Corporation of the City of Thunder Bay

NEIGHBOURHOOD MASTER STORMWATER DRAINAGE STUDY

Final Report

Prepared by:

Hatch Mott MacDonald
301 - 200 S. Syndicate Avenue
Thunder Bay, Ontario
P7E 1C9
(807) 623-3449 (phone)
(807) 623-5925 (fax)

Delivering Solutions

312068 July 2014

1.0 INTRODUCTION

The City of Thunder Bay experienced widespread flooding following unpredictable and unprecedented rainfall events on May 24, 27 & 28, 2012. Over 3,000 residents reported basement flooding as a result of the storm. In response to the storm, the City has been proactive in commissioning a study of several of the neighbourhoods that were impacted by the storm.

Hatch Mott MacDonald was retained by the City to complete a Neighbourhood Master Stormwater and Drainage Study, and the study is to focus on the McKellar and Northwood Wards.

The study is to include:

- an analysis of the flooding;
- assessment of storm sewer performance under varying conditions;
- current and historical data review, and
- specific storm water infrastructure and management recommendations to minimize future flooding events.

2.0 STUDY LIMITS

The four areas reviewed and assessed as part of this study are as follows:

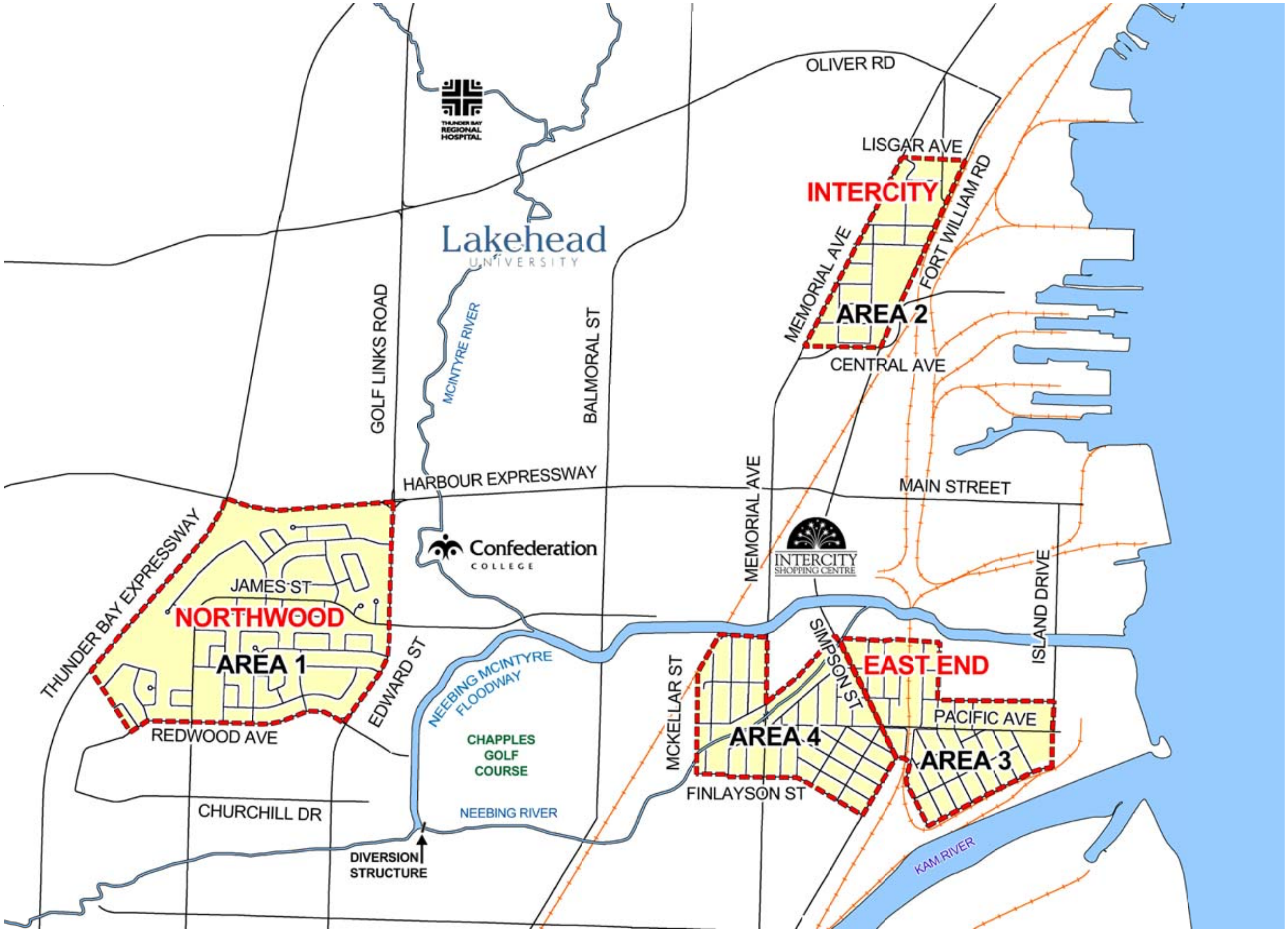
Area 1 – Northwood – generally bordered by the Harbour Expressway on the north, Thunder Bay Expressway on the west, Redwood Avenue on the south and Edward Street on the east. The area is located near two of the city's waterways, the McIntyre River to the north-east and the Neebing River to the south. The Neebing-McIntyre floodway is also located to the east of the study area.

Area 2 – Intercity – generally bordered by Lisgar Street on the north, Memorial Avenue on the west, Seventh Avenue on the south, and Fort William Road on the east.

Area 3 – East End (East of Simpson Street) – generally bordered by the Neebing River to the north, Simpson Street on the west, the Kaministiquia River on the south and Island Drive on the east.

Area 4 – East End (West of Simpson Street) – generally bordered by the Neebing River on the north, Vickers Street on the west, Finlayson Street on the south and Simpson Street on the east.

The four study areas are illustrated on Figure 1.



Hatch Mott MacDonald

STUDY AREAS

FIGURE 1

3.0 EXISTING STORM SEWER SYSTEMS

Area 1 - Northwood

Piped storm sewers are provided throughout the area. Generally, there are two main tributary drainage areas. The first area includes the areas south of James St. which flow in a southerly direction, eventually discharging to the Neebing River. The second area, north of James St., discharges easterly to the Neebing McIntyre Floodway.

Area 2 - Intercity

Storm water drainage in the area is a mix of piped storm sewers and open ditches. Drainage for the majority of the area is in an easterly direction towards Lake Superior. The storm sewers east of Memorial Ave. drain into two pumping stations, which pump the water up into two concrete lined open channels. The concrete channels connect to an open ditch system on the east side of Fort William Road that extends through the CPR/CNR rail yard and industrial lands, and outlets into Lake Superior at Maureen Street. A small portion of the sewers along Memorial Ave. discharge to downstream systems south of the study area.

Area 3 – East End (East of Simpson Street)

Storm water drainage in the area is a mix of piped storm sewers and open ditch/swale drainage.

There are two major tributary drainage areas. Generally, surface drainage south of Pacific Ave. flows south to an outfall at the Kaministiqua River. The Northwest section of the area flows north to an outfall at the Neebing-McIntyre Floodway.

Some combined sewers still exist on McLaughlin St. and McIntosh St. north of Atlantic Ave.

Area 4 – East End (West of Simpson Street)

Storm water drainage in the area is a mix of piped storm sewers and open ditch/swale drainage.

All of the storm sewers in this area discharges to the Neebing River. There are a total of four outfalls to the river, three on the south side of the river and one on the north side of the river.

Some combined sewers remain in the area west of Prince Arthur Blvd.

4.0 STORM SEWER HYDRAULIC MODEL

The analysis of the existing storm sewer system utilized a hydraulic model of the storm sewer system as one of the tools. The main purpose of the modeling assignment was to identify the existing level of service provided by the storm sewer system, establish the location and magnitude of existing storm sewer system deficiencies (if any) under the specific storm events identified, and test the effectiveness of potential remedial measures under design storm conditions.

The software PC SWMM was selected as the preferred software to complete the hydraulic modeling, as it provides good hydrologic and hydraulic modeling and data processing capabilities and features.

To produce accurate, reliable results the PC SWMM model needed to be properly calibrated and verified to ensure it is reflective of the actual system. The City did not have any historical storm sewer flow data. As a result the City undertook a rainfall and flow monitoring program as part of this study and that data was utilized in calibration of the model.

5.0 EXISTING SYSTEM PERFORMANCE

The criteria used in the model was to identify those nodes or pipe junctions that are predicted to experience surface flooding for a time period greater than 0.02 hour (1.2 minutes). Surface flooding indicates that the storm sewers are full of storm water and the manholes are also full of storm water up to the ground level.

Surface flooding was chosen as the reporting criteria rather than predicted basement flooding as the depths and existence of basements in the study areas is unknown, and is likely to vary widely depending on the type and age of structure. For example, there may be homes without basements, homes that are elevated above the roadway such that the basement elevation is similar to the roadway, homes with low basements, homes with high basements, homes that are bi-levels, etc. It should be noted that using the surface flooding as the reporting criteria provides indications of problems within the specific study areas. It should also be noted when reviewing the findings of the analysis that some areas of basement flooding may still occur under a given storm event.

The model predicts that a few isolated subareas of the City in Area 1, Area 2, and Area 3 would be flooded during a 2-year design storm.

Analyzing the study areas under 5, 10 and 25 year design storms identified other areas of predicted surface flooding.

Analysis of the sanitary sewer systems, combined sewer systems and overland storm water flow was not included as part of the study.

6.0 ALTERNATIVES

Alternatives were identified and assessed to eliminate the areas of predicted surface flooding under the different storm conditions.

The strategy used was to first review each of the study areas to identify improvements under a 2 year and 5 year storm event. The trunk sewers for each of the study areas were then reviewed to identify improvements under a 10 year storm event. A review of the local sewers was again conducted under both a 2 year and 5 year storm event to assess the effectiveness of the trunk sewer improvements. The analysis was repeated to identify improvements under a 25 year storm condition.

Other alternatives such as constructing new sewers, utilizing stormwater ponds to reduce peak storm runoff to the sewer system, additional pumping stations, etc. were also evaluated.

7.0 RECOMMENDATIONS

Several recommendations for changes to the City's existing Engineering and Development Standards are summarized below:

a) Incorporate the most recent Environment Canada data into revised Intensity Duration Frequency curves for use on future City projects;
b) For minor storm sewer systems, review the level of enhancement identified (if any) to utilize a 5 year design storm vs. a 2 year design storm;
c) Increase the use of curb inlet or double catchbasins to allow the storm water to enter the sewer system on the roadways faster;
d) Consider catchbasin restrictors on catchbasins located on publically owned parklands to provide storage to reduce peak flows to the sewer system;
e) Consider increasing the size of storm sewer laterals between the catchbasins and the storm sewers to a minimum of 250mm to improve the ability of the sewer system to remove the surface water;
f) Review the existing Site Plan Control Bylaw and the Stormwater Bylaw to address storm drainage requirements between pre and post development conditions.

Specific recommendations for each study area have also been prepared.

Existing programs including the Residential Drainage Rebate Program, Rain Garden Rebate Program and Rain Barrel Program are also included as recommendations to carry forward.

8.0 COST ESTIMATES AND STAGING

Cost estimations for the recommended projects and programs have been prepared. The Implementation Schedule has been developed to assist the City with the planning and establishment of budgets for the various recommendations. It should be noted that funding for each project will have to be confirmed annually as the capital budgets are approved by City Council. As a result, the timing of the various works may vary from that presented.

Proposed Construction Year	Estimated Cost
2014	$1,349,250
2015	$3,139,250
2016	$5,124,250
2017 + post 2017	$3,144,250

TABLE OF CONTENTS

LIST of FIGURES

Page No.

LIST of FIGURES Cont'd …

Page No.

LIST of TABLES

APPENDICES

1.0 INTRODUCTION

1.1 Background

The City of Thunder Bay experienced widespread flooding following unpredictable and unprecedented rainfall events on May 24, 27 & 28, 2012. Over 3,000 residents reported basement flooding as a result of the storm. In response to the storm, the City has been proactive in commissioning a study of several of the neighbourhoods that were impacted by the storm.

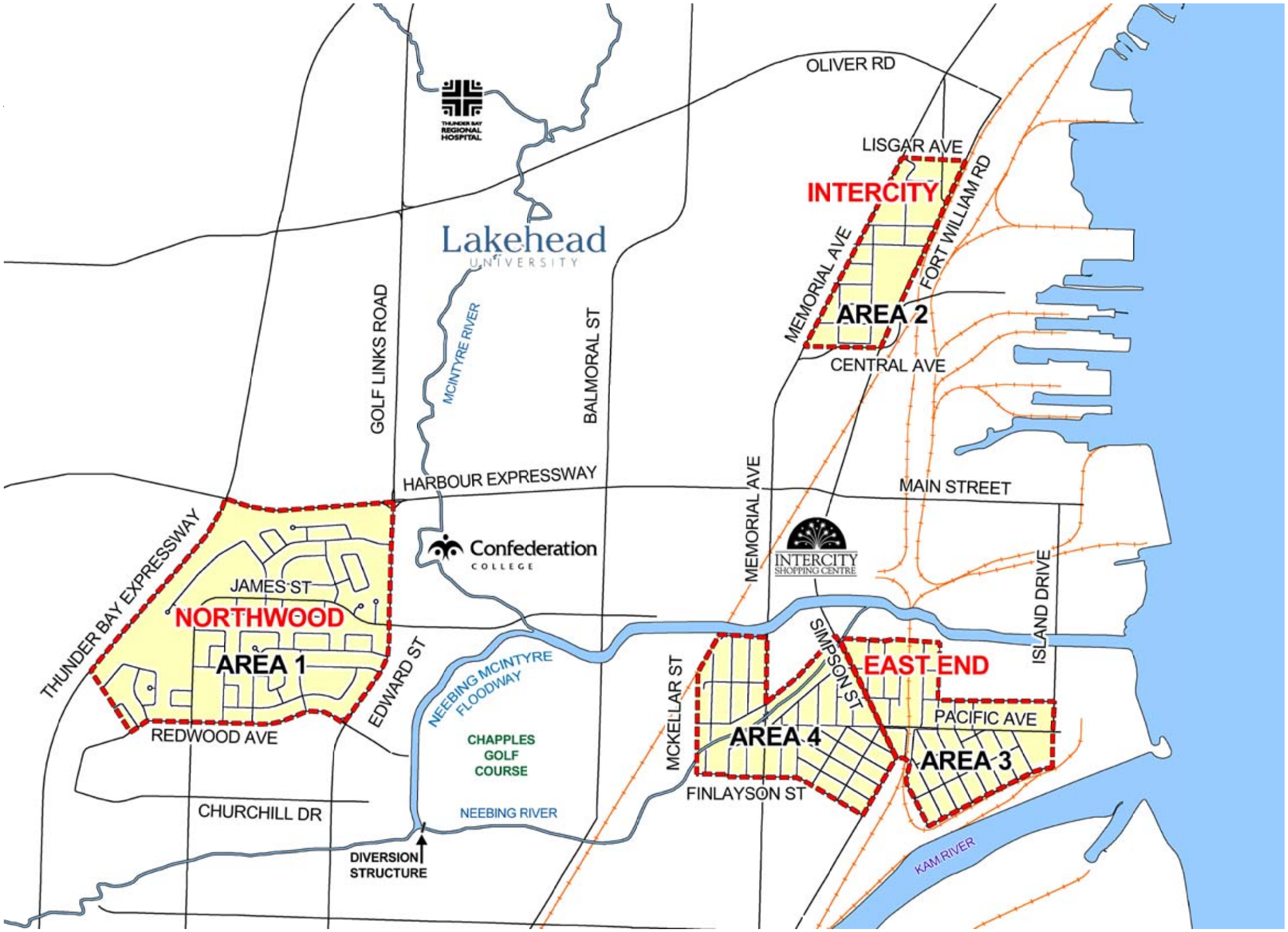
Hatch Mott MacDonald was retained by the City to complete a Neighbourhood Master Stormwater and Drainage Study, and the study is to focus on the McKellar and Northwood Wards. The study is to include:

- an analysis of the flooding;
- assessment of sewer performance;
- current and historical data review, and
- specific storm water infrastructure and management recommendations to minimize future flooding events.

The four areas reviewed and assessed as part of this study are as follows:

- Area 1 – Northwood – generally bordered by the Harbour Expressway on the north, Thunder Bay Expressway on the west, Redwood Avenue on the south and Edward Street on the east. Approximately 190 homes in this 155 ha ± area reported flooding.
- Area 2 – Intercity – generally bordered by Lisgar Street on the north, Memorial Avenue on the west, Seventh Avenue on the south, and Fort William Road on the east. There were 85 homes in this 46 ha ± area that reported flooding.
- Area 3 – East End (East of Simpson Street) – generally bordered by the Neebing River to the north, Simpson Street on the west, the Kam River on the south and Island Drive on the east. This area is approximately 72 ha ±, and 157 homes in this area reported flooding.
- Area 4 – East End (West of Simpson Street) – generally bordered by the Neebing River on the north, Vickers Street on the west, Finlayson Street on the south and Simpson Street on the east. There were 114 homes in this 70 ha ± area that reported flooding.

