacement value of culverts less than 3 metres in diameter.
- Assuming that the majority of culverts are CSP at an average length of 15 - 20 metres, use the following 2014 replacement costs (need to be validated before using in the SAMP update):
  450 mm: $250/m
  1,050 mm: $540/m
  2,000 mm: $1,100/m
  3,000 mm: $2,200/m
- These costs include road replacement.
- The value of the culvert network can be estimated using the following unit costs:
  3,000 mm - 2,000 mm: $28,000/unit
  1,999 mm - 1,050 mm: $14,000/unit
  1,049 mm - 450 mm: $6,700/unit

Manholes and Catchbasins

- Add estimation of replacement value for manhole and catchbasins.
- The replacement value of the system's manholes and catchbasins was already incorporated into the AMP as part of the pipe system replacement cost per linear metre.
- It is recommended to separate the replacement costs of the pipes from the costs of manholes and catchbasins (including catchbasin leads). The categories by depth and diameter shown above should be used to estimate costs per unit.

Outfalls

- Add estimation of replacement value for outfalls.
- The replacement value of the system's outfalls was already incorporated into the AMP as part of the pipe system replacement cost per linear metre.
- It is recommended to separate pipes from the outfall cost.
- Use the following 2014 replacement costs (need to be validated before using in the next SAMP update):
  Diameter ≤ 900 mm: $6,000
  Diameter > 900 mm: $14,000

Ditches

- Add estimation of replacement value for ditches more than 1 bottom width (excluding standard, roadside grassed ditches).
- Use the following 2014 replacement costs (need to be validated before using in the next SAMP update):
  1 m – 2 m bottom width: $110/m
  > 2 m bottom width: $200/m

Ponds

- Add estimation of replacement value for ponds.
- Use the following 2014 replacement costs (need to be validated before using in the next SAMP update):

$$\$30/\ m^3 \begin{cases} < 4\ \text{ml: } \$90{,}000 \\ 4\ \text{ml} – 8\ \text{ml: } \$210{,}000 \\ < 8\ \text{ml: } \$300{,}000 \end{cases}$$

LID/BMPs

- Add estimation of replacement value for BMPs.
- Costs will be very dependent upon the type of BMP. Based on the previous categorization, the following 2014 replacement unit costs per individual facility are proposed (need to be validated by actual construction costs of future BMPs):

  Infiltration BMPs: $80/m^2 (includes plant material)

  Filtration BMPs: $150/m^2 (includes plant material)

OGS

- Add estimation of replacement value of City owned OGS. Because of the current lack of maintenance of privately owned OGS (as opposed to other privately owned stormwater facilities), the City may want to consider obtaining ownership and maintenance responsibilities of all the OGS within the City.
- Costs of OGS will vary significantly by type, manufacturer and size. Based on the previous categories, use the following 2014 replacement costs (need to be validated by actual costs): OGS < 60 L/sec: $60,000/unit

  OGS > 60 L/sec: $120,000/unit

Skimmers/debris barrier

- Add estimation of replacement value for skimmers.
- A general replacement value of $10,000/unit can be used for estimation purposes.

Fish ladders

- Add estimation of replacement value for City's fish ladder.
- Construction costs need to be obtained from the City records.

Lake dams

- Reclassify estimation of replacement value for Boulevard Lake and Carp River dam
- Construction costs need to be obtained from the City records

6.3.2.3 AMP Section 3.8.3 What condition is it in?

Culverts:

- The condition of the linear Stormwater Network was assessed by assuming an average useful life of 50 years, not by inspection. The inspection support documentation outlined before needs to be developed to assess the conditions vs. performance of culverts less than 3 metres.
- The condition vs. performance grading scale on pages 2 and 13 of the AMP (Table 87) should be used during inspection and should be part of the inspection record.

Table 87. Grading Scale: Condition vs. Performance

Rating	Letter Grade	Description
5	A	Excellent: No noticeable defects.
4	B	Good: Minor deterioration.
3	C	Fair: Deterioration evident, function is affected.
2	D	Poor: Serious deterioration, function is reduced.
1	F	Critical: No longer functional, general or complete failure.

Source: Page 2 AND 13 of the City's AMP (2014)

- Culverts under 3 metres should have a condition vs. performance rating independent from the linear storm sewer network. With the available inventory, a graphic similar to those of page 45 of the City's 2014 AMP should be developed for culverts under 3 metres.

The same recommendations outlined above for culverts below 3 metres under Section 3.8.3 of the AMP are applicable for the rest of the stormwater assets (manholes, ditches, ponds, BMPs, etc.).

6.3.2.4 AMP Section 3.8.4 What we need to do to it?

- For all the stormwater assets contained in the SAMP, assume the replacement life or useful life shown in Table 88. This table is based on some of the plans and reports shown in Section 6.1 (including the AMP), and on our experience with cold weather climate municipalities.