The four study areas are illustrated on Figure 1.



Hatch Mott MacDonald

STUDY AREAS

FIGURE 1

1.2 Study Objectives

The objective of this study is to complete a detailed Stormwater Drainage Study. The study is to incorporate the following key tasks, and is to follow the Municipal Class Environmental Assessment (EA) process:

- Public education;
- Identify problems related to storm water and surface drainage runoff within the designated areas (capacity problems, groundwater levels, etc.);
- Review, investigate and monitor the existing storm sewer systems to establish the location and magnitude of basement flooding within the designated areas;
- Review all available data;
- Identify remedial measures to reduce basement flooding;
- Develop hydraulic models of the storm sewer systems for the purpose of establishing the location and magnitude of existing system (storm sewer) deficiencies and test the effectiveness of remedial measures under the 2, 5, 10, 25 year design storm condition;
- Develop a prioritized implementation plan for capital projects including recommendations for site selection, protecting and purchasing property, budget cost estimates and requirements for regulatory approvals.

It should be noted that analysis of the sanitary sewer systems, combined sewer systems and overland storm water flow was not included as part of the study.

The implementation plan will be aimed at reducing risk to the Municipality and property owners and improve the storm system to reduce:

- Consumer complaints;
- Operations and maintenance activities;
- Infiltration/inflow;
- Overflows, flood damage, basement flooding;
- Service interruptions.

The prioritized plan will include:

- Recommendations for site selection;
- Recommendations for protecting and purchasing property;
- An evaluation of which works require amendments to existing Certificates of Approval (or Environmental Compliance Approvals) or other approvals (such as the completion of a Class Environmental Assessment);
- Cost estimates.

1.3 Environmental Assessment Process

The proposed improvements resulting from this study will ultimately be subject to the requirements of the Municipal Class Environmental Assessment (EA). The Municipal Class EA applies to municipal infrastructure projects including water and wastewater projects. As projects undertaken by municipalities can vary in their environmental impacts, the projects are classified in terms of schedules.

The schedules in the Class EA include:

Schedule A	Generally includes normal or emergency operational and maintenance activities. The environmental effects of these projects are usually minimal, and these projects are pre-approved.
Schedule A+	Similar to Schedule A projects, but involves notifications to the public prior to proceeding.
Schedule B	Generally includes improvements and minor expansions to existing facilities. These projects have the potential for some adverse environmental impacts and therefore require a screening process including consultation with those who may be affected.
Schedule C	Generally involves the construction of new facilities and major expansions to existing facilities. These projects proceed through all five phases of the EA planning process.

The determination of which schedule the proposed improvements fall under will be required at the time of implementation.

1.4 Report Format

The main body of the report includes a summary of the analysis and recommendations to be carried forward. The detailed information pertaining to the development of a computerized model and analysis of the storm sewer system in enclosed as Technical Appendix A.

2.0 REGULATIONS AND STANDARDS

2.1 Regulations

The Environmental Assessment Act (EAA), the Ontario Water Resources Act (OWRA), the Clean Water Act (CWA), the Nutrient Management Act (NMA), the Environmental Protection Act (EPA) and the Environmental Bill of Rights 1993 (EBR), are statutes administered by the Ontario Ministry of the Environment that are applicable to municipal sewage works. Ministry Guidelines and associated Procedures that are of importance to this study include:

- MOE Design Guidelines for Sewage Works (2008);
- MOE Stormwater Management Planning and Design Manual (2003)

It should be noted that the design of the existing storm sewer systems would have been completed with reference to the applicable Design Guidelines in place at the time. For example, the MOE Guidelines for the Design of Storm Sewer Systems were initially published in 1979 and updated in 1985 and 2008. Prior to those Guidelines being developed, engineers used the Ten States Standards for Sewage Works as reference design guidelines, as well as other technical reference documents.

The current MOE Design Guidelines state that at a minimum, a 2-year return design storm should be used for minor systems. The minor drainage system includes roof gutters, service connections, street gutters, catch basins and storm sewers. The major system encompasses natural streams and valleys, and roads, swales, channels and ponds.

2.2 Municipal By-Laws

The City of Thunder Bay has several By-Laws in place that address storm water and storm drainage on private properties and discharge of same to the municipal sewer system. Excerpts from these By-Laws are summarized as follows, and are also enclosed in Appendix B.

<u>2.2.1 By-Law 66-2008 Property Standards By-Law</u>

"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."

2.2.2 Municipal Code Sewage Discharge

"1052.3.5 Stormwater – drainage – exception – combined sewer

Without limiting the generality of Sections 1052.3.1 and 1052.3.2, except in the case of discharge into a combined sewer, stormwater, water from drainage of roofs or land, water from a watercourse or uncontaminated water is prohibited."

2.2.3 By-Law 373-1992 Control of Waste Discharge to Municipal Sewers

"2.01 (b)(iii) No person shall discharge or deposit or cause or permit the discharge or deposit of matter of a kind listed below into or in land drainage works, private branch drains or connections to any sanitary sewer or combined sewer: except in the case of discharge into a combined sewer, stormwater, water from drainage of roofs or land, water from a watercourse or uncontaminated water."

2.3 City Design Standards

The City of Thunder Bay has developed Engineering and Development Standards for use in designing roads and municipal services within the City. The 2013 Design Standards include the following with respect to storm sewer systems:

"Assuming a major system can be adequately provided and foundation drains are not connected by gravity to the storm sewers, the criteria for the design of the minor system would be a 2-year return storm. The combination of the minor and major storm system should be checked for a total capacity to accommodate either the regional storm or the 100 year storm event whichever results in the greater rainfall"

The theoretical return period is the inverse of the probability that the event will be exceeded in any one year (or more accurately the inverse of the expected number of occurrences in a year). For example, a 10 year storm has a 1/10 or 10% chance of being exceeded in any one year and a 50 year storm has a 1/50 or 2% chance of being exceeded in any one year.

This does not mean that a 100 year storm will happen regularly every 100 years, or only once in 100 years, despite the connotations of the name "return period". In any given 100 year period, a 100 year event may occur once, twice, more, or not at all, and each outcome has a probability. These return periods or design storms are a standard method of designing and evaluating the performance of a storm sewer system.

A review of several other Ontario municipalities design standards was conducted. The City of London, the City of Sudbury, and the City of Welland utilize the 2-year design storm for the minor storm system. The City of Dryden utilizes the City of Thunder Bay Engineering Standards for their storm sewer designs. Other municipalities in Northwestern Ontario (Town of Fort Frances, Municipality of Sioux Lookout, City of Kenora) utilize the MOE Design Standards, which utilize a 2-year design storm for the minor storm system. The City of Barrie, the City of St. Catherines, the Region of Waterloo and the City of Oakville use a 5 year design storm for the minor storm system and up to a 100 year design storm for the Major Drainage Elements.

The City's design practice is very similar to the design standards used by several other municipalities as noted above.

2.4 Analysis of May 2012 Storm

The City commissioned a meteorological study of the May 28, 2012 rainfall. The report that was prepared titled "A Meterological Analysis of the Thunder Bay Heavy Rain Event: May 28, 2012, prepared by Graham Saunders, Weather Works, November 24, 2012" concluded that the May 28, 2012 storm reached the 100-year return period, and the storm reached this condition more quickly than any other historical storm experienced in Thunder Bay. The storm was localized in the south ward of the City, and significant differences in the rainfall was detected between the Neebing River gauge at Confederation Dr. and the LRCA gauge at Oliver Road and Golf Links Road,

3.0 Description of the Study Areas

All four of the study areas are impacted by upstream storm events due to the proximity of the Neebing River and the Kaministiquia River to the study areas, causing water levels to rise, and entering the storm sewer systems limiting/restricting discharge of rainwater. The Floodway Diversion Structure is located south of Area 1, and during rainfall events when the levels in the Neebing River rise to 184.17 m, the diversion structure begins to divert water into the floodway to minimize impacts on properties downstream on the Neebing River.

In addition there are inherent problems in certain areas due to the low relief as well as proximity to the rivers,

3.1 Area 1

3.1.1 Study Area Features

Area 1 (Northwood) is generally bordered by the Harbour Expressway on the north, Thunder Bay Expressway on the west, Redwood Avenue on the south and Edward Street on the east, and is approximately 155 hectares in size.

The area is located near two of the city's waterways, the McIntyre River to the north-east and the Neebing River to the south. The Neebing-McIntyre floodway is also located to the east of the study area.

The soils in the area are generally described as 1 – 1.5m of peat, underlain by loose sands, silts and silty clays.

3.1.2 Land Use

The land use in Area 1 is primarily residential, with a mix of single family, semi-detached, townhouses, and apartments. There are several small parkettes and one large park, Kinsmen Park, located in the western portion of the study area. There are also three elementary schools within the area and one shopping mall located on the southern boundary of the study area.

Most of the single family homes are of a similar size, with fairly large lots with mainly grassed surfaces. The majority of the homes have paved driveways. The Limbrick area has a number of smaller semi-detached and townhouse lots, with a smaller grassed surface area.

The ground surface on quite a number of the lots has settled which is evident by gaps under the front stairs and marks on the foundation walls where the ground used to be. In some cases this has resulted in the surface drainage being directed towards the house.

3.1.3 Storm Drainage

Piped storm sewers are provided throughout the area, and the roads are paved and have curb and gutter. Generally, there are two main tributary drainage areas. The first area includes the areas south of James St. which flow in a southerly direction, eventually discharging to the Neebing River. The second area, north of James St., discharges easterly to the Neebing McIntyre Floodway.

The topography is fairly flat, with an overall slope of the northerly catchment area in the range of 0.6%. and 0.4 to 0.5% in the southerly catchment area.

Homes in some areas of the Northwood area are known to have direct gravity weeping tile connections to the storm sewers, which was allowed under previous/older engineering standards. Additionally, sump pump connections to the storm sewers are also known to exist. The Engineering Standards dating back to 1985 contained drawings for weeping tile connections to the storm sewer utilizing a sump pump, with a cautionary note that storm sewers are susceptible to surcharging and this should be considered.

Eavestroughs are directed to the surface of the lots, although the length of the extensions varies considerably – some homes have very short or no extensions to direct the water away from the foundation wall, while others have longer leads.

Continual flow in the storm sewers is typically observed as a result of naturally occurring high ground water conditions and the weeping tile/sump pump connections to the storm sewer. The peat materials underlying the majority of Area 1 retain water from spring melt and rainfall events, leading to a high water table resulting in high inflow to the sewer system through both weeping tile connections and infiltration. During the summer the peat dries and rainfall does not immediately impact the water table. As the peat absorbs the precipitation and becomes saturated, the inflow/infiltration increases.

The storm sewer piping in the area is a mix of concrete (66%), PVC (12%) Corrugated Steel Pipe (CSP) (7%) and other pipe types (15%). The sewers are typically in the age range of 30-40 years old. The City's Asset Management Plan indicates a 100 year life cycle for storm sewers.

3.1.4 Historical Data

There are a number of historical flooding events in Area 1 that have caused problems with street, yard and basement flooding, briefly summarized as follows:

- June 28 and 29, 1996
- July 2, 1997
- June 29, 2005
- June 6 – 9, 2008

The extent of flooding in Area 1 varied with the above storm events, and information on the intensity and duration of the above storm events is not available, i.e. were the storm events 2, 5, 10 year return storms.

3.1.5 May 2012 Storm Event

As a result of the May 2012 rainfall events, reported basement flooding was generally widespread throughout the study area with the exception of the Limbrick Area and Redwood Ave., where basement flooding was not as extensive. Approximately 190 homes reported flooding.

The following are some general observations and photos depicting the extent of flooding in Area 1:

- Humber Parkette flooded (Figure 2)
- Northwood Park Plaza parking lot flooded (Figure 3)
- The Neebing River located to the south of the study area was flooded and the Edward St. Bridge was temporarily closed to traffic as the flood water was up to the underside of the bridge girders (Figure 4)

Figure 2 – Humber Parkette Looking Southwest May 28, 2012 7:41 AM (local Resident)

Figure 3 – Northwood Park Plaza Parking Lot, looking south-west

Figure 4 – Edward St. Bridge over the Neebing River Looking East

3.1.6 Recent Storm Drainage Improvements

The following general improvements have been made to the storm sewer system in and around Area 1 during the 2013 construction season:

- Sycamore Ave. sewer improvements from Churchill Dr. to Amethyst Cr., – increased the outfall sewer size from 600 mm to 900 mm, and replaced the outfall and constructed a new outfall structure between Amethyst Cr. to the Neebing River (this is outside of the Area 1 study area);
- Cambrian Cres. – installed an additional section of 450 mm storm sewer on the east leg of Cambrian Cres. upstream of Redwood Ave. to increase capacity.

3.2 Area 2

3.2.1 Study Area Features

Area 2 (Intercity) is bordered by Lisgar Street on the north, Memorial Avenue on the west, Seventh Avenue on the south, and Fort William Road on the east, and the approximate land area is 46 hectares.

This is a low lying area of the City, which has historically been plagued with drainage problems.

Most of the dwellings are lower than the existing road elevation, so if the catchbasin and ditch system is overwhelmed by a severe weather event, flooding onto private property can occur.

The area is flat and soils are generally described as surface organics, 0.5 m+/- of peat, 1m +/- organic silt, a layer of silty clay and then silt to clayey silt. The water table is generally quite high (approximately 1 m below the surface). Ground surface elevations range from 185 m to 186 m, compared to the average level of Lake Superior of 183.2 m.

3.2.2 Land Use

The land use in Area 2 is a mix of residential and commercial uses. Commercial uses are generally along the western border Memorial Ave. as well as the north end of the area. The Thunder Bay Transit Garage is located in the south east portion of the area.

Located immediately east of the study area is the Canadian Pacific Railway (CPR) rail yard as well as industrial lands along the shore of Lake Superior. Lake Superior is located approximately 750 m to the east of the study area.

The residential areas are all fairly similar, with smaller lots and older homes, and the homes situated close to the street with a small front yard. The newer homes have more of a setback and a larger front yard. Driveways are a mix of paved and gravel surfaces.

3.2.3 Storm Drainage

Storm drainage in the area is a mix of piped sewers and open ditches. Drainage for the majority of the area is in an easterly direction towards Lake Superior. A small portion of Memorial Ave. discharges to downstream systems south of the study area.

The roadways are paved, with open ditches and no curb and gutter. Eavestroughs are directed to the surface of the lots, and the majority of the homes have very short or no extensions to direct the water away from the foundation wall. The commercial areas have large paved parking areas.

The storm sewers east of Memorial Ave. drain into two pumping stations, which pump the water up into two concrete lined open channels at Beverly Street and Third Avenue. The concrete channels connect to an open ditch system on the east side of Fort William Road that extends through the private CPR/CNR rail yard and industrial lands, and outlets into Lake Superior at Maureen Street.

The tributary drainage area for the storm sewer system extends to the north and the west well beyond the study area boundaries. The concrete channels accept flow from the study area via the two pumping stations, as well as surface drainage from west of the study area. A considerable component of the drainage external to the study area does not enter the storm sewer system, as it is conveyed through separate open ditch and culvert systems directly to the Beverly Street and Third Avenue concrete drainage channels.

There is very little grade between the study area and the outlet, and the ditches often remain full of water after a rainfall event or during the spring thaw. The effectiveness of the existing system is highly dependent on the lake level, which fluctuates throughout the year. The overall grade differential from the pumping station outlets to the lake is less than 0.1%. At Lake Superior’s highest water level (i.e. 183.6 m), there is zero grade difference in the drainage system.

The pumping stations are located on the south side of the Beverly St. right of way east of Ontario St., and on the south side of the Third Ave. right of way east of High St. The more northerly pumping station, Intercity Pumping Station, receives storm water from the storm sewers between Lisgar/Spofford St. to the north and First Ave. to the south as well as areas west of the study area. The Third Ave. Pumping Station receives piped storm water from Second Ave. to the north and Seventh Ave. to the south.

There is a separate storm sewer system along Memorial Ave. that only collects water from the Memorial Ave. roadway, and eventually discharges to the Central Ave. Pumping Station that is south of the study area.

The storm sewers and pumping stations in the study area east of Memorial Ave. were constructed between 2007 and 2009. The Memorial Ave. storm sewers are approximately 30 years old.