Table 88. Useful Life for Various Stormwater Assets When Properly Maintained

Stormwater Asset	Years
Gravity Pipes/Culverts (Concrete, Brick, Vitrified Clay, Ductile Iron)	100
Gravity Pipes (HDPE, PVC, Truss Pipe)	100
Gravity Pipes/Laterals/Culverts (Corrugated Metal)	50
Laterals (Concrete, Brick, Vitrified Clay, Ductile Iron)	50
Laterals (HDPE, PVC, Truss Pipe)	50
Pressurized Mains	100
Manholes (Brick and Concrete)	100
Catchbasins	50
Outfalls	75
Ditches/Open Channels (excluding standard, roadside grassed ditches)	100
Dry and Wet Detention Basins (Basin/Outlet)	100/50
Infiltration Basins (Natural Soils)	50-100
Infiltration/Infiltration Basins (Engineered Soils, Drain tile)	50
Pump Station - Pumps	30
Pump Stations - Electrical	25-50
Pump Stations - Mechanical	25-50
Pump Stations - Structural	75
Other LID/BMPs	30-100
OGS	50-100
Skimmers	30-75
Fish Ladders (concrete)	100

- Based on the available inventory, age of assets and/or verified conditions in the field, develop replacement needs for all the assets listed in Section 6.2 and create a similar graphic as the one shown on page 46 of the City's 2014 AMP. When no field assessment of the conditions of the assets is available, use the useful life table above and the construction date of the assets to estimate replacement schedule.
- Table 89 shows a comprehensive list of the optimal preventive and corrective actions that need to be taken in order to maximize the useful life of all stormwater assets. Table 88 shows the ideal frequency of preventive and corrective action as compared to the estimated useful life of the asset
- This table should be used as a baseline to determine desired level of service and to estimate costs associated to preventive and corrective maintenance when the AMP is updated.

Table 89. Preventive/Corrective Maintenance and Asset Replacement Recommendations

Stormwater Asset	Preventive Maintenance		Corrective Measures		Replacement (lifespan)
	Action	Frequency	Action	Frequency	
Gravity Pipes	• Flushing to remove/prevent blockages	• Year-round as identified by CCTV inspection or visual observation • At a minimum, all pipes need to be flushed once every 10 years	• Planned and urgent (unplanned) repairs replacements like cured in place pipe lining methods, corrosion reduction, reaming and sealing and spot repairs of less than 10 m • Emergency repairs as described above using either dig-up or trenchless methods. Action to be taken in less than 24 hours from notice	• Year round as identified by CCTV inspection and/or by functional emergency • At a minimum, rehabilitation to be performed once every 10 years for all inspected sewers over 10 years old. Priorities are determined by the results of regularly scheduled CCTV inspection	• 100 years for concrete, brick, vitrified clay, and ductile iron pipes • 100 years for HDPE and PVC pipes • 50 years for CSP pipes • 50 years for all laterals
Pumping Stations and Force Mains	• For pumping stations; full station maintenance and servicing of parts • For force mains; fixing minor corrosion and incrustation problems	• Year round as prioritized by CCTV inspections and the scheduled maintenance and servicing for the stations	• Planned and emergency repairs of pump stations based on inspections and/or breakdowns or failures. These involve the use of specialized tools and/or replacement parts. • Planned and emergency repairs of force mains based on inspections and/or failures. These repairs can be performed by dig-up or trenchless methods and include reaming and sealing, spot repair less than 10 metres and relining. Replacement of force main is excluded.	• Year round based on CCTV and station inspection and/or failures	• 100 years for pressurized mains • 30 years for pumps • 75 years for structural components and 25-50 years for electrical and mechanical components

Stormwater Asset	Preventive Maintenance		Corrective Measures		Replacement (lifespan)
	Action	Frequency	Action	Frequency	
Culverts <3m	• Remove debris and sediment • Remove blockages • Fix minor corrosion issues	• Once every 2-3 years for culverts 2,000 mm to 3,000 mm • Once every 5 years for culverts under 2,000 mm	• Fix corrosion and misalignment • Replace grates as needed • Repair caving and partial breakdown either by sealing or replacing (open trench) • Repair/replace riprap	• Year round as identified by visual inspection and/or by functional emergency • At minimum, corrective measures need to be performed once every 20 years. Priorities are determined by regular inspection	• 100 years for concrete culverts • 50 for CSP culverts
Manholes	• Remove debris/sediment and other materials • Remove obstructions • Minor grouting	• 10% annually or once every 10 years. Priorities determined by the regular inspection program	• Structural rehabilitation • Grouting cracks and connections to pipes • Replacing covers and mechanical elements (e.g. weirs, splitters, restrictions, etc.)	• As needed determined by prioritization of inspection results • At a minimum, corrective actions need to be performed every 10 years for manholes over 10 years old	• 100 years for brick and concrete manholes
Catchbasins	• Remove debris/sediment • Remove obstructions • Minor grouting	• Once every 4 years. Priorities determined by the regular inspection program	• Structural rehabilitation • Grouting cracks and pipe connections • Replacing grates and other elements as needed	• As needed determined by prioritization of inspection results • At a minimum, corrective actions need to be performed every 10 years for catch basins over 10 years old	• 50 years for brick and concrete catchbasins
Outfalls	• Remove debris and sediment • Remove blockages • Fix minor corrosion issues	• Once every 2 years for outfalls larger than 900 mm • Once every 5 years for outfalls equal to or less than 900 mm	• Fix corrosion, misalignment and/or overhanging • Replace aprons, grates and other flow control elements as needed • Repair caving and partial breakdown • Repair/replace/add riprap • Repair bank erosion and stabilize with vegetation • Track potential water quality discharge issues back in the system	• Year round as identified by inspection and/or by functional emergency • At a minimum, corrective measurements should be performed every 10-15 years, with priorities being determined by regular inspections	75 years

Stormwater Asset	Preventive Maintenance		Corrective Measures		Replacement (lifespan)
	Action	Frequency	Action	Frequency	
Ditches/open channels (excluding standard, roadside grassed ditches)	• Trash/debris removal • Remove/cut overgrown vegetation • Remove other minor blockages	• Once every 5 years for ditches with bottom width of 3 m or more • Once every 10 years for medium size ditches (2 m - 3 m bottom width)	• Sediment removal and minor re-grading to preserve design slopes • Re-vegetate exposed areas • Fill and re-vegetate eroded areas	• Once every 20 years or as determined by regular ditch walk outs and inspections	100 years
Wet Ponds	• Remove trash and debris from side slops, embankment, spillways, outlet and trash gates • Harvest vegetation • Minor repairs to embankment and side slopes • Minor repairs to outlet structure and riprap	• Twice a year during growing season • Annually as needed • 5 year cycle • 5 year cycle	• Repair control structure • Remove accumulated sediment from fore-bays or pre-treatment areas when 60% of the original volume has been lost • Remove accumulated sediment from main cells of pond once 50% of the original volume has been lost • Major erosion repairs, vegetation reestablishment and embankment subsidence	• As needed or every 20 years • 5 year cycle • 20 year cycle • 20 year cycle	Outlet: 50 years Pond: 100 years
Dry Ponds	• Minor repairs to the pilot channel: erosion and vegetation reestablishment • Remove trash and debris from side slops, embankment, spillways, outlet and trash gates • Harvest vegetation	• 5 year cycle • Twice a year during growing season • Annually as needed	• Major repairs to pilot channel • Repair control structure • Remove accumulated sediment from forebays or pre-treatment areas when 60% of the original volume has been lost	• 20 year cycle • As needed or every 20 years • 5 year cycle	Outlet: 50 years Pond: 100 years

Stormwater Asset	Preventive Maintenance		Corrective Measures		Replacement (lifespan)
	Action	Frequency	Action	Frequency	
	• Minor repairs to embankment and side slopes • Minor repairs to outlet structure and riprap	• 5 year cycle • 5 year cycle	• Remove accumulated sediment from main cells of pond once 50% of the original volume has been lost • Major erosion repairs, vegetation reestablishment and embankment subsidence	• 20 year cycle • 20 year cycle	
Infiltration Basins	• Remove debris and trash • Clean pre-treatment devices • Mow/maintain upland vegetated areas • Minor replanting on eroded or barren spots • Minor repairs to outlet structure and riprap	• Twice a year during growing season • Twice a year during growing season • As needed • Annually as needed • 5 year cycle	• Remove accumulated sediment from forebays or sediment storage areas when 50% of the original volume has been lost • Remove accumulated sediment (only top layer) when standing water exceeds 72 hours • Repair outlet control structure	• 3-5 year cycle • 15-20 year cycle • As needed or every 20 years	30-50 years
Infiltration Trenches	• Remove clogging in inlet/outlet pipes • Remove leaves, grass clippings, debris and trash • Clean pre-treatment devices • Mow/maintain upland vegetated areas • Minor replanting on eroded or barren spots	• Twice a year during growing season • Twice a year during growing season • Twice a year during growing season • As needed • Annually as needed	• Replace layers of stone aggregate, the filter fabric, drain tile (if present) and perform bottom scarification/tilled • Remove accumulated sediment from forebays or sediment storage areas when 50% of the original volume has been lost • Remove accumulated sediment (only top layer) when standing water exceeds 72 hours • Repair outlet control structure	• 15-20 year cycle • 3-5 year cycle • 10 year cycle • As needed or every 20 years	30-50 years

	Preventive Maintenance		Corrective Measures		
	Action	Frequency	Action	Frequency	
	• Minor repairs to outlet structure and riprap	• 5 year cycle			
Bioretention Systems and Rain Gardens	• Water plants • Water as necessary during dry periods • Re-mulch void areas • Repair eroded areas • Remove litter and debris	• As necessary during the first growing season • As needed for the next 2 growing seasons • Annual • Monthly until full vegetation establishment • Once a year or during inspections	• Treat or Remove and replace all dead and diseased vegetation • Add mulch • Remove vegetation and mulch, and replace with new layer • Repair check dams (if present)	• As needed or every 2 years • As needed or every 2 years • 3-5 year cycle • • As needed or 5-10 year cycle	50+ years
Sand filters	• Remove trash and debris from basin and control openings • Surficial sand filters often have a vegetation component for soil stabilization and erosion reduction. If that is the case, a strong vegetation establishment needs to be maintained (re-seeding, mulching, etc.)	• Annual • As needed or annually	• Remove the top few centimetres of sand, and vegetation, when filter bed is clogged • Clean out accumulated sediment from filter bed chamber once depth exceeds approximately 2 – 3 cm, or when the filter layer will no longer draw down within 24 hours • Cleaning out accumulated sediment from pre-treatment chamber once depth exceeds 30 cm • Repair leaks from the sedimentation chamber or deterioration of structural components	• 10-20 year cycle • 10 year cycle • 3-5 year cycle • 10 year cycle	20-40 years