3.2.4 Historical Data

Area 2 is a low lying area of the City, which has historically been plagued with drainage problems. The improvements to provide the localized storm sewer systems as noted above has helped minimize flooding problems under smaller and less intense storm events such as a 2 or 5 year return storms. During larger and more intense storms, the downstream ditch system through the CPR and CNR private railway lands is an impediment to the flow. The storm sewers and pumping stations may be able to collect and deliver the water to the discharge point, but the storm water flow is reduced due to backups and standing water in the downstream ditches. The water recirculates at the pumping station and backs up in the storm sewers causing surface flooding.

There are a number of historical flooding events in Area 2 that have caused problems with street, yard and basement flooding, briefly summarized as follows:

- July 2, 1997
- July 4, 1999
- June 29, 2005
- June 2008

The extent of flooding in Area 2 varied with the above storm events. The intensity and duration of the above storm events is not available, i.e. were the storm events 2, 5, 10 year return storms.

3.2.5 May 2012 Storm Event

Basement flooding was generally widespread throughout the northern portion of the study area (Second Ave. and north) as a result of the May 2012 storm event(s). Less extensive basement flooding was reported to the south of Second Ave and occurring generally in the area of Fourth Ave. Approximately 85 homes reported flooding in both parts of the study area.

The following are some general observations and photos depicting the extent of flooding in Area 2:

Figure 5 - First Ave. Area

Figure 6 – Discharge from the Intercity Pumping station to the Beverly concrete lined ditch looking north east toward the Moose Hall

3.2.6 Recent Storm Drainage Improvements

The following general improvements have been made to the storm sewer system in and around Area 2 during the 2013 construction season:

- Fort William Road – installed an additional 1200mm culvert across Fort William Road at the Beverly ditch to increase the capacity under Fort William Road;
- Plugged catch basin lead from Fort William Road onto First Ave.

3.3 Area 3

3.3.1 Study Area Features

Area 3 (East End east of Simpson St.) is generally bordered by the Neebing McIntyre Floodway to the north, Simpson Street on the west, the Kaministiqua River on the south and Island Drive on the east. Lake Superior is approximately 600 m to the east of the study area.

This area is approximately 72 hectares in size.

The soils in the area are generally described as surface organics, with a layer of sand and silt, then clay.

3.3.2 Land Use

The land use in Area 3 is primarily residential. Located immediately to the south of the study area is the Canadian Pacific Railway (CPR) rail yard which extends along the shore of the Kaministiqua River.

The City's Water Pollution Control Plant is located immediately north east of this study area.

The majority of the study area has smaller lots and the homes are situated close to the street with small front yards. There are few driveways, and the driveways are a mix of paved and gravel surfaces. The topography is very flat, and the lots have little or no slope between the homes and the street.

3.3.3 Storm Drainage

Historically, storm water drainage and sanitary collection service in this area were provided by combined sewers. Over the past several years the City has replaced combined sewers with separate storm sewers and sanitary sewers throughout most of the area. Combined sewers still exist on McLaughlin St. and McIntosh St. north of Atlantic Ave.

Eavestroughs are directed to the surface of the lots, and the majority of the homes have very short or no extensions to direct the water away from the foundation wall.

The roadways are paved and, in the majority of the area, there is no curb or curb and gutter, but the sidewalk is adjacent to the asphalt and acts as the curb. Surface drainage along small areas of Atlantic Ave. and N. McLauglin Ave. is provided by open ditches.

There are two major tributary drainage areas. Generally, surface drainage south of Atlantic Ave. flows south to an outfall at the Kaministiqua River. The Northwest section of the area flows north to an outfall at the Neebing-McIntyre Floodway.

The topography is fairly flat, with an overall surface slope of less than 0.1%. Due to the area's low relief and proximity to the Floodway and Kaministiqua rivers, the storm sewers are generally very shallow and are impacted by the river levels. The storm sewer systems normally contain river water to some degree, dependent on the river level, and are designed to surcharge. Despite this, surface drainage in the area is generally not problematic.

Both outfalls are fitted with sluice gates which can be used to isolate the storm sewer from the river in order to conduct maintenance of the sewers. The sluice gates are manually operated, and are normally left in the open position.

The storm sewers are generally shallow and there are no gravity foundation drain connections to the storm sewers.

3.3.4 Historical Data

The flooding records that were provided for Area 3 did not indicate a history of storm related flooding events.

3.3.5 May 2012 Storm Event

As a result of the May 2012 storm event(s) reported basement flooding was generally widespread throughout the entire study area.

Approximately 157 homes reported basement flooding.

3.4 Area 4

3.4.1 Study Area Features

Area 4 (East End west of Simpson St.) is generally bordered by the Neebing River on the north, Vickers Street on the west, Finlayson Street on the south and Simpson Street on the east. The Area is approximately 70 hectares in size.

The soils in the area are generally described as surface organics, with a layer of sand and silt, then clay.

3.4.2 Land Use

The land use in Area 4 is primarily residential. West of May Street the lots are larger and the houses set back from the street, such that the front yards are larger. East of May Street the lots are smaller, and the homes are situated close to the street with a small front yard. Driveways are a mix of paved and gravel surfaces.

3.4.3 Storm Drainage

Historically, storm water drainage and sanitary collection service in this area were provided by combined sewers. Over the past several years the City has replaced combined sewers with separate storm sewers and sanitary sewers throughout most of the area. Some combined sewers remain in the area west of Prince Arthur Boulevard.

Eavestroughs are directed to the surface of the lots, and the majority of the homes have very short or no extensions to direct the water away from the foundation wall.

The roadways are paved and there is a mix of areas with curb and gutter drainage, and those with open ditch/swale drainage.

Storm sewer drainage in this area discharges to the Neebing River. There are a total of four outfalls to the river, three on the south side of the river and one on the north side of the river.

The topography is fairly flat, with an overall surface slope of less than 0.1%. Due to the area's low relief and proximity to the Neebing River, the storm sewers are generally very shallow and are impacted by the river levels. The lower reaches of the storm sewer system can be flooded when the river levels are high. Despite this, surface drainage in the area is not problematic.

The storm sewers are generally shallow and as a result, gravity foundation drains, where they exist, are likely not connected to the storm sewer system. The extent of such connections is unknown, but not expected to be widespread.

3.4.4 Historical Data

There are a number of historical flooding events in Area 4 that have caused problems with street, yard and basement flooding, briefly summarized as follows:

- June 28 and 29, 1996
- July 2, 1997
- June 29, 2005
- June 6 – 9, 2008

The extent of flooding in Area 4 varied with the above storm events. The intensity and duration of the above storm events is not available i.e. were the storm events a 2, 5, 10 year return storm.

3.4.5 May 2012 Storm Event

As a result of the May 2012 storm event(s) reported basement flooding was generally widespread throughout the entire study area. Approximately 114 homes reported flooding.

The following photo depicts some of the flooding in Area 4:

Figure 7 – Southern Avenue

4.0 STORM SEWER SYSTEM HYDRAULIC MODEL DEVELOPMENT

The analysis of the existing storm sewer system utilized a hydraulic model of the storm sewer system as one of the tools. The main purpose of the modeling assignment was to identify the existing level of service provided by the storm sewer system, establish the location and magnitude of existing storm sewer system deficiencies (if any) under the specific storm events identified, and test the effectiveness of potential remedial measures under design storm conditions.

The software PC SWMM was selected as the preferred software to complete the hydraulic modeling, as it provides good hydrologic and hydraulic modeling and data processing capabilities and features. The relatively low cost and features of the PC SWMM modeling package will be an advantage should the City ultimately decide to purchase a copy of the model for future sewer modeling in-house.

4.1 Sewer Model Development

The hydraulic model development included the following tasks:

1. Collection of the existing Geographic Information System (GIS) information and as-built drawings on the storm sewer system from the City;
2. Selection of a preferred hydraulic model for the assignment;
3. Importation of the existing GIS fabric into the stormwater management model;
4. Inferring non-existing data or obtaining data from the drawings or obtaining field verifications from the City;
5. Delineation of tributary drainage areas for each catchment area;
6. Developing an Extended Transport Model and Runoff Model;
7. Calibration and validation of the model by using collected flow and rainfall data;
8. Analysis of the existing storm sewer capacity for different design storms.

The City supplied Hatch Mott MacDonald (HMM) with the existing GIS fabric of the storm sewer system, which was imported into and formed the base for the model. During the importation of the received GIS data into the model, it was noted that the existing GIS information was not complete. Some manhole information was missing such as depths of manholes, invert elevations of the sewers at manhole locations, etc. Other information was erroneous, such as catchbasins labeled as manholes, and vice versa.

We also noted that the GIS information was not completely up to date, as some recent storm sewer installations were not reflected in the GIS data. This was expected, and in order to assist in the modeling development process, HMM staff used inference techniques to fill in some data gaps. A summary of missing junction and pipe invert elevations was submitted to the City, and the information subsequently provided.

Once the modeling framework was completed with the elevation information obtained from the City, the tributary drainage areas for each catchment area were incorporated into the rainfall Run-off Model, and the Extended Transport model was completed to route the flows.

There are several combined sewers in Areas 3 and 4, but they were not modeled or included in the analysis of this study. The analysis of overland flow was also not included in the study.

4.2 Flow and Rainfall Monitoring

To produce accurate, reliable results the PC SWMM model needed to be properly calibrated and verified to ensure it is reflective of the actual system. Accurate hydrology is critical to developing a reliable model - the rainfall and infiltration information is important as well as the amount of storm water in the system. The use of rainfall and sewer flow monitoring data was used to calibrate the model, as well as historical flooding information.

The City did not have any historical storm sewer flow data. As a result the City undertook a rainfall and flow monitoring program as part of this study and that data was utilized in calibration of the model.

Rainfall gauges were established in three locations within the study area at Confederation College, the Thunder Bay Transit Garage, and the Atlantic Avenue Waste Water Treatment Plant. The gauges were set in place in October 2012, and a report of the data collected was provided to the City on a monthly basis by an independent contractor. The rainfall data was provided in 5 minute intervals, and almost 20 rainfall events were captured. During the data collection there was one very significant rainfall event on May 19, 2013 which was beneficial in calibrating the models for two of the study areas.

Flow monitor locations were identified in each of the study areas, with a total of thirteen (13) monitors recommended. The locations were reviewed with City staff, and the City undertook the installation and maintenance of the flow monitors, and provided the data to HMM for use in the model calibration and verification. Six (6) monitors were established in Area 1, two (2) in Area 2, two (2) in Area 3 and three (3) in Area 4. The flow data was only reviewed during periods of rain events.

4.3 Model Calibration and Validation

The rainfall and sewer flow data that was collected by the City was used to calibrate and validate the model. Half of the data was used to calibrate the model and the other half to validate the model. The Code of Practice for the Hydraulic Modeling of Sewer Systems, published by the Wastewater Planning Users Group (WaPUG, 2002) was used to establish criteria for the calibration and validation exercise. In all 4 of the study areas the simulated and observed event volumes and peak flows are generally within the acceptable WaPUG Code of Practice. Comparisons of the simulated and measured events are presented in Appendix A on Figures 7 to 14.

4.4 Rainfall Intensity

Historical rainfall data provided by Environment Canada is used to develop Rainfall Intensity-Duration-Frequency (IDF) curves for different areas of the country.

Environment Canada has accumulated data from 1952 to 2006 for Thunder Bay. The City of Thunder Bay's Engineering Standards also include IDF curves for use in designing storm sewer systems. A comparison of the IDF curves was made and the Environment Canada data incorporates more recent data that should be representative and reflective of current climate conditions, and indicates a trend toward larger and more intense storms on a more frequent basis. The difference between the two sets of data varies but is approximately 5%, with the Environment Canada data reporting higher intensities. The Environment Canada data was therefore used in the analysis of the storm sewer systems for a more conservative approach.

4.5 Other Investigations

The City undertook an extensive closed circuit camera (CCTV) investigation of the existing storm sewer systems following the May 2012 storm event. There were no significant pipe breakages, settlements, low areas, etc. reported.

5.0 PERFORMANCE OF THE EXISTING STORM SEWER SYSTEM

The purpose of the performance evaluation is to analyze the storm sewer capacity under 2, 5, 10 and 25 year design storm conditions (return period) taking into consideration factors which may include socio-economic, environmental, health and safety or financial factors. Some specific criteria that may be included in the performance evaluation may be:

- Potential for environmental pollution (i.e. overflows);
- Potential for flooding and damage to public and private property;
- Potential for service interruptions;
- Costs for upgrade/replacement.

For example, a section of sewer may be prone to overflowing to a waterway causing environmental effects and potential fines from the MOE and DFO. This may be a lower priority for upgrades when compared to sewers in residential areas that are prone to overflows and basement flooding.

The criteria used in the model was to identify those nodes or pipe junctions that are predicted to experience surface flooding for a time period greater than 0.02 hour (1.2 minutes). The minimum time interval that could be reported by the model is 0.01 hour (0.6 minutes), however the 0.02 hour provides a better representation and is less subject to minor variations in the analysis. Surface flooding indicates that the storm sewers are full of storm water and the manholes are also full of storm water up to the ground level.

Surface flooding was chosen as the reporting criteria rather than predicted basement flooding, as the depths and existence of basements in the various study areas is unknown, and is likely to vary widely depending on the type and age of structure. For example there may be homes without basements, homes that are elevated above the roadway such that the basement elevation is similar to the roadway, homes with low basements, homes with high basements, homes that are bi-levels, etc. It should be noted that using the surface flooding as the reporting criteria provides general indicators of problems within the specific study areas. It should also be noted when reviewing the findings of the analysis that some areas of basement flooding may still occur under a given storm event.

The figures illustrating the predicted extent of surface flooding with the existing storm sewer systems are included in the Technical Memo included as Appendix A.

5.1 Area 1

The results of the analysis under a 2 year design storm indicate that there is one area of predicted surface flooding on Kensington Dr. south of Ironwood Ave. This area does not appear to be an area of historical basement flooding based on the available records.

Analyzing the study area under 5, 10 and 25 year design storms identified other areas of predicted surface flooding. The 5 year storm condition predicts some areas of surface flooding of the local sewers in approximately 8% of the study area. Local surface flooding areas were identified on Trinity Cres., Fanshaw St., Ryerson Pl., Ingelwood Cres., Vale St., University Dr., and Kensington Dr.

The 10 and 25 year design storms predict additional surface flooding throughout Area 1 on both the trunk and local sewers. Approximately 22% of the study area is predicted to have surface flooding under the 10 year storm condition and 50% of the study area is predicted to have surface flooding under the 25 year storm condition. (Based on the extent of the piped storm sewer system.)

The drawings indicating the predicted levels of surface flooding for Area 1 are included in Appendix A as Figures 16 to 19.

5.2 Area 2

The results of the analysis under a 2 year design storm indicate that there is one area of predicted surface flooding on the west side of Memorial Ave. between Fourth Ave. and Seventh Ave.

Analyzing the study area under 5, 10 and 25 year design storms identified other areas of predicted surface flooding. The 5 year storm condition predicts some areas of surface flooding of the local and trunk sewers on Memorial Ave. between Fourth Ave. and Seventh Ave., and on High St. south of Fourth Ave to Seventh Ave.

The 10 year design storm indicates predicted surface flooding additional to that noted above, on High St. between Third Ave and Seventh Ave., on Second St. from Ontario St. to Fort William Rd., and on First St. between Ontario St. and Fort William Rd.

Extensive surface flooding is predicted under the 25 year storm condition, encompassing over 50% of the study area. (Based on the extent of the piped storm sewer system.)

The drawings indicating the predicted levels of surface flooding for Area 2 are included in Appendix A as Figures 20 to 23.

5.3 Area 3

The analysis under a 2 year design storm indicates that there is one area of predicted surface flooding on Pacific Ave. between McBain St. and Hargrave St.

Additional surface flooding is predicted under the 5 year storm condition on McIntosh St., McLeod St. and McPherson St. between Pacific Ave and Atlantic Ave., on McMcBain St. between Christie St. and Pacific Ave., on Hargrave St. between Christie St. and Pacific Ave. and on McLaughlin St. at McNaughton St.

The 10 and 25 year design storms predict additional surface flooding throughout Area 3 on both the trunk and local sewers.

The drawings indicating the predicted levels of surface flooding for Area 3 are included in Appendix A as Figures 24 to 27.

5.4 Area 4

There are no areas of predicted surface flooding under a 2 year design storm in Area 4.

Under the 5 year design storm condition there is predicted surface flooding on Durban St. from McKellar to Syndicate Ave., and along Syndicate Ave. from Durban St. to the outlet at the Neebing River.

The 10 and 25 year design storm predicts very limited surface flooding. There is surface flooding predicted on Durban St. and Syndicate Ave. north of the Neebing River, as well as on Wiley St. from Pacific Ave. to Southern Ave.

The drawings indicating the predicted levels of surface flooding for Area 4 are included in Appendix A as Figures 28 to 31.

6.0 Evaluation of Alternatives

The storm sewer model has identified areas that are predicted to experience surface flooding under varying intensities of storms. These areas along with areas of historical reported basement flooding were reviewed, and alternatives assessed to reduce the flooding.