Stormwater Asset	Preventive Maintenance		Corrective Measures		Replacement (lifespan)
	Action	Frequency	Action	Frequency	
Filter Strips	• Mow grasses (low pressure equipment) to about 10 cm high • Trimming, removal of invasive species and replanting when necessary • Remove litter/debris • Manage nutrient and pesticide use • Aerate soil on the filter strip	• 3-4 times during growing season (only once in early Spring if native grasses are used) • Annual • Annual • Annual • 2-3 year cycle	• Repair eroded or sparse grass areas • Sediment removal and regarding and reseeding/replanting of upslope edge • Replace pea gravel diaphragm	• 2 year cycle • 5 year cycle • 5-10 year cycle	100
Dry Swale	• Mow grasses (low pressure equipment) to about 10 cm high • Trimming, removal of invasive species and replanting when necessary • Remove litter/debris • Manage nutrient and pesticide use • Aerate soil on the filter strip	• 3-4 times during growing season (only once in early Spring if native grasses are used) • Annual • Annual • Annual • 2-3 year cycle	• Stabilize eroded side slopes and bottom • Scrape swale bottom and remove sediment to restore original cross section and infiltration rate • Re-seed or sod to restore ground cover • Replace pea gravel diaphragm • Repair check dams (if present)	• As needed • 5-10 year cycle • 5 year cycle • 5-10 year cycle • As needed or 5-10 year cycle	100
Permeable Pavers	• Vacuuming • Minimizing salt use or sand for de-icing and traction in the winter, keeping the landscaping areas well maintained, pulling out weeds and preventing soil from being washed onto the pavement	• As needed or twice per year (April and November) • On going	• Potholes patching with standard patching mixes • Replacing pavers	• As needed • As needed	20-60 years

Stormwater Asset	Preventive Maintenance		Corrective Measures		Replacement (lifespan)
	Action	Frequency	Action	Frequency	
	• Maintenance agreements should note which conventional parking lot or driveway maintenance tasks must be avoided (e.g., sanding, re-sealing, re-surfacing, power-washing, etc.)	• On going			
OGS	• Remove sediment, grit, trash, organics and oil accumulation • Remove flow obstructions	• At least once a year or as often as recommended by manufacturer or as determined by targeted inspections before and after storm events	• Correct structural displacement and cracks • Replace leaking or corroded components • Grout as needed • Replace filters	• Once every 20 years or as determined by inspections	50 to 100 years depending upon OGS type
Skimmers	• Remove sediment, grit, trash, organics and oil accumulation • Remove flow obstructions	• At least once a year or more often as determined by regular inspection	• Replace or reseal leaking components • Remove sediment accumulated at the skimmer that restricts pass through flows • Correct erosion around skimmer • Replace boards as needed	• Once every 15 years or as determined by regular inspection	20 to 50 years depending upon material used
Fish ladder	• Remove blockage and debris • Operate mechanisms to verify functions and regular maintenance of equipment as per manufacturer requirements	• Once a year	• Replacement of non-functioning equipment and emergency repairs	• As needed after failure or as determined by inspection.	100 for concrete
Tree Trenches *	Practice dependent	Practice dependent	Practice dependent	Practice dependent	Practice dependent

*Preventive and corrective maintenance requirements and frequency for Tree Trenches vary significantly with the type of BMP (e.g. Structural cells/ suspended pavement, rock based structural soil, sand based structural soil, concrete boxes, etc.) and the type of trees.

Recommendations for the development of the SAMP continue in the following sections organized by the sections of the City's 2014AMP.

6.3.2.5 AMP Section 3.8.5 How much money do we need?

- Based on field conditions, field information (3.1 Inventory of Stormwater Assets) and replacement costs for each stormwater asset, determine the annual investment in today's dollars to replace the existing stormwater system.
- Consider inflation and interest to determine the average annual investment needed over the life cycle of the assets.
- Use the useful life for each type of asset shown in Table 88 and Table 89 to calculate the annual capital funding needed for each asset replacement.
- Incorporate long term maintenance costs into the analysis. Use the recommendations in Table 89 and Table 90 regarding inspection and preventive/corrective maintenance needs to determine costs.

  As an alternative, these costs could be handled separately from the SAMP by increasing the Environment Division's operating budget enough to cover all maintenance needs. Implementing the revenue generation alternatives recommended in this SMP, will help to finance the operation and maintenance of the stormwater assets.
- Upfront capital investment and replacement costs for future infrastructure expansions needs to be estimated and included in the overall annual financing needs.
- Inspections need to be significantly expanded to more thoroughly evaluate the actual conditions of all the stormwater assets using the recommended rating system in Section 6.3.2. A replacement cost estimate based upon the age of the asset could be used in the cases when field information on the asset's condition is not available.

6.3.2.6 AMP Section 3.8.6 How do we reach sustainability?

- Replacement costs for stormwater assets, other than gravity pipes, culverts greater than 3m in diameter, and pumping stations, are not currently included in the City's 2014 AMP. These costs need to be incorporated in future updates of the AMP or included in a separate SAMP.
- As per the City's 2014 AMP, the storm sewer network replacement is already at a \$3.8 million annual deficit. Therefore, if no financing action is taken, the funding grade for the all the stormwater assets will continue to be a grade of F.