One of the methods commonly used to reduce flooding is to increase the capacity of the storm sewer system such that it can convey more water and therefore reduce the volume of water that may cause flooding. Storm sewer capacity can be increased by providing larger drain sewers, by providing additional storm sewers, and by providing underground or surface storage such as tanks or ponds.

Alternatives were identified and assessed to eliminate the areas of predicted surface flooding and to reduce basement flooding under the different storm conditions.

The strategy used was to first review each of the study areas to identify improvements under a 2 and 5 year storm event. The trunk sewers for each of the study areas were then reviewed to identify improvements under a 10 year storm event. A review of the local sewers was again conducted under both a 2 year and 5 year storm event to assess the effectiveness of the trunk sewer improvements. The analysis was repeated to identify improvements under a 25 year storm condition.

The City's current design standards specify that the minor storm sewer system should be designed to a 2 year return period, assuming that a major storm system can be adequately provided and foundation drains are not connected by gravity to the storm sewer. The frequency of short duration and intense storms seems to have increased in recent years, and our analysis focused on enhancements to the existing standards where practical. For example, if a storm sewer pipe should be 375mm diameter to meet a 2 year design storm, and 450mm diameter to meet a 5 year design storm, utilizing the larger sewer will provide the City with a considerable additional benefit for a nominal additional cost.

Further alternatives such as twinning pipes, provision of storage, provision of pumping stations etc. were also assessed.

6.1 Area 1

The Area 1 study area is comprised of several tributary drainage areas, and 4 main trunk sewers. The trunk sewers are located on:

- Fanshaw St. flowing east from Ryerson Cres. to Edward St.,
- James St., flowing east from Ryerson Cres. to Edward St.,
- James St. flowing south from Ryerson Cres. to Redwood Ave., and
- Edward St. flowing south from James St. to Redwood Ave.

The 4 main trunk sewer areas are reviewed as follows.

6.1.1 Fanshaw St. Area

There are no improvements identified in the Fanshaw St. catchment area to meet a 2 year storm event. Under a 5 year storm event upgrades are identified on Trinity Cres. and on Fanshaw St. from Trinity Cres. to Seneca Cres.

Applying the above noted strategy of carrying out improvements to the trunk sewers to meet a 10 year storm event identified improvements on Fanshaw St. from Ryerson Cres. to Seneca Cres. These improvements also eliminate the predicted surface flooding on the local sewers under the 5 year storm conditions.

Increase in the size of the trunk sewer was identified, thereby increasing the capacity under a 10 year design storm, as well as under a 25 year design storm.

6.1.2 James St. East Area

There are no improvements identified in the James St. East. catchment area under a 2 year storm event. Under a 5 year storm event upgrades are identified on Conestoga St. and on Sheridan Cres.

Applying the above noted strategy of carrying out improvements to the trunk sewers to meet both a 10 year and 25 year storm event identified improvements on James St between Sheridan Cres. and Edward St. (and extending east on William St. to the Floodway). These improvements eliminate all but one of the predicted surface flooding areas on Conestoga St. under the 5 year storm conditions. The improvements to the trunk sewer will also alleviate potential surface flooding on Sheridan Cres., Ryerson Cres., and Humber Cres. up to a 10 year storm condition.

Under a 25 year storm condition, surface flooding on some local streets will be experienced even if the trunk sewer is upgraded to meet a 25 year storm condition. Improvements to the trunk sewer to upgrade from a 910 mm diameter to a 1,050 mm diameter was identified under both the 10 and 25 year design storm conditions.

In addition to the above alternatives, the provision of an additional storm sewer, i.e. twin storm sewers on James St. between Conestoga St. and Edward St., (and eventually extending east on William St. to the Floodway) was assessed as an alternative to increase the system capacity. This alternative provides some relief for the upstream local sewers, alleviating potential flooding on Sheridan Cres., Ryerson Cres., and Humber Cres. up to a 10 year storm condition. The analysis was completed using twin 900 mm sewers. The benefit in proceeding with this alternative compared to upgrading the trunk sewer to a single 1,050 mm diameter is it provides additional capacity to alleviate flooding under a 25 year storm event for several areas on Humber Cres. and Conestoga St. Constructability, cost and spatial restrictions due to existing utilities may also result in the twin sewer option being more practical than increasing the size of the sewer.

6.1.3 James St. South Area

There are no improvements identified in the James St. South catchment area to meet a 2 year storm event. There is one section of sewer on Ryerson Pl. identified for upgrading from 300 mm to 375 mm diameter under a 5 year storm condition.

Improvements to the sewer on Redwood Ave. west of James St., and between Dalhousie Dr. and James St. (through Kinsmen Park) are also recommended to help alleviate historical basement flooding in the McMaster St./Dalhousie Dr. area.

The model identified improvements to the south James St. trunk sewer to meet a 10 year storm, from south of Limbrick St. to Vale Ave. An increase in pipe size from a 910 mm diameter to a 1,050 mm diameter was identified under both the 10 and 25 year design storm conditions. The model also identified upgrades to the above noted section of sewer on Ryerson Pl. under a 5 year storm condition, even if the James St. trunk sewer is upgraded. Improvements to the trunk sewer between Vale Ave. and Redwood Ave. have not been identified by the model under the 10 year design storm conditions. However, increasing the trunk sewer size in this area is recommended to alleviate flooding under more severe storm conditions in tributary areas draining to this sewer.

Further improvements to the downstream sewer system and trunk sewer outside the study area limits may also be identified, which will require further analysis of both the capacity and condition of the sewers.

6.1.4 Edward St. Area

There is one area of predicted surface flooding under a 2 year storm event on Kensington Dr. south of Ironwood Ave., and one section of sewer was identified for upgrading. There are several areas of predicted flooding under a 5 year storm event, and upgrades have been identified on Bayberry Cres., University Dr., Ingelwood Cres., Sherbrooke St., Vale Cres., Huntington Cres., and Kensington Dr. to alleviate the predicted flooding. Improvements to the sewer on Ironwood Ave. west of Edward St. are also recommended to help alleviate historical flooding in this area.

Improvement to the Edward St. trunk sewer under both the 10 year and 25 year design storm conditions were not identified, if the local sewers are assessed against a 2 year design storm. If the local sewers that contribute to the Edward St. drainage area are upgraded under a 5 year design storm, an increase to the trunk sewer pipe size to a minimum of 675 mm diameter from the existing 610 mm diameter was identified.

The provision of a new sewer on Edward St. and Woodlawn Ave. was also assessed as an alternative to alleviate flooding in the University Dr. and Ironwood Ave. areas. The improvements would necessitate the construction of new sewers on Ironwood Ave. from Sherbrooke St. to Kensington Dr., on Edward St. between University Dr. and Woodlawn Ave., and along Woodlawn Ave. from Edward St. to the Floodway. This provides additional capacity to alleviate some flooding on Bayberry Cres., but would not alleviate predicted flooding on Kensington Dr. or Ironwood Dr., and is therefore not recommended as an improvement.

Further improvements to the downstream sewer system and trunk sewer outside the study area limits may also be identified, which will require further analysis of both the capacity and condition of the sewers.

6.1.5 Storm Water Detention/Retention

Area 1 is highly developed, with limited publically owned areas available for the provision of storm water detention/retention ponds and/or underground tanks. The Humber parkette and the Kinsmen fields are public areas that could be used for the storage of storm water during larger storms until such time as the storm sewers can convey the water to the downstream system.

Off-line sewage equalization/detention storage is a popular and effective means of reducing peak stormwater flows, which assists in alleviating flooding. Other methods of storage include parking lot storage which uses catchbasin restrictors to detain stormwater on parking lots, oversizing of storm sewers to create pipe storage, rear yard and park storage which uses catchbasin restrictors to detain stormwater on yards or in park areas, and wet and dry ponds. These methods are designed to detain stormwater to reduce peak runoff rates. Underground storage tanks can be constructed of PVC tanks, reinforced concrete tanks, modular plastic cubes (similar to a milk crate), etc. that capture excess storm flows prior to discharge to local receiving waters and store them during wet weather. During dry weather, the captured flows are pumped and/or drained back into the sewer system and conveyed to the downstream system.

A preliminary review of the storm sewer systems in the area of the Humber parkette and Kinsmen field was conducted. Storage of approximately 100 m^3 external to the piped sewer system on the east leg of Humber Crescent could result in some reductions in the extent of downstream sewer improvements on James St., when assessed with a 10 year design storm. The area of the parkette is approximately 20,000 m^2, which is sufficient to store 100 m^3 of storm water. The parkette would have to be regraded to create a low area large enough for this required volume. Alternately, below grade tanks could be utilized as storage.

In the area of the Kinsmen Park, storage of approximately 70 m^3 external to the James St. south trunk sewer could reduce the extent of upgrades to the James St. Trunk sewer (under a 10 year design storm). The Kinsmen Park is extensive, however it is heavily developed with soccer fields, baseball fields and playground areas. Regrading to provide for this storage would be required, and may not be feasible in this location. Underground tanks would likely be a more preferred option.

Further detailed design is required to confirm the extent and details of the storage, however this preliminary review indicates there are some benefits when assessing the extent of sewer upgrades required. The recommendation that will be carried forward will be to upgrade the downstream sewers to provide the additional conveyance capacity for larger and more intense storms, assuming stormwater retention storage is not provided. If upon further analysis some upstream stormwater retention is developed, the additional storage will allow for more capacity in the overall system, providing more protection against flooding.

There is also a large open space area between Ryerson Cres. and James St., however it is primarily tree covered and does not provide much opportunity for regrading without significant clearing.

6.1.6 Impacts on the Neebing McIntyre Floodway

Increases in the storm sewer conveyance capacities as noted above will result in the storm water discharging to the Floodway sooner and with a greater volume than under the current conditions. The watercourses that contribute to the Neebing River upstream of Area 1 will reach peak flow conditions at different and later times than the storm sewer system. This is evidenced by the gap in time between storm events and the start of flow diversion in the Floodway. Given the longer length of time for the upstream river sources to peak, it is unlikely that improvements to the storm sewer system conveyance capacity will have an impact on the capacity of the Floodway.

The figures illustrating the above analysis are enclosed as Figures 8 to 17.