6.3.2.7 AMP Section 3.8.7 Recommendations

- All recommendations contained in Section 3.8.7 of the City's 2014 AMP would apply to all the stormwater assets considered here.
- Recommendations outlined throughout this section of the report should also be incorporated.

6.3.2.8 AMP Section 5.0 Desired Level of Service

- A complete stormwater assets inventory database, as described in Section 3.1 above, is needed to link performance measures and current/expected performance to each one of the assets.
- This SMP (in alignment with the City's Official Plan) reviews design guidelines, provides metrics, recommends regulatory changes and establish service level expectations. This SMP should be used as a template to develop Section 5.0 when updating the City's AMP or developing a separate SAMP.

6.3.2.9 AMP Section 5.4 Water/Wastewater/Storm Services

- Separate stormwater from sanitary sewer and water.

6.3.2.10 AMP Section 5.4.1 Service Description

- Include descriptions of each stormwater asset (i.e. linear systems, pumps, culverts less than 3 metres, ditches, OGS, LID/BMP practices, debris barriers and fish ladder).

6.3.2.11 AMP Section 5.4.2 Scope of Services

- Describe functionality of all stormwater elements (i.e. what do the culverts under 3 metres, ditches, ponds, OGS, etc. do and their purpose).

6.3.2.12 AMP Section 5.4.3 Performance Indicators

- Develop a performance indicator table only for the additional stormwater assets (culverts under 3 metres, ditches, ponds, OGS, LID/BMP practices, skimmers/debris barriers, fish ladders etc.).
- Use sections of this SMP to incorporate and track the following performance indicators for each of the assets:

Strategic Indicators:

- Incorporate SMP objectives and targeted time line from the CIP.

Financial Indicators:

- Track stormwater revenue vs. stormwater expenditures for all stormwater assets (i.e. linear systems, plus culverts less than 3 metres, ditches, ponds, etc.).
- Track new construction annually for all stormwater assets and assess the annual increase in operating funds.
- Determine revenue required to maintain annual Stormwater Network growth (i.e. funds needed to build or replace infrastructure to support that growth, and determine if the expected additional tax revenue out of future subdivisions would be enough to pay for the additional infrastructure needed to serve those subdivisions).

Tactical Indicators:

- Average age of all stormwater elements by element and by material (e.g. linear systems and culverts need to track CSP, RCP and wooden pipes separately).
- Ditches and ponds also need to be inventoried separately for average age determination (e.g. natural ditches vs. armoured, dry ponds vs. wet ponds).
- Percentage of stormwater assets older than expected useful service life.
- Percentage of stormwater assets rehabilitated/reconstructed annually.
- Annual percentage of growth for all stormwater assets.
- Percentage of stormwater elements replacement value spent on operations and maintenance.

Operational Indicators:

- Percentage of Stormwater Network that is inspected annually by asset (e.g. percentage of ponds inspected annually).
- Operating cost by stormwater asset (i.e. operating cost per km. of pipe or ditches, operating cost per culverts less than 3m, operating cost per pond, BMP OS, etc.).
- Number of customer requests received annually per stormwater asset.
- Percentage of customer requests responded to within 24 hours per stormwater asset.

6.3.2.13 AMP Section 6.1 Objective

- Include language from this SMP to define the objective of the management strategy for all stormwater assets.

6.3.2.14 AMP Section 6.2 Non-Infrastructure Solutions and Requirements

- Incorporate specific sections of this SAMP (including parts of the CIP) to provide a picture of future activities and priority stormwater assets to guide the planning process.
- Incorporate the issues and priorities identified in this SAMP through public consultation.
- Incorporate the policies and recommendations contained in this SAMP guided to improve the life cycle of the different stormwater assets.

6.3.2.15 AMP Section 6.3 Condition Assessment Programs

- The foundation of a good SAMP is based upon comprehensive and reliable information of the current condition of all stormwater assets. Therefore, following the inventory recommendations of Section 3.1 above is crucial.
- Elements of this SAMP together with more detailed assets' current conditions should be used to update this section in the future.

6.3.2.16 AMP Section 6.3.4 Sewer Network Inspections

- Table 90 shows the recommended inspection activities and inspection frequency for each stormwater asset. Table 90 also shows the benefits of developing a comprehensive inspection schedule for the stormwater assets.
- It is recommended that 6.3.4 of the City's AMP is modified to incorporate the inspection recommendations of Table 90.