LEGEND

SEWER IMPROVEMENTS
EXISTING SEWERS
EXISTING MANHOLES
3250 SEWER ID
OUTFALL

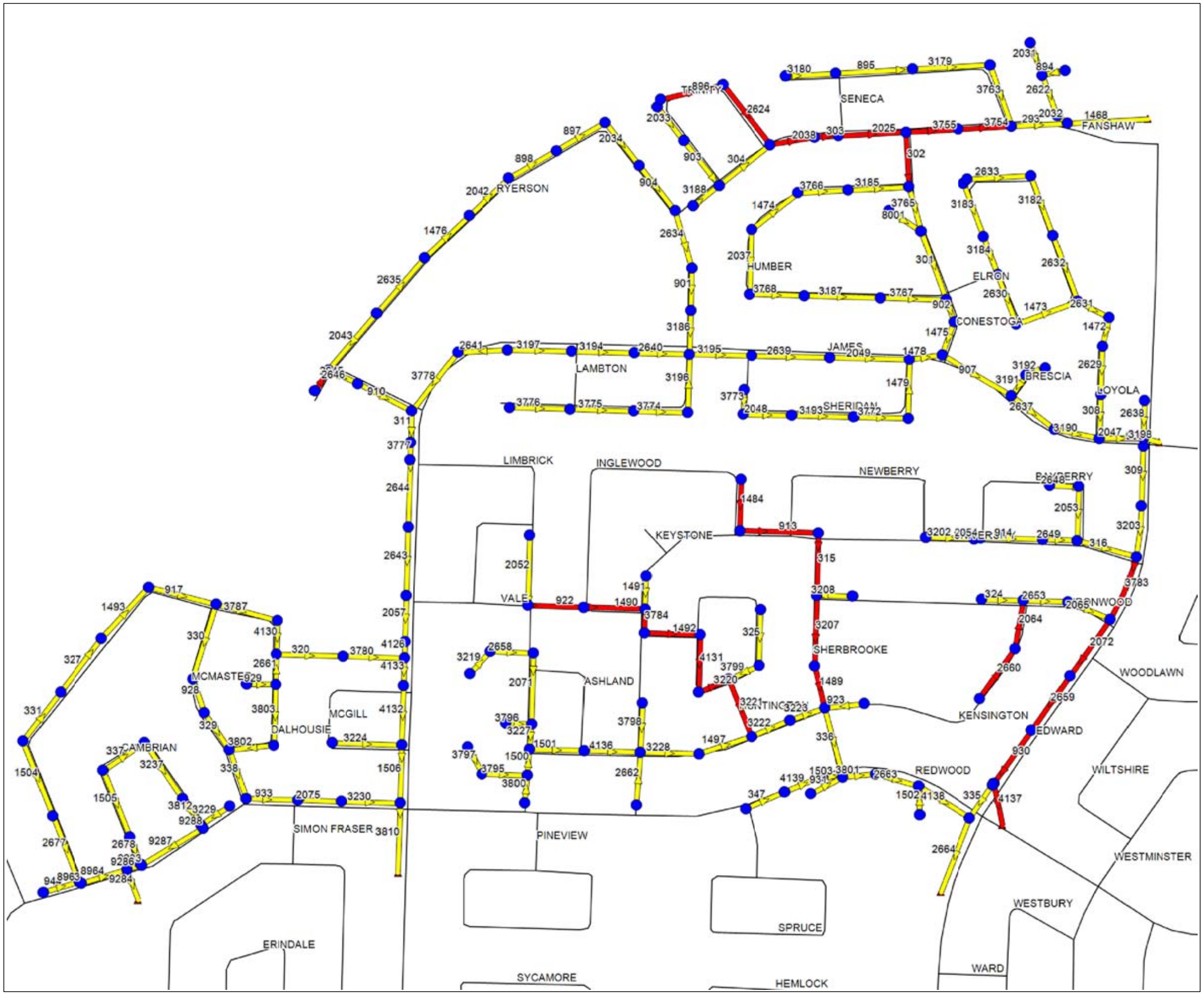
N

300 m

Hatch Mott MacDonald

AREA 1– IMPROVEMENTS IDENTIFIED UNDER 2 YEAR DESIGN STORM CONDITIONS

FIGURE 8



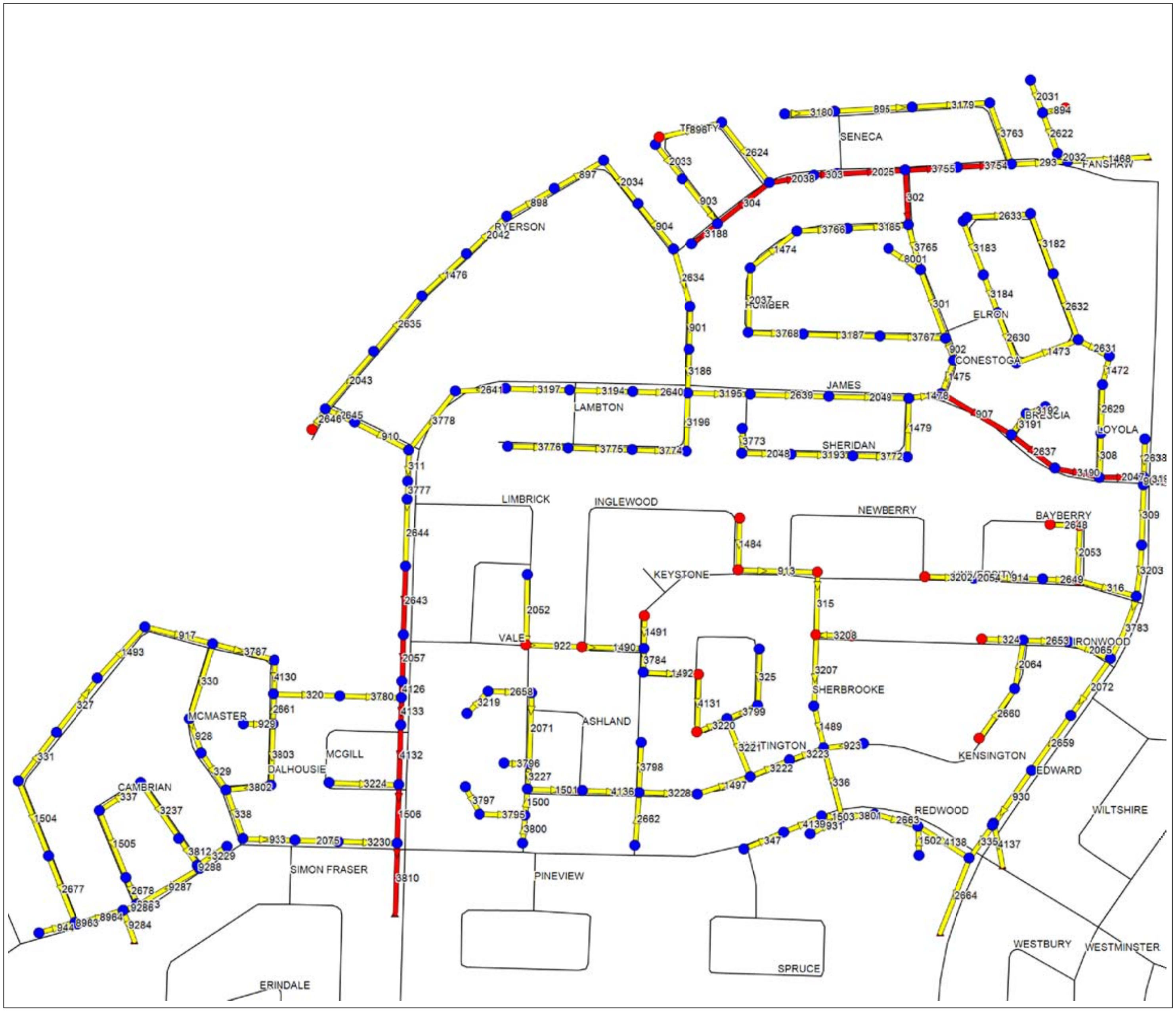
LEGEND

- SEWER IMPROVEMENTS
- EXISTING SEWERS
- EXISTING MANHOLES
- 3250 SEWER ID
- OUTFALL

Hatch Mott MacDonald

AREA 1– IMPROVEMENTS IDENTIFIED UNDER 5 YEAR DESIGN STORM CONDITIONS

FIGURE 9



LEGEND

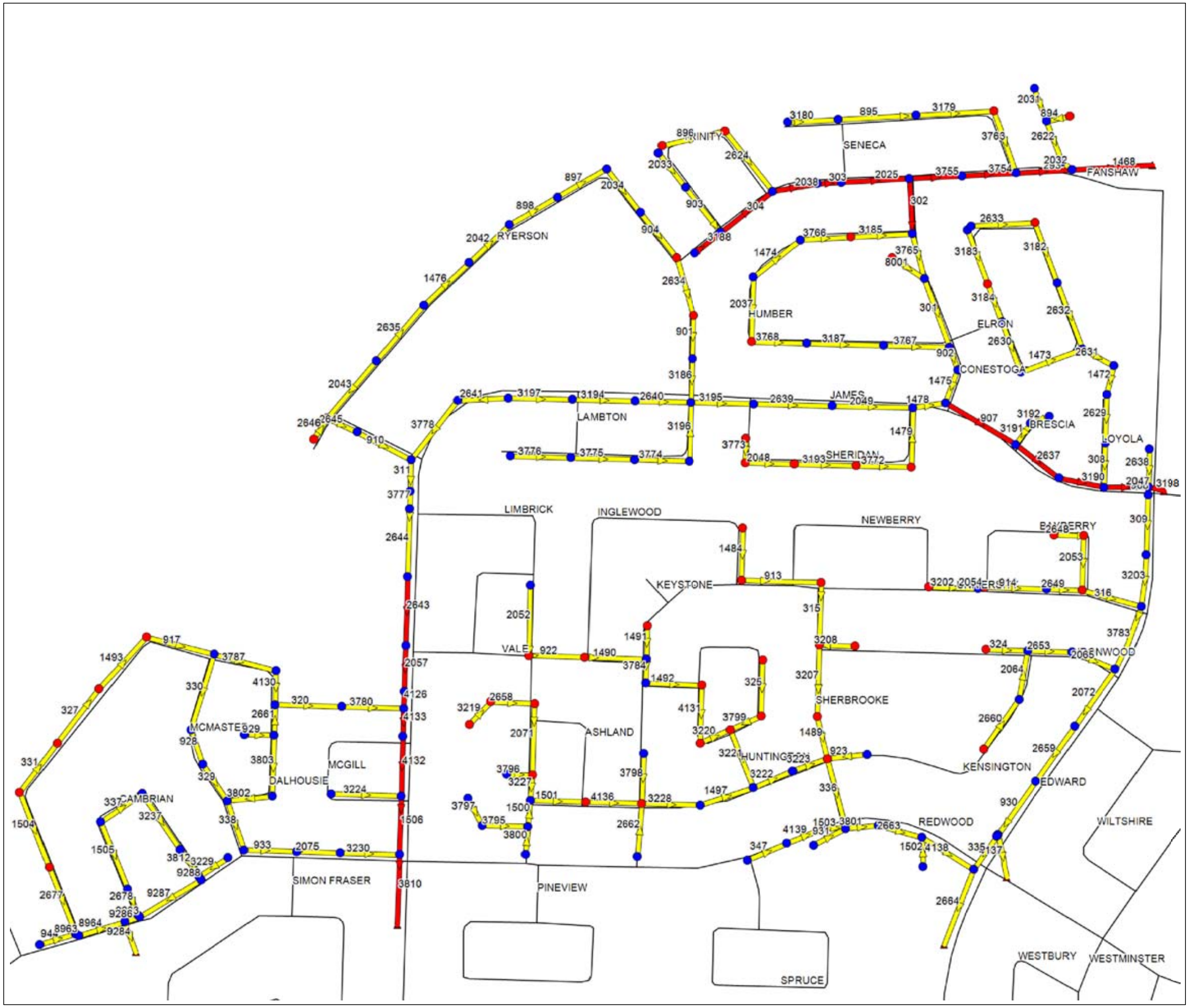
EXISTING SEWERS
EXISTING MANHOLES
SEWER ID
3250 OUTFALL
FLOODED MANHOLE
(≥ 0.02hr)

N

300 m

Hatch Mott MacDonald

AREA 1– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 10 YEAR DESIGN STORM CONDITIONS FIGURE 10



LEGEND

- SEWER IMPROVEMENTS
- EXISTING SEWERS
- EXISTING MANHOLES
- 3250 SEWER ID
- OUTFALL
- FLOODED MANHOLE (≥ 0.02hr)

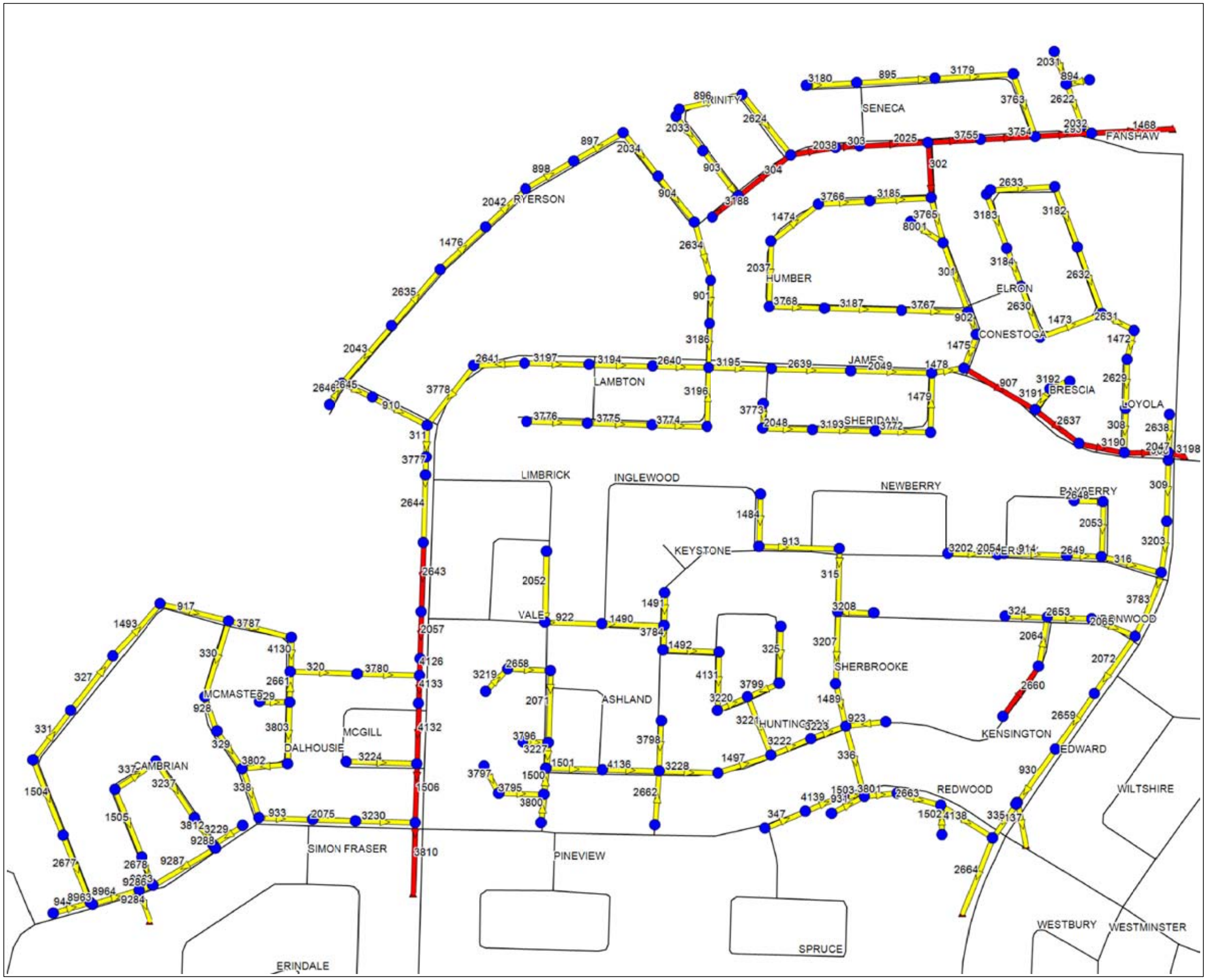
Hatch Mott MacDonald

AREA 1– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 25 YEAR DESIGN STORM CONDITIONS FIGURE 11

Hatch Mott MacDonald

AREA 1– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 10 YEAR DESIGN STORM CONDITIONS AND LOCAL SEWER IMPROVEMENTS IDENTIFIED UNDER 2 YEAR DESIGN STORM CONDITIONS

FIGURE 12



LEGEND

- SEWER IMPROVEMENTS
- EXISTING SEWERS
- EXISTING MANHOLES
- 3250 SEWER ID
- OUTFALL

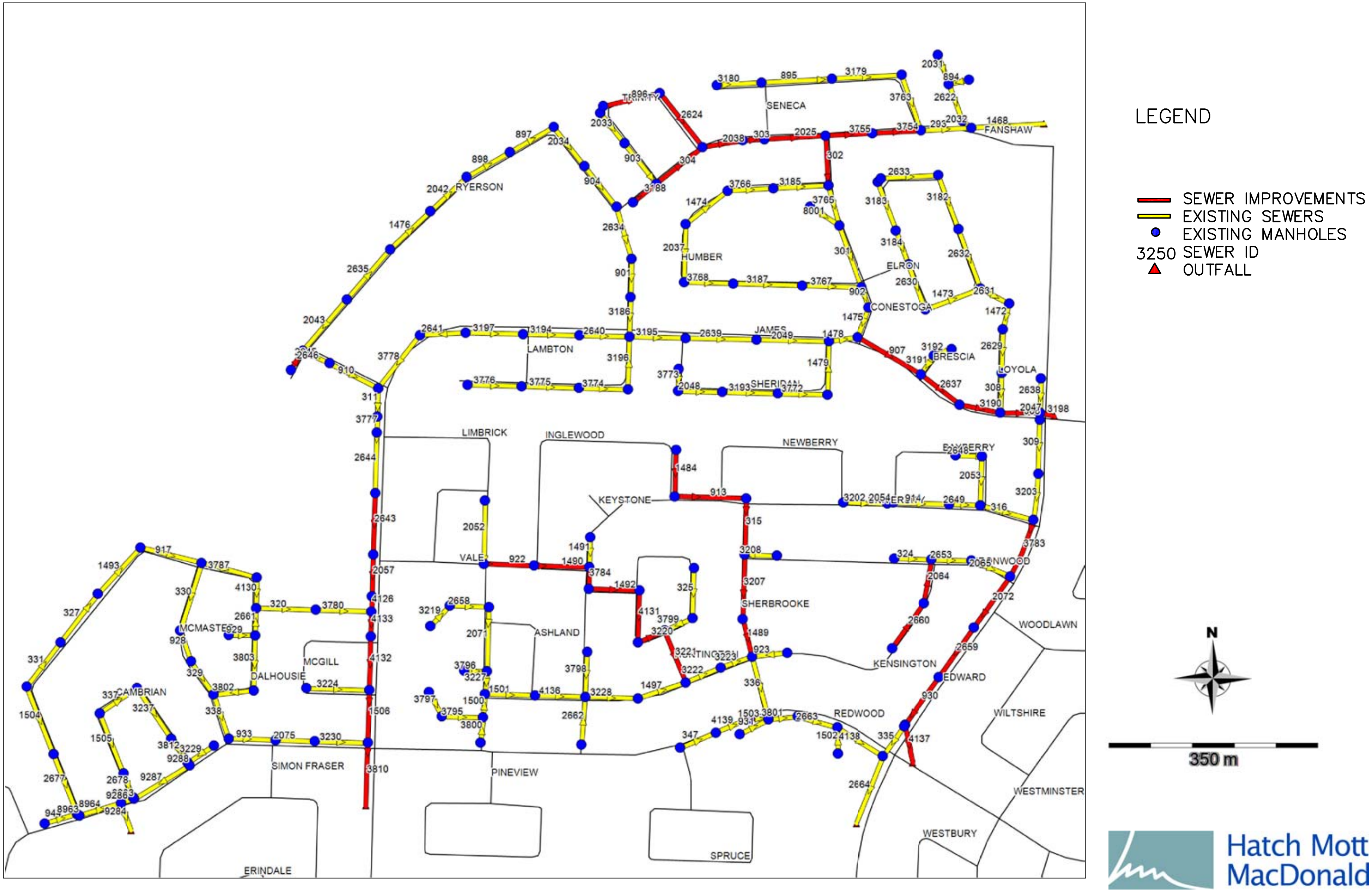
N

300 m

Hatch Mott MacDonald

AREA 1– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 25 YEAR DESIGN STORM CONDITIONS AND LOCAL SEWER IMPROVEMENTS IDENTIFIED UNDER 2 YEAR DESIGN STORM CONDITIONS

FIGURE 13



AREA 1– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 10 YEAR DESIGN STORM CONDITIONS AND LOCAL SEWER IMPROVEMENTS IDENTIFIED UNDER 5 YEAR DESIGN STORM CONDITIONS

FIGURE 14

AREA 1– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 25 YEAR DESIGN STORM CONDITIONS AND LOCAL SEWER IMPROVEMENTS IDENTIFIED UNDER 5 YEAR DESIGN STORM CONDITIONS

FIGURE 15

LEGEND

SEWER IMPROVEMENTS
EXISTING SEWERS
EXISTING MANHOLES
3250 SEWER ID
OUTFALL

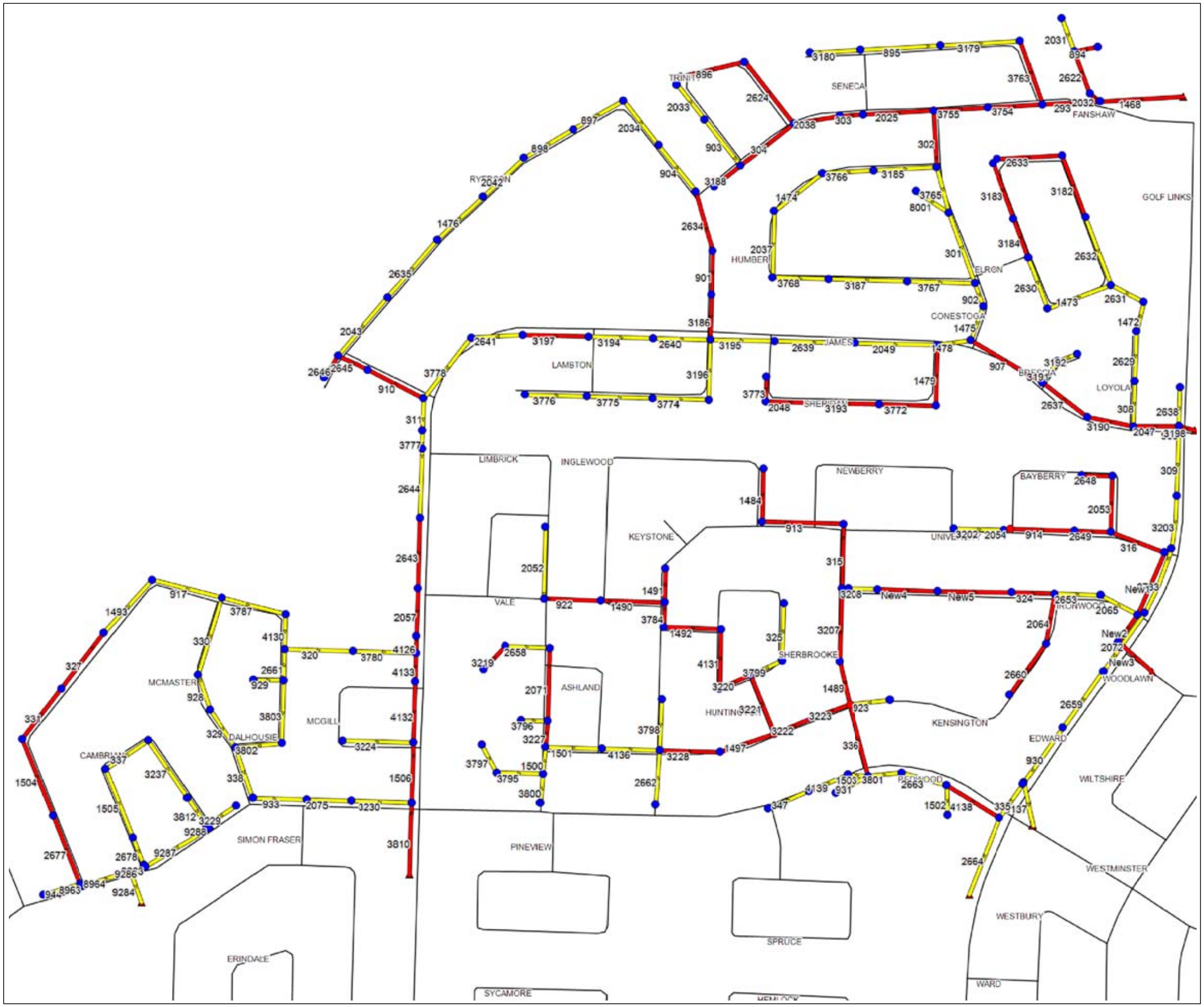
N

350 m

Hatch Mott MacDonald

AREA 1– JAMES STREET TRUNK SEWER TWINNING AND IRONWOOD EXTENSION IMPROVEMENTS IDENTIFIED UNDER 10 YEAR DESIGN STORM CONDITIONS

FIGURE 16



LEGEND

SEWER IMPROVEMENTS
EXISTING SEWERS
EXISTING MANHOLES
3250 SEWER ID
OUTFALL

N

350 m

Hatch Mott MacDonald

AREA 1– JAMES STREET TRUNK SEWER TWINNING AND IRONWOOD EXTENSION IMPROVEMENTS IDENTIFIED UNDER 25 YEAR DESIGN STORM CONDITIONS

FIGURE 17

6.1.7 Recommended Improvements for Area 1

Table 1 contains a summary of proposed improvements to the minor storm sewer system under the various design storm conditions that were assessed.

The sewer sizes identified in the table as predicted by the model will provide the increase in capacity needed to reduce the surface flooding and basement flooding under the various design storm conditions.

In some cases, an increase in pipe size to provide additional capacity under a 5 year design storm will also provide a higher level of service.

The recommended improvements were identified based on the following rationale:

- The improvements will provide a level of service consistent with standards used by municipalities across the province.
- The improvements are consistent with current Ministry of the Environment Design Guidelines.
- The increase in capacity in the storm sewer system will provide a reduction in basement and surface flooding in the study areas.
- Some flooding can still be expected under severe storm conditions, such as a 50 or 100 year design storm. The provision of a minor storm system with capacity to convey a severe storm such as a 50 or 100 year storm is not practical nor is it standard practice throughout the Province. Extensive infrastructure including very large storm sewers, and/or storm water retention tanks and ponds would be required, and could create other downstream problems. The overland flow system is intended to accommodate the major storms conditions.

TABLE 1: Summary of Proposed Improvements in Area 1

Pipe ID	Description	Existing Size (m)	Existing Length (m)	Proposed Sewer Sizes (m) Under Varying Conditions								Estimated Cost $/m[1]	Total Estimated Cost
				Local 2-Y-S[4]	Local 5-Y-S	Trunk 10-Y-S	Trunk 25-Y-S	Trunk 10-Y-S Local 2-Y-S	Trunk 25-Y-S Local 2-Y-S	Trunk 10-Y-S Local 5-Y-S	Trunk 25-Y-S Local 5-Y-S		
FANSHAW TRUNK													
1468	Fanshaw to outfall	0.51	121				0.6		0.6		0.6		$0
293	Fanshaw West of Seneca	0.51	85				0.6		0.6		0.6		$0
3754	Fanshaw East End of Seneca	0.3	80		0.375	0.375	0.525	0.375	0.525	0.375	0.525	$659	$52,704
3755	Fanshaw East of Conestoga	0.25	79		0.375	0.375	0.525	0.375	0.525	0.375	0.525	$659	$52,045
2025	Fanshaw West of Conestoga	0.46	101		0.525	0.525	0.6	0.525	0.6	0.525	0.6	$702	$70,902
303	Fanshaw West of Seneca	0.46	37		0.6	0.525	0.6	0.525	0.6	0.525	0.6	$702	$25,974
2038	Fanshaw @ Trinity East	0.46	69		0.525	0.525	0.6	0.525	0.6	0.525	0.6	$702	$48,438
304	Fanshaw Between Trinity	0.38	97			0.525	0.525	0.525	0.525	0.525	0.525	$702	$68,094
3188	Fanshaw @ Trinity West	0.3	51			0.375	0.375	0.375	0.375	0.375	0.375	$659	$33,599
LOCAL SEWERS DISCHARGING TO FANSHAW TRUNK													
896	Trinity Cres.	0.25	97.1		0.375					0.375	0.375	$659	$63,989
2624	Trinity Cres.	0.3	113.2		0.375					0.375	0.375	$659	$74,599

TABLE 1: Summary of Proposed Improvements in Area 1

Pipe ID	Description	Existing Size (m)	Existing Length (m)	Proposed Sewer Sizes (m) Under Varying Conditions								Estimated Cost $/m[1]	Total Estimated Cost
				Local 2-Y-S[4]	Local 5-Y-S	Trunk 10-Y-S	Trunk 25-Y-S	Trunk 10-Y-S Local 2-Y-S	Trunk 25-Y-S Local 2-Y-S	Trunk 10-Y-S Local 5-Y-S	Trunk 25-Y-S Local 5-Y-S		
JAMES ST. EAST TRUNK [2]													
3198	James to East of Edward	0.91	26			1.05	1.05	1.05	1.05	1.05	1.05	$1,694	$44,051
2047	James East of Loyola	0.91	65			1.05	1.05	1.05	1.05	1.05	1.05	$1,694	$110,126
3190	James West of Loyola	0.91	72			1.05	1.05	1.05	1.05	1.05	1.05	$1,694	$121,986
2637	James East of Brescia	0.91	87			1.05	1.05	1.05	1.05	1.05	1.05	$1,694	$147,400
907	James West of Brescia	0.91	123			1.05	1.05	1.05	1.05	1.05	1.05	$1,694	$208,393
Trunk East of Edward to Outfall Ditch[3]		1.2	290							1.35		$2,126	$616,613
LOCAL SEWERS DISCHARGING TO JAMES ST EAST TRUNK													
302	Conestoga	0.51	82		0.6	0.6	0.6	0.51	0.6	0.6	0.6	$744	$60,996
JAMES ST. SOUTH TRUNK													
3810	James St. south of Redwood	0.91	105			1.05	1.05	1.05	1.05	1.05	1.05	$1,694	$177,896
1506	James between McGill & Redwood	0.91	87			1.05	1.05	1.05	1.05	1.05	1.05	$1,694	$147,400
4132	James St. Between McGill	0.91	87			1.05	1.05	1.05	1.05	1.05	1.05	$1,694	$147,400
4133	James St. North of McGill	0.91	44			1.05	1.05	1.05	1.05	1.05	1.05	$1,694	$74,547
4126	James St. Between McGill & Vale	0.91	24			1.05	1.05	1.05	1.05	1.05	1.05	$1,694	$40,662
2057	James South of Vale	0.91	73			1.05	1.05	1.05	1.05	1.05	1.05	$1,694	$123,680
2643	James North of Vale	0.76	104			0.9	0.9	0.9	0.9	0.9	0.9	$1,308	$136,048
Trunk South of Redwood to Neebing River Outfall[3]		0.91 - 1.2	793							1.05 - 1.35		Varies	$1,505,041

TABLE 1: Summary of Proposed Improvements in Area 1

Pipe ID	Description	Existing Size (m)	Existing Length (m)	Proposed Sewer Sizes (m) Under Varying Conditions								Estimated Cost $/m[1]	Total Estimated Cost
				Local 2-Y-S[4]	Local 5-Y-S	Trunk 10-Y-S	Trunk 25-Y-S	Trunk 10-Y-S Local 2-Y-S	Trunk 25-Y-S Local 2-Y-S	Trunk 10-Y-S Local 5-Y-S	Trunk 25-Y-S Local 5-Y-S		
LOCAL SEWERS DISCHARGING TO JAMES ST SOUTH TRUNK													
2646	Ryerson South end	0.3	43		0.375					0.375	0.375	$659	$28,328
3230	Redwood west of James	0.61	91							0.75		$1,058	$96,314
2075	Redwood west of James	0.61	63							0.75		$1,058	$66,679
933	Redwood west of James	0.61	83							0.75		$1,058	$87,847
3780	Kinsmen Park west of James	0.35	98							0.45		$714	$69,987
320	Kinsmen Park west of James	0.35	100							0.45		$714	$71,415
EDWARD ST. TRUNK													
4137	Edward outfall to Redwood E.	0.61	66		0.675					0.675	0.675	$1,058	$69,854
930	Edward south of Woodlawn	0.61	98		0.675					0.675	0.675	$1,058	$103,723
2659	Edward south of Woodlawn	0.61	104		0.675					0.675	0.675	$1,058	$110,074
2072	Edward South of Ironwood	0.61	104		0.675					0.675	0.675	$1,058	$110,074
3783	Edward South of University	0.46	104							0.675		$1,058	$110,074
Trunk South of Redwood to Neebing River Outfall[3]		1.2	729							1.35		$1,844	$1,344,349
Trunk East of Edward to Floodway[3]		0.91	408							1.05		$1,694	$691,254
LOCAL SEWERS DISCHARGING TO EDWARD TRUNK													
2064	Kensington South of Ironwood	0.38	74		0.45					0.45	0.45	$714	$52,847
2660	Kensington	0.3	94	0.375	0.45			0.375	0.375	0.45	0.45	$714	$67,130
2065	Ironwood	0.46	68							0.525		$714	$48,562
2653	Ironwood	0.46	70							0.525		$702	$49,140
324	Ironwood	0.3	64							0.525		$702	$44,928
1489	Sherbrooke North of Kensington	0.38	68		0.45					0.45	0.45	$714	$48,562
3207	Sherbrooke South of Ironwood	0.38	104		0.45					0.45	0.45	$714	$74,272

TABLE 1: Summary of Proposed Improvements in Area 1

Pipe ID	Description	Existing Size (m)	Existing Length (m)	Proposed Sewer Sizes (m) Under Varying Conditions								Estimated Cost $/m[1]	Total Estimated Cost
				Local 2-Y-S[4]	Local 5-Y-S	Trunk 10-Y-S	Trunk 25-Y-S	Trunk 10-Y-S Local 2-Y-S	Trunk 25-Y-S Local 2-Y-S	Trunk 10-Y-S Local 5-Y-S	Trunk 25-Y-S Local 5-Y-S		
315	Sherbrooke North of Ironwood	0.38	95		0.45					0.45	0.45	$714	$67,844
913	University East of Inglewood	0.38	122		0.45					0.45	0.45	$714	$87,126
1484	Inglewood North of Keystone	0.3	78		0.375					0.375	0.45	$659	$51,386
3221	Huntington St.	0.46	93		0.525					0.525	0.525	$702	$65,286
3220	Huntington Ct.	0.46	48		0.525					0.525	0.525	$702	$33,696
4131	Huntington West	0.46	87		0.525					0.525	0.525	$702	$61,074
1492	Huntington Ave.	0.46	85		0.525					0.525	0.525	$702	$59,670
3784	University South of Inglewood	0.46	38		0.525					0.525	0.525	$702	$26,676
1490	Inglewood West of University	0	94		0.45					0.45	0.45	$714	$67,130
922	Between Inglewood and Limbrick	0.38	86		0.45					0.45	0.45	$714	$61,417

Shading denotes recommended improvements to the storm sewer system

Notes:
[1] Estimated cost, $/m, includes surface restoration and 35% engineering and contingencies for the recommended improvements.
[2] Estimated cost to twin the existing 910mm sewer as an alternative to upgrading the James St. East Trunk sewer is $490,000
[3] Estimated cost of downstream sewer upgrades, requires further analysis to confirm the extent of improvements.
[4] 2-Y-S = 2 Year Design Storm (typ.)
[5] Refer to Figures 8 to 17 for illustrations of the improvements identified under varying conditions.
[6] If the cells are left blank there is no change to the existing sewer size identified under the varying conditions.

6.2 Area 2

The Area 2 study area is comprised of several tributary drainage areas, and 2 main trunk sewers. The trunk sewers are located on Ontario St. between First Ave. and Spofford St., discharging to the Intercity Pumping Station at the Beverly St. channel, and on High St. flowing north from Sixth Ave. to Third Ave. whereby it discharges to the Third Ave. Pumping Station. A separate and adjacent drainage system is located along Memorial Ave., which collects drainage from the Memorial Ave. roadway.

6.2.1 Ontario St. Area

There are no improvements identified in the Ontario St. area to meet a 2 or 5 year storm event. The trunk sewer has sufficient capacity under both the 10 and 25 year storm conditions, when assessing the local sewers against a 2 and 5 year storm event.

6.2.2 High St. Area

The High St. area does not require any improvements under a 2 year storm event. Under a 5 year storm event upgrades are identified on High St. from Seventh Ave. to north of Fifth Ave.

Applying the above noted strategy of carrying out improvements to the trunk sewers under a 10 year storm event indicate that improvements are identified on High St. from Seventh Ave. to the Third Ave. Pumping Station. The High St. sewer would also require further improvements under a 25 year storm event. There are no improvements to local sewers identified under any of the above scenarios.

Improvements to the storm sewer systems as noted above will result in increased capacity in the sewers and also increased conveyance of the storm water flow to the pumping station. Increased pumping capacity to address the increase in flow reaching the pumping station would be required if the sewer capacity is increased. Alternately, additional storage could be provided at the pumping station to retain the water until such time as the peak has subsided and the stormwater can then be pumped into the ditch. Due to the restrictions of the downstream ditch system resulting from very little vertical relief and the presence of high lake levels, increasing the pumping capacity is not recommended as it will create additional downstream problems.

Estimates of the required storage at the pumping station to accommodate the additional flows if the trunk sewers were upgraded and the pumping station is <u>not</u> upgraded to meet a 10 and 25 year storm event were determined. At the Third Ave. Pumping Station, additional storage of approximately 1,000 m^3 was identified if the trunk sewers are upgraded under the 10 year storm event. This can be provided by below grades tanks, or possibly a pond in the area adjacent to the pumping station as the City owns a sizable piece of property. A preliminary review of the vacant City property north of the Third Ave. channel indicates there is sufficient property for a 1,000 $m^3 \pm$ pond, which would require an area of approximately 2,000 m^2 (1.5 m water depth, and the top water level 1 m below grade). There is also sufficient City property for below grade tanks/crates.

6.2.3 Memorial Ave. Area

The model has identified predicted surface flooding on the west side of Memorial Ave. between Squier St. and Seventh Ave. under the 2, 5, 10 and 25 year storm events. There were however, no reported flooding events in the flooding records provided by the City for this area. This storm sewer system was originally developed as a shallow system due to limitations with downstream connecting sewers and outfall sewers and was intended to only service the Memorial Ave. corridor.

Improvements under the 2, 5, 10 and 25 year storm events involve increasing the size of the sewers to provide additional capacity. These identified improvements should be reviewed again prior to implementation, as if there is no current negative impact on the adjacent properties resulting from the predicted flooding, there may be no real benefit in proceeding with the changes. Any increase in size to the Memorial Ave. sewers will increase the conveyance capacity and impact the downstream Central Ave. Pumping Station. A thorough investigation of impacts on the downstream sewers and Central Ave. Pumping Station would also have to be completed prior to proceeding with any improvements.

The figures illustrating the above analysis are enclosed as Figures 18 to 25.