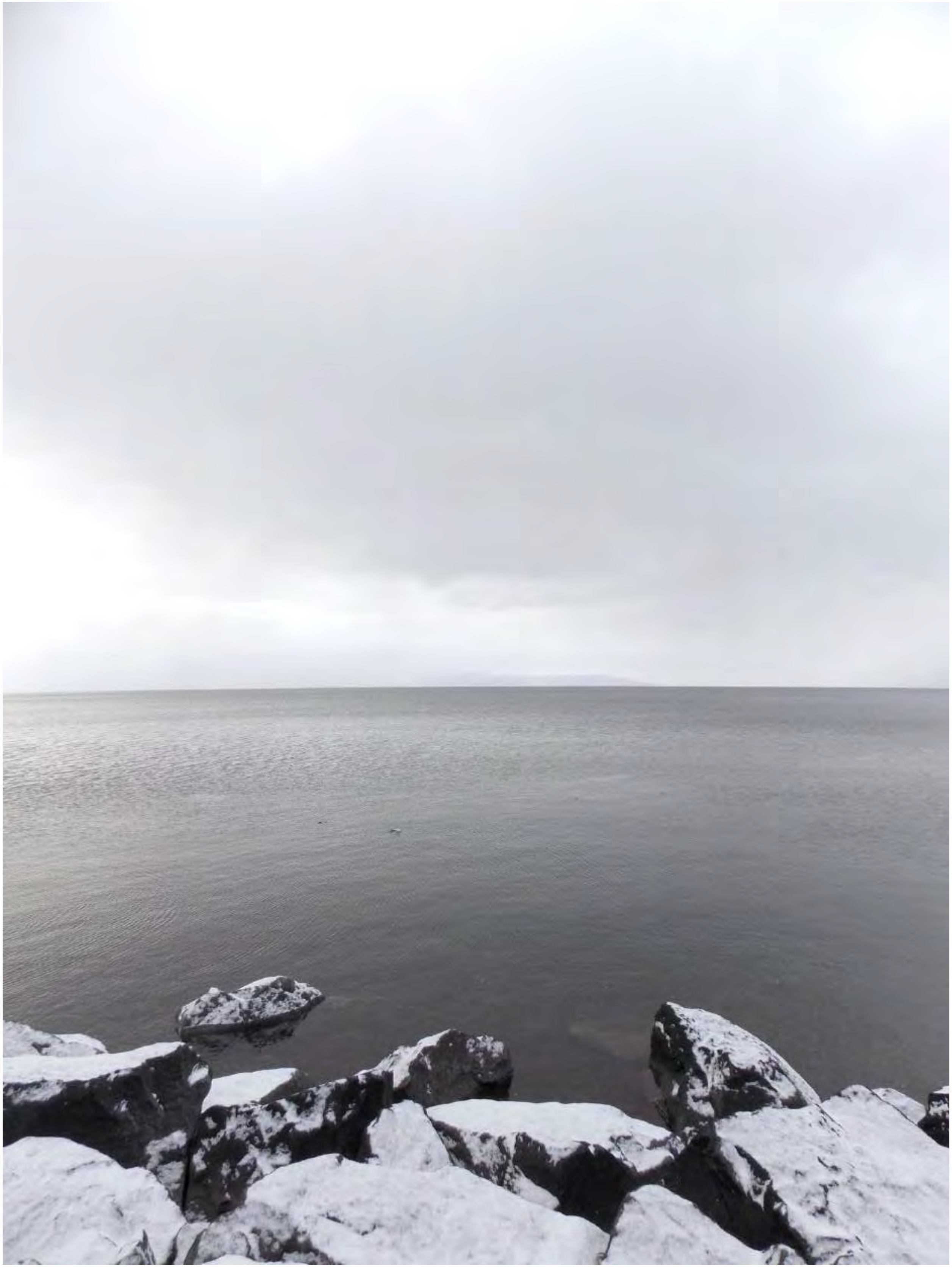

Table 90. Inspection Recommendations

Stormwater Asset	Description	Frequency	Benefits for City/Watershed
Gravity Pipes	• Inspection by Close Circuit TV (CCTV) including Aqua Zooming • Use Water Resource Centre (WRC) rating on a 1-5 scale	• CCTV inspection of pipes older than 30 years over a 10 year period	• Detects defects, corrosion, blockages, sources of contamination, and disrupted flow regime • Helps prioritize preventive, corrective, and replacement actions • Helps prevent flooding due to reduced pipe capacity and protects property
Pumping Station and Force Mains	• Visual Inspection of pump station • Inspection by CCTV including Aqua Zooming for corrosion and incrustation	• Station: Every 2 weeks. Log data in GIS every three months • Force mains: Every 2 weeks during station inspection. CCTV every 10 years	• Early detection of areas and equipment of concern • CCTV detects defects and corrosion/incrustation that reduces capacity • Provides for continued operation
Culverts 3 m or less	• Visual inspection for debris, sediment, or vegetation limiting capacity and any signs of caving, riprap deterioration or corrosion (All culverts 450 mm - 3,000 mm) (Inspection optional for culverts <450 mm)	• 50% Annually (culverts 2,000 – 3,000 mm) • 20% Annually (culverts <2,000 mm)	• Helps prevent/eliminate flooding and protects property • Prevents road caving and potential road safety issues
Manholes	• Visual inspection of manholes owned by City • Record and monitor debris/sediment levels, blockage and salt accumulation for cleaning prioritization • Identify structural problems, and assess manhole cover	• Inspect manholes older than 30 years over a 10 year period	• Provides for operational and effective drainage system and no safety hazard for workers • Prevents removed sediment and debris from reaching downstream water resources
Catchbasins	• Visual inspection of catchbasins owned by City • Record and monitor debris/sediment levels for potential cleaning prioritization • Identify structural problems, and assess catchbasin cover	• 35% Annually (once every 3 years)	• Provides for proper drainage • Restores flow and functionality • Prevents removed sediment and debris from entering downstream resources • Prevents inlet control under severe storm events
Outfalls	• Visual inspection of outlets owned by City to assess structural integrity, obstructions to trash racks, and erosion • Visual inspection of discharge water quality (e.g. colour, smell, sediments, debris, oil, etc.)	• 50% annually (Outfalls >900 mm) • 20% annually (Outfalls <900 mm)	• Improves areas where the outfalls were obstructed or structurally compromised • Identifies potential illicit discharges, water quality issues, and potential upstream inefficiencies