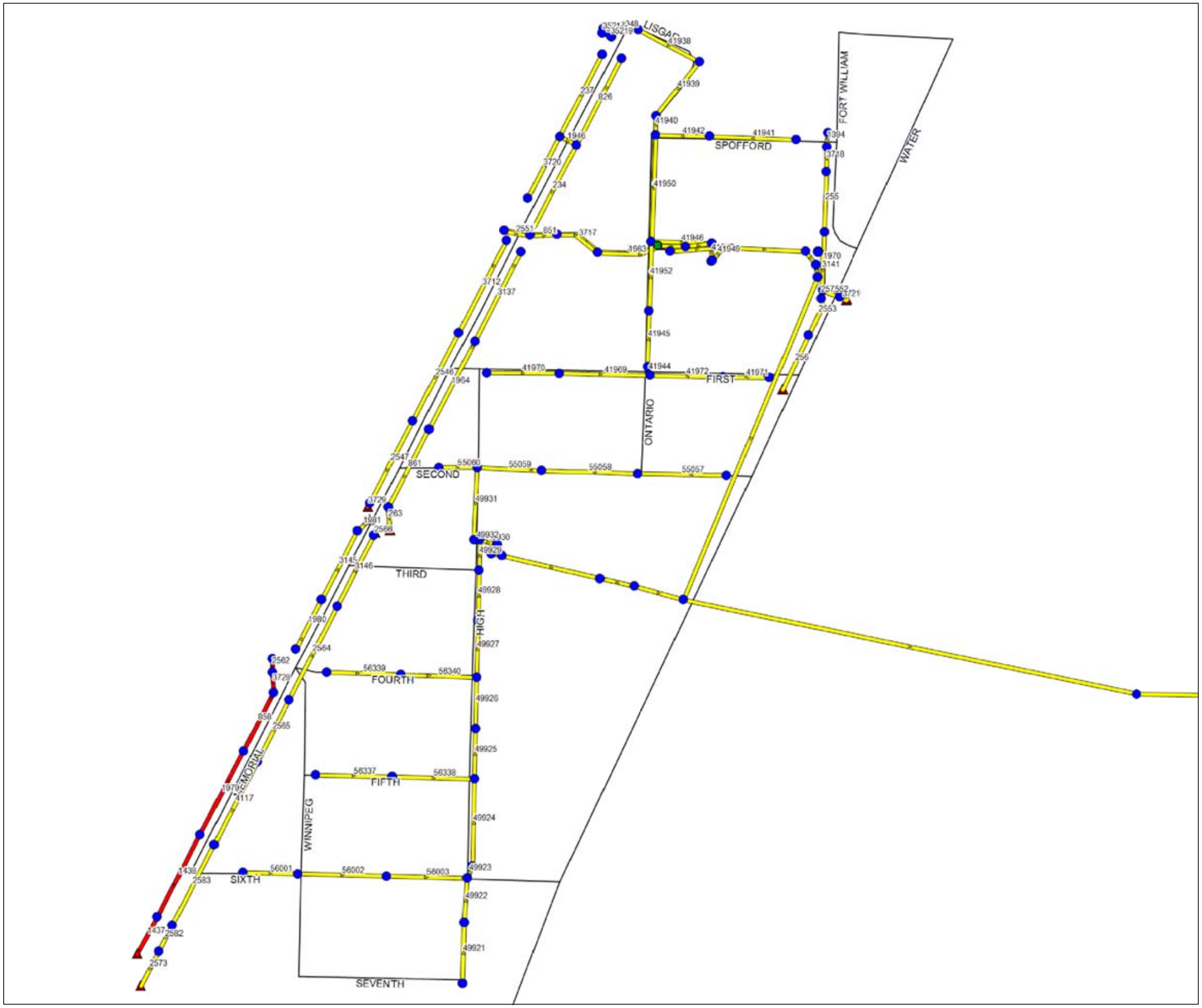
6.2.4 Other Improvements

Improvements to the downstream ditch system may increase conveyance of the stormwater to the lake, and could provide additional storage as well. An alternative which included construction of a new ditch between the CPR tracks and the lake was investigated. The proposed ditch would follow the existing alignment easterly from Fort William Road at the Beverly channel, but then veer in a northerly direction along the east side of the CPR tracks, eventually outletting to the lake north of the property formally known as Northern Wood Preservers, now privately owned. This alignment is longer than the current route, and has an overall slope of less than 0.1%. A new ditch in this location could be constructed along with other future improvements in this area. It will not eliminate, however, the existing restriction to the storm water flows caused by the routing through the private CP/CNR railway lands. The only advantage to utilizing an additional ditch is that it will provide additional downstream storage for the storm water. It would however, be impacted by backflow from Lake Superior reducing its capacity.

Figure 26 provides an illustration of the existing downstream ditch system, as well as the location of the alternative ditch discussed above.

If improvements to the existing ditch system capacity through the CP/CNR railway lands is planned in the future, then at that time the construction of other ditch improvements as discussed above can be re-assessed.

Other improvements proposed for Area 2 include raising the grade on the south side of Second Ave. along the extension of the Ontario St. right-of-way to eliminate ponding onto private properties. This is a localized improvement, and can be implemented separate from other improvements discussed above.



AREA 2– IMPROVEMENTS IDENTIFIED UNDER 2 YEAR DESIGN STORM CONDITIONS

LEGEND

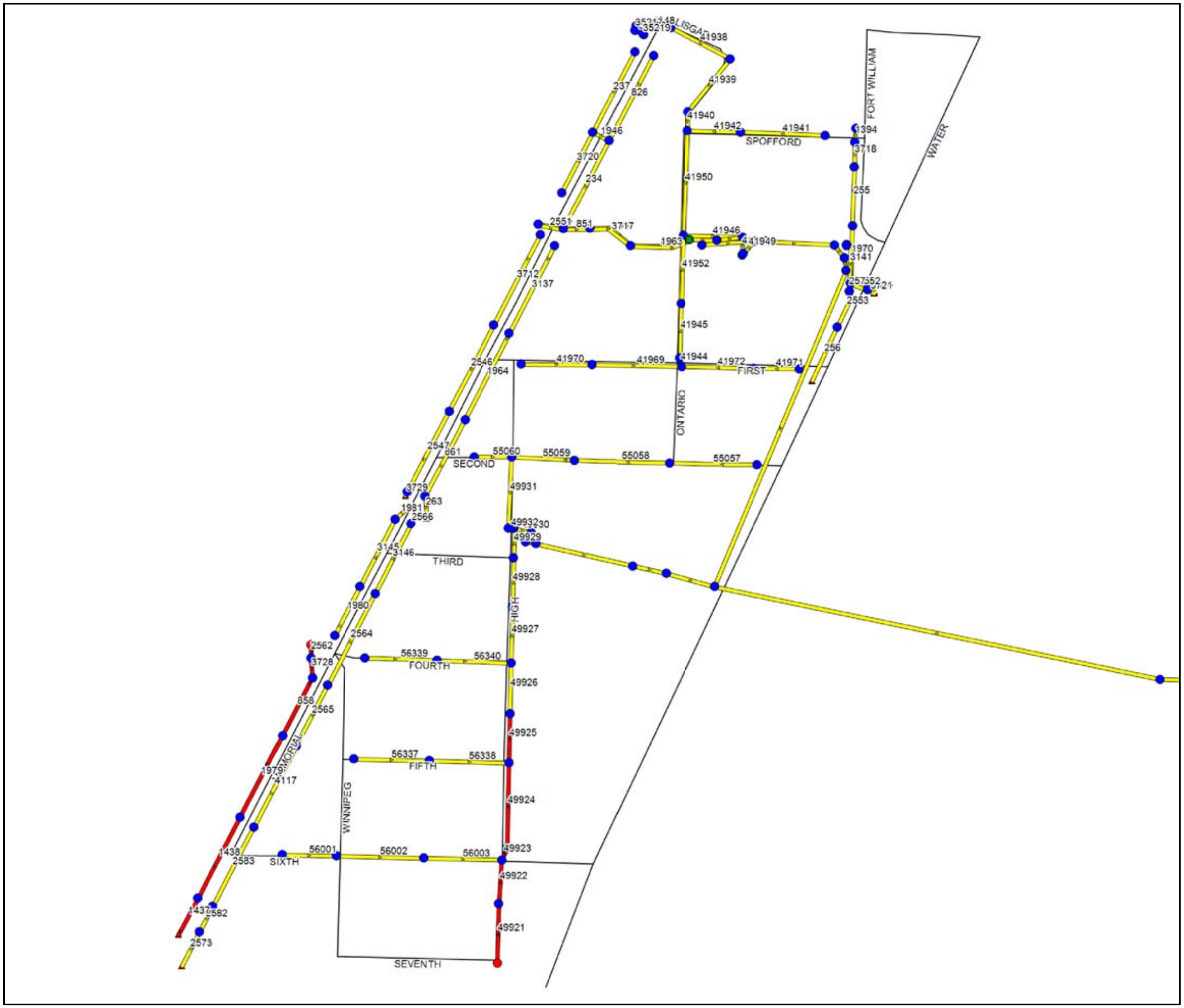
- SEWER IMPROVEMENTS
- EXISTING SEWERS
- EXISTING MANHOLES
- 3250 SEWER ID
- OUTFALL

N

250 m

Hatch Mott MacDonald

FIGURE 18



LEGEND

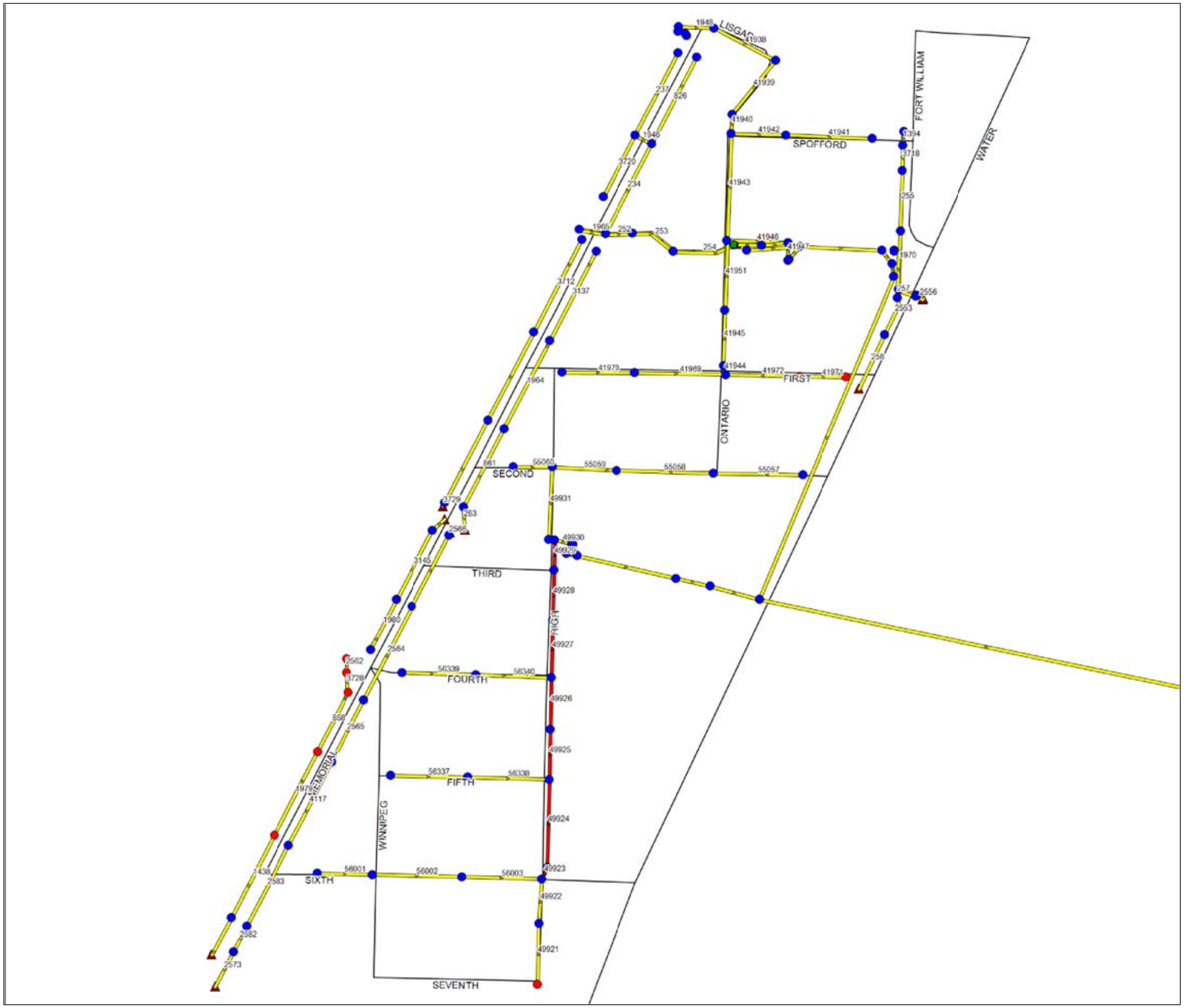
- SEWER IMPROVEMENTS
- EXISTING SEWERS
- EXISTING MANHOLES
- 3250 SEWER ID
- OUTFALL

250 m

Hatch Mott MacDonald

AREA 2– IMPROVEMENTS IDENTIFIED UNDER 5 YEAR DESIGN STORM CONDITIONS

FIGURE 19



LEGEND

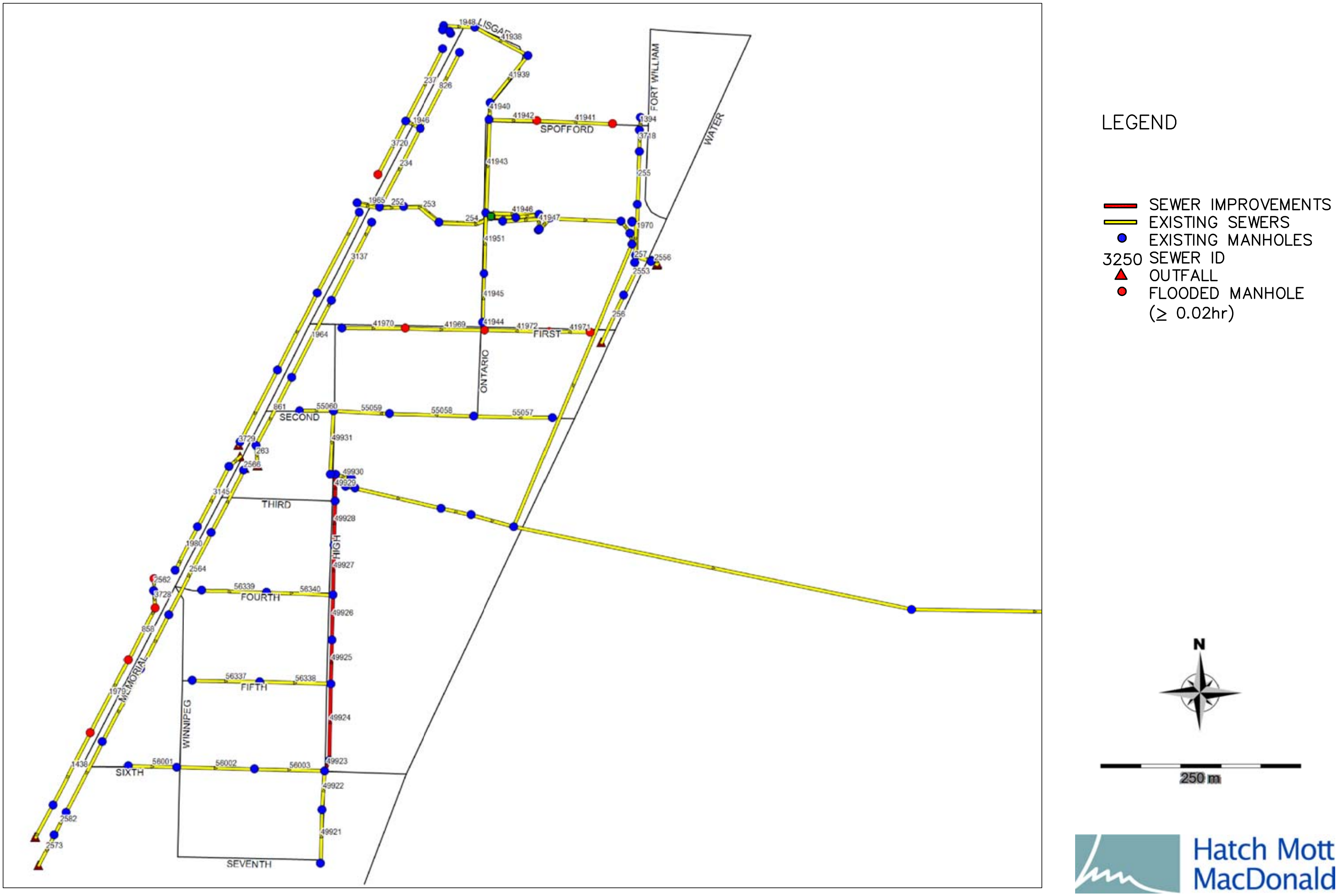
SEWER IMPROVEMENTS
EXISTING SEWERS
EXISTING MANHOLES
3250 SEWER ID
OUTFALL
FLOODED MANHOLE (≥ 0.02hr)