Stormwater Asset	Description	Frequency	Benefits for City/Watershed
Ditches/open channels (excluding standard, roadside grassed ditches)	• Visual inspection to identify condition (e.g. erosion, vegetation overgrowth, soil exposure, etc.) • Visual inspection to assess sediment deposition and change In design slope	• Annually inspect 10 km of main ditch/open channels (bottom width of 3m or more) • Annually inspect 20% of medium size ditches (bottom width 2 m to 3m)	• Reduces potential of ditch flooding and failure by allowing clear channel flow • For those open channels that have more of a natural setting, regular inspection will identify potential actions to reinstate the loss of natural features. • Protects water quality
Wet Ponds	• Inspect for sediment accumulation, outlets operation and potential obstructions, emergent pond vegetation and embankment and spillway stability	• Inspect after storm events during first year • Twice per year during growing season	• Removes solid/soluble pollutants • Aesthetically pleasing BMP • Creates wildlife habitat • Increases adjacent property values
Dry Ponds	• Inspect for sediment accumulation, outlets operation and potential obstructions, emergent pond vegetation and embankment and spillway stability	• Inspect after storm events during first year • Twice per year during growing season	• Very effective in cold climate • Limits scour and aquatic vegetation by reducing flow rate and discharge energy • Can be used as part of recreational area (athletic fields)
Infiltration Basins	• Inspect pre-treatment devices, water levels after storm events, vegetation establishment, sediment accumulation, and erosion on basin floor	• Pre-treatment devices inspected twice per year • After every major storm event during initial months after construction • Twice per year after vegetation establishment	• Reduces runoff volume • Very effective in removal of sediment, metals, nutrients, bacteria, and organics • Reduces size and cost of downstream stormwater practices • Provides groundwater for recharge and stream baseflow • Reduces local flooding • Appropriate for small site
Infiltration Trenches	• Inspect for water levels, accumulated sediment, leaves and debris, clogged inlet/outlet pipes, and ponded water inside and outside the trench	• After every significant storm event for a few months after construction • Twice per year after vegetation establishment	• Can be utilized where space is limited

Stormwater Asset	Description	Frequency	Benefits for City/Watershed
Bioretention Systems and Rain Gardens	• Inspect for: plant establishment, adequate soil moisture to support planting, eroded areas, litter and debris, ponded water, sediment deposition, and the integrity of check dams	• After every significant storm event for a few months after construction • 3 times per year after vegetation establishment	• More aesthetically pleasing than other types of filtration or infiltration systems • Reduces volume runoff • Can be very effective for removing fine sediment, trace metals, nutrients, bacteria, and organics • Can be adapted to location various landscape designs • Can be applied in many different climates • Ideal for highly impervious areas • Reduces local and downstream flooding • Provides groundwater recharge • Can be used as retrofit by modifying existing landscaped areas
Sand filters	• Inspect for discoloured sand and sediment accumulation • Inspect for strong vegetation establishment • Inspect pre-treatment basin for sediment, trash, and debris	• After every major storm in first few months • Twice per year afterwards	• Applicable in small drainages • Have few constraints • Requires less space than other BMPs • Good retrofit capability • Can be used on highly developed and steeply design slopes • Provides high removal efficiencies of TSS
Filter Strips	• Inspect for: sediment, vegetation establishment, vegetation density, clogged pea gravel or levels spreader, rills and gullies	• 2-3 times after large storm events during initial months of first establishment • Once per year after vegetation establishment	• Helps remove sediment and associated insoluble pollutants • Allow increased infiltration opportunities • Work wells in residential areas • Helps maintain riparian zones and reduce bank erosion • Can provide visual barrier • Relatively simple and inexpensive to install • Relatively low maintenance and low cost
Dry Swale	• Inspect for grass cover establishment and density, clogged pea gravel, check dams integrity, trash and debris, and sediment build-up	• 2-3 times for the first 3-4 months • Once per year after turf establishment	• Traps sediment and pollutants • Controls peak discharges by reducing runoff velocity and promoting infiltration • Provides for general water recharge • Good option for small area retrofits replacing existing ditches • Linear nature makes them well suited for treating highway or residential road runoff

Stormwater Asset	Description	Frequency	Benefits for City/Watershed
Tree Trenches	• Inspect for: erosion, weeds, sediment/debris, standing water, outlet/overflow structure, need for irrigation, need for pruning and overall tree health	• Once per month and after major storm for first year • Inspect twice per year after first year (Spring and Fall)	• Consistent with Thunder Bay's "greening" vision • Excellent tool for stormwater detention/retention • Cleans air • Reduces "heat island" effects • Sequesters carbon • Reduces noise pollution • Reduces pavement maintenance • Shades parking lots and roads • Reduces irrigation needs if properly tied into stormwater system
Permeable Pavers	• Inspect for: organic matter clogging, deterioration of pavers, and signs of long-term water ponding	• Twice per year immediately before and after winters	• Reduces runoff peak and volume • Ideal for areas with light traffic (parking lots, sidewalks, driveways, patios) • Reduces runoff temperatures • Reduces solids and pollutant transfer downstream • Well suited for high density areas
Oil Grit Separators	• Inspect for sediment accumulation, trash, and oil retention • Inspect for structural failures like leakage, corrosion, or displaced components	• Inspection of all OGS in the City twice per year • Targeted inspection of 3-5 OGS per year before and after a storm event to assess separation efficiency and proper sizing	• Makes sure that OGS are clear and fully operational • Reduces amount of oil/sediment/debris that reaches downstream water resources
Skimmers	• Inspect for sediment accumulation, trash, and oil retention • Inspect for structural failures like leakage, corrosion, or displaced components	• Inspection of all Skimmers in the City twice per year • Targeted inspection of 3-5 Skimmers per year before and after a storm event to assess separation efficiency and proper sizing	• Makes sure that Skimmers are clear and fully operational • Reduces amount of oil/sediment/debris that reaches downstream
Fish Ladder	• Visual inspection of units, blockages, and operational mechanisms	• Once per year during fish most critical fish migration	• Enhances fish reproduction and prevents fish mortality

6.3.2.17 AMP Section 6.4 Life Cycle Analysis Framework

- The detailed preventive and corrective measures, outlined in Table 89 for each of the stormwater assets, should be incorporated into this section and into the overall City's asset management strategy.
- Table 89 also identifies the key times at which small prevention/correction investments within the life cycle of the asset would result in an increase of the asset's life and lower overall operating costs.

6.3.2.18 AMP Section 6.4.3 Sanitary and Storm Networks

- For proactive inspection prioritization, refer to the life cycles shown in Table 88 and Table 89, the inspection frequency recommended in Table 90, and the rational for inspection prioritization articulated throughout this SMP.
- Articulate that reactive asset inspection prioritization based mostly on near term forecasted road/water work, highest volume of service records or dollars being spent on rehabilitation, would result in higher life cycle costs overall.

6.3.2.19 AMP Section 6.5 Growth and Demand

- Projected growth of stormwater assets constructed by the City need to be incorporated into future AMP/SAMP updates.
- Unlike with other utilities, policies and recommendations in this SAMP report regarding development and runoff rate/volume controls, will significantly help to reduce the city's new infrastructure costs.

6.3.2.20 AMP Section 6.6.1 Risk Matrix and Scoring Methodology

- Incorporate Environmental Risk (i.e. the level of impact to the downstream water resources and the environment should the asset fail). The environmental risk would be primarily based upon proximity to environmental features such as rivers, creeks, wetlands, etc.
- Incorporate the potential for contaminants to accumulate in the soil media of infiltration basins in the risk matrix and scoring methodology.
- Incorporate the potential for groundwater contamination from infiltration BMPs especially in high groundwater level areas.
- The probability of failure vs. consequence of failure graphic on page 78 of the City's 2014 AMP should be modified to include Environmental Risks.

6.3.2.21 AMP Section 7.0 Financial Strategy

- This section should be updated to include a discussion on how stormwater utility and development fees would affect the stormwater assets funding.
- The stormwater utility could be used to finance inspection, preventive/corrective maintenance and rehabilitation, but also to offset some of the stormwater asset replacement costs.
- In a similar way, development area changes could be used to partially finance both new stormwater infrastructure construction and assets' replacement.
- Financing alternatives for full stormwater assets funding should also be discussed in this section.

7 CONCLUSION

The overall purpose of the SMP is to guide the City in the development of a sustainable stormwater management program that meets the following goals and objectives:

1. **Ecosystem Health**:
   The City's surface water, groundwater and natural resources maintain their ecological integrity and provide their original level of function and value
2. **Water Quality:**
   To improve and maintain the quality of the streams, rivers, lakes and wetlands in the Lakehead Watershed
3. **Water Quantity:**
   The City's stormwater system effectively manages the quantity and delivery of runoff in a manner that protects the environment, infrastructure, and the health and safety of the residents of Thunder Bay
4. **Operations and Maintenance:**
   The City's stormwater systems are maintained, managed and operated sustainably
5. **Monitoring and Data Assessment:**
   Support a healthy watershed through effective monitoring and data management
6. **Regulation and Enforcement:**
   Engineering Design Standards and By-Laws are in place and enforced to effectively manage the impact of new development and redevelopment activities in the City
7. **Education and Outreach:**
   The City's residents, businesses and institutions have a good understanding of stormwater management and are committed stewards of the Lakehead Watershed's resources
8. **Funding and Organization:**
   The City of Thunder Bay has the resources and capacity needed to adequately implement an effective Integrated Stormwater Management Program
9. **Climate Change Adaptation:**
   The City of Thunder Bay has evaluated the potential impacts related to climate change, built resiliency into its stormwater management system and incorporated adaptation strategies that will translate into long-term cost savings to the City and its inhabitants

The SMP's implementation plan includes the activities, timing, and investment required to achieve the goals and objectives of the SMP in its 20-year time frame.

The City's SMP outlines a recommended path towards sustainable stormwater management in Thunder Bay that can be funded through a refined financing strategy. Implementation will prepare the City's infrastructure for the growing challenges of climate change and will need to adapt to lessons learned through evaluating progress over the next 20 years.

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