250 m

Hatch Mott MacDonald

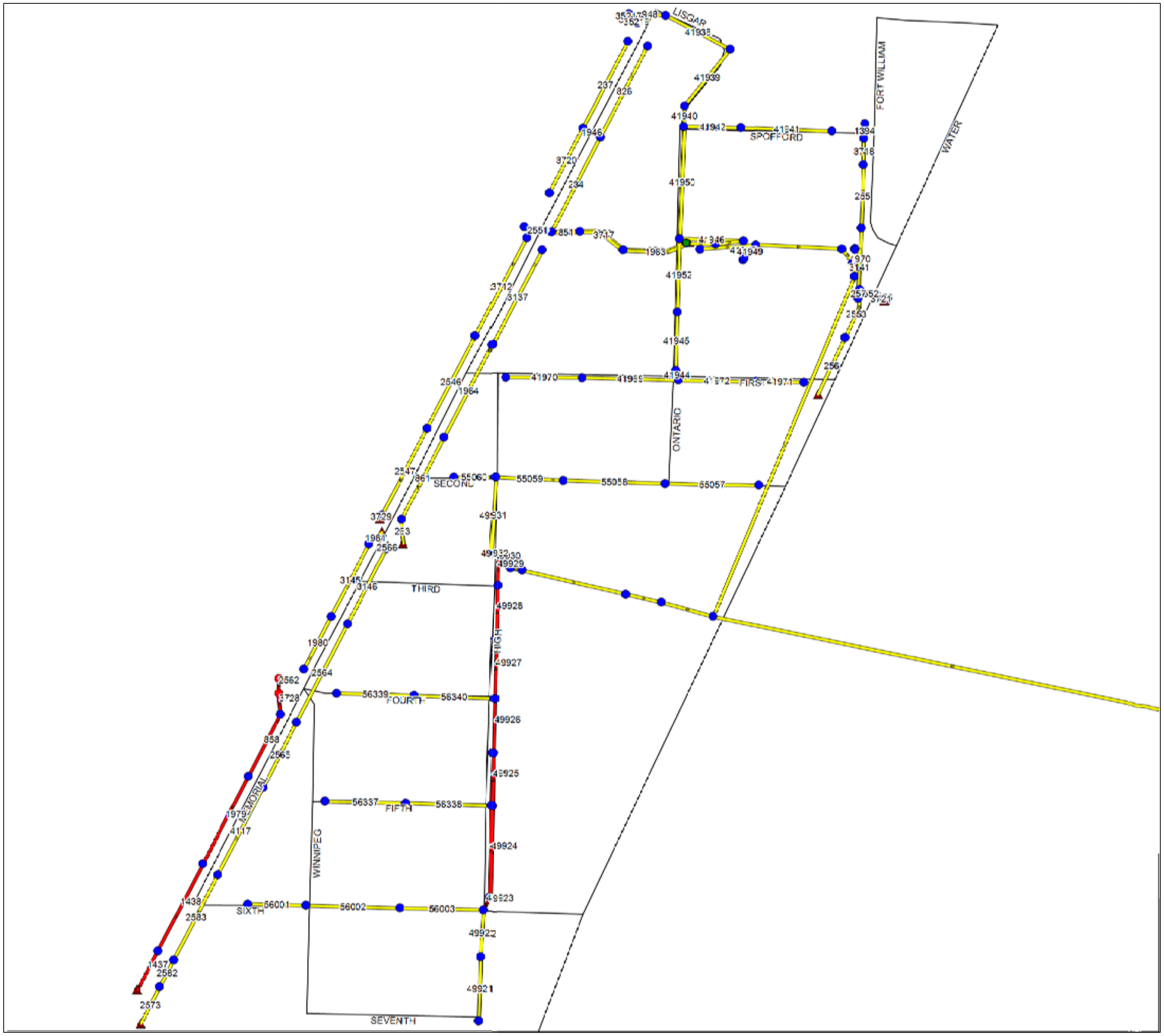
AREA 2–TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 10 YEAR DESIGN STORM CONDITIONS

FIGURE 20



AREA 2– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 25 YEAR DESIGN STORM CONDITIONS

FIGURE 21



LEGEND

SEWER IMPROVEMENTS
EXISTING SEWERS
EXISTING MANHOLES
3250 SEWER ID
OUTFALL

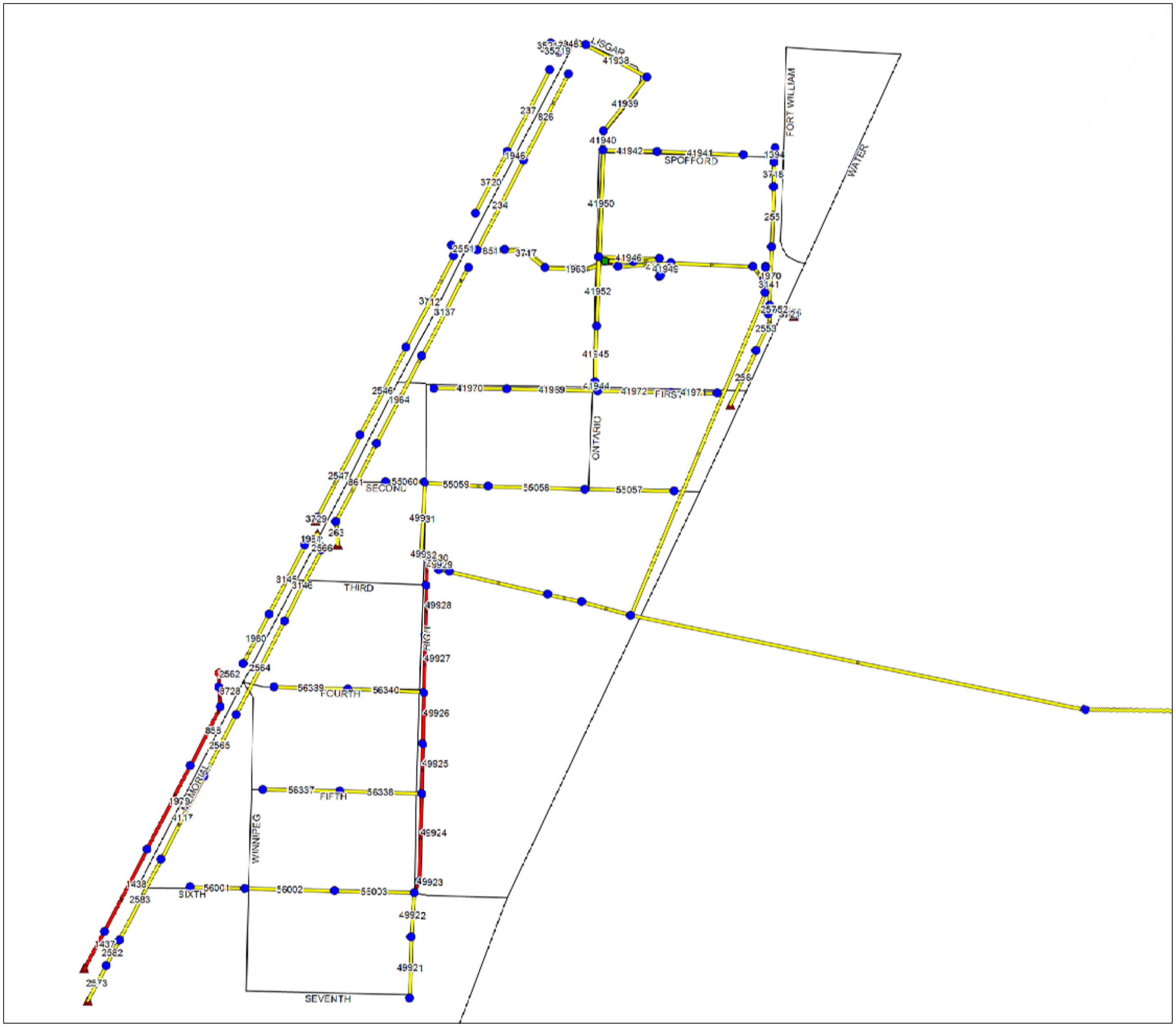
N

200 m

Hatch Mott MacDonald

AREA 2– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 10 YEAR DESIGN STORM CONDITIONS AND LOCAL SEWER IMPROVEMENTS IDENTIFIED UNDER 2 YEAR DESIGN STORM CONDITIONS

FIGURE 22



LEGEND

- SEWER IMPROVEMENTS
- EXISTING SEWERS
- EXISTING MANHOLES
- 3250 SEWER ID
- OUTFALL

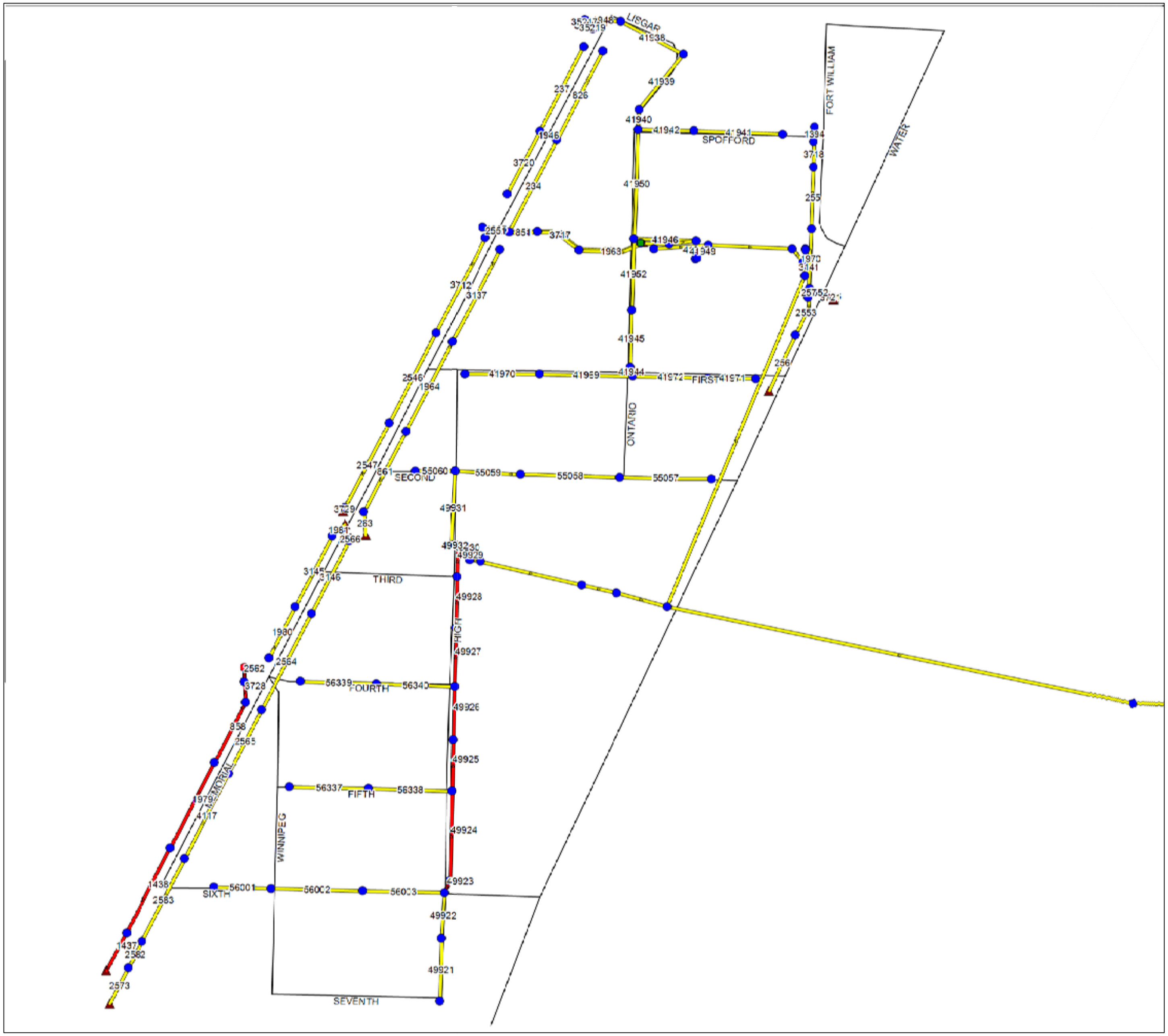
N

250 m

Hatch Mott MacDonald

AREA 2– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 25 YEAR DESIGN STORM CONDITIONS AND LOCAL SEWER IMPROVEMENTS IDENTIFIED UNDER 2 YEAR DESIGN STORM CONDITIONS

FIGURE 23



LEGEND

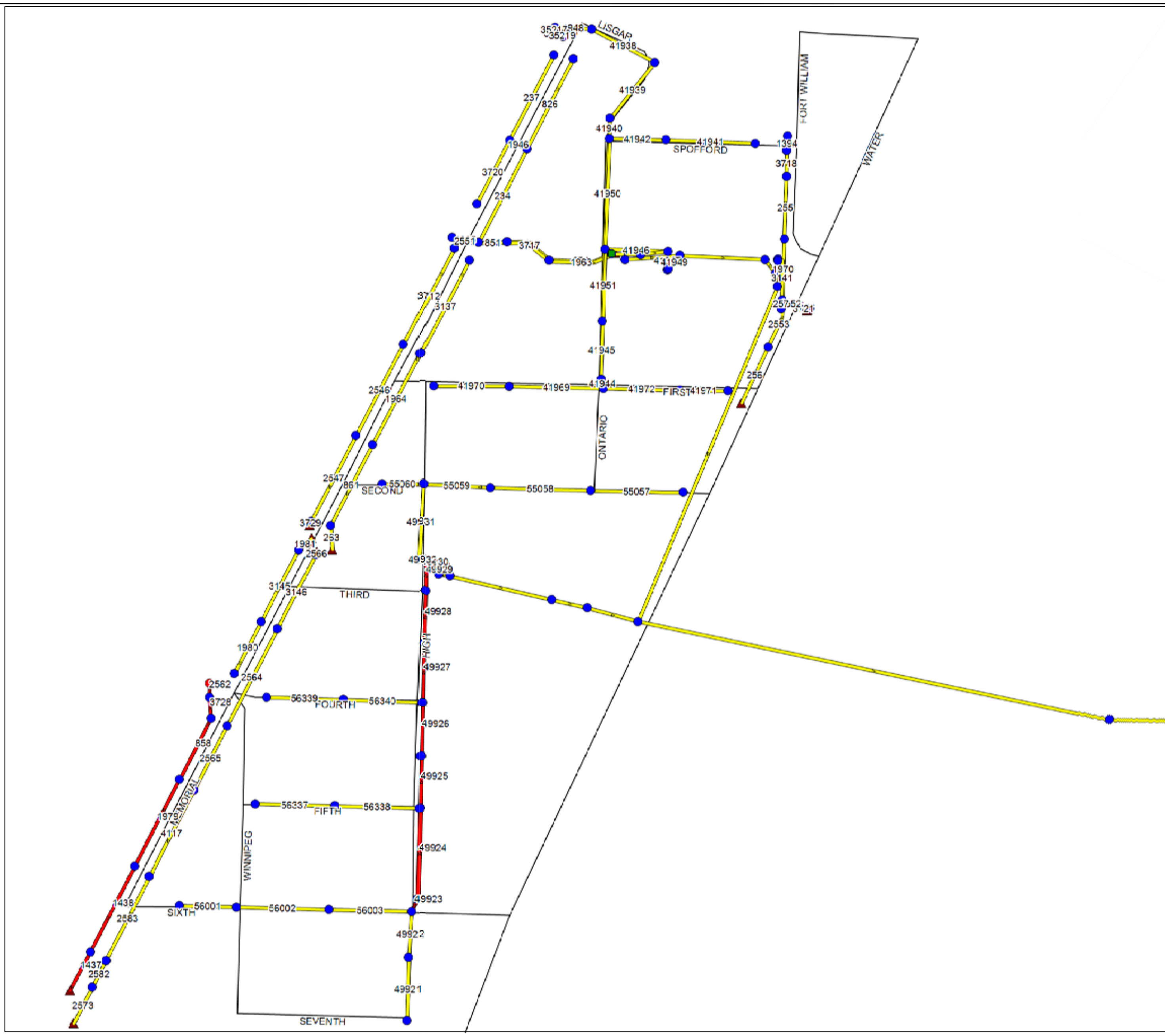
- SEWER IMPROVEMENTS
- EXISTING SEWERS
- EXISTING MANHOLES
- 3250 SEWER ID
- OUTFALL

200 m

Hatch Mott MacDonald

AREA 2– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 10 YEAR DESIGN STORM CONDITIONS AND LOCAL SEWER IMPROVEMENTS IDENTIFIED UNDER 5 YEAR DESIGN STORM CONDITIONS

FIGURE 24



LEGEND

SEWER IMPROVEMENTS
EXISTING SEWERS
EXISTING MANHOLES
3250 SEWER ID
OUTFALL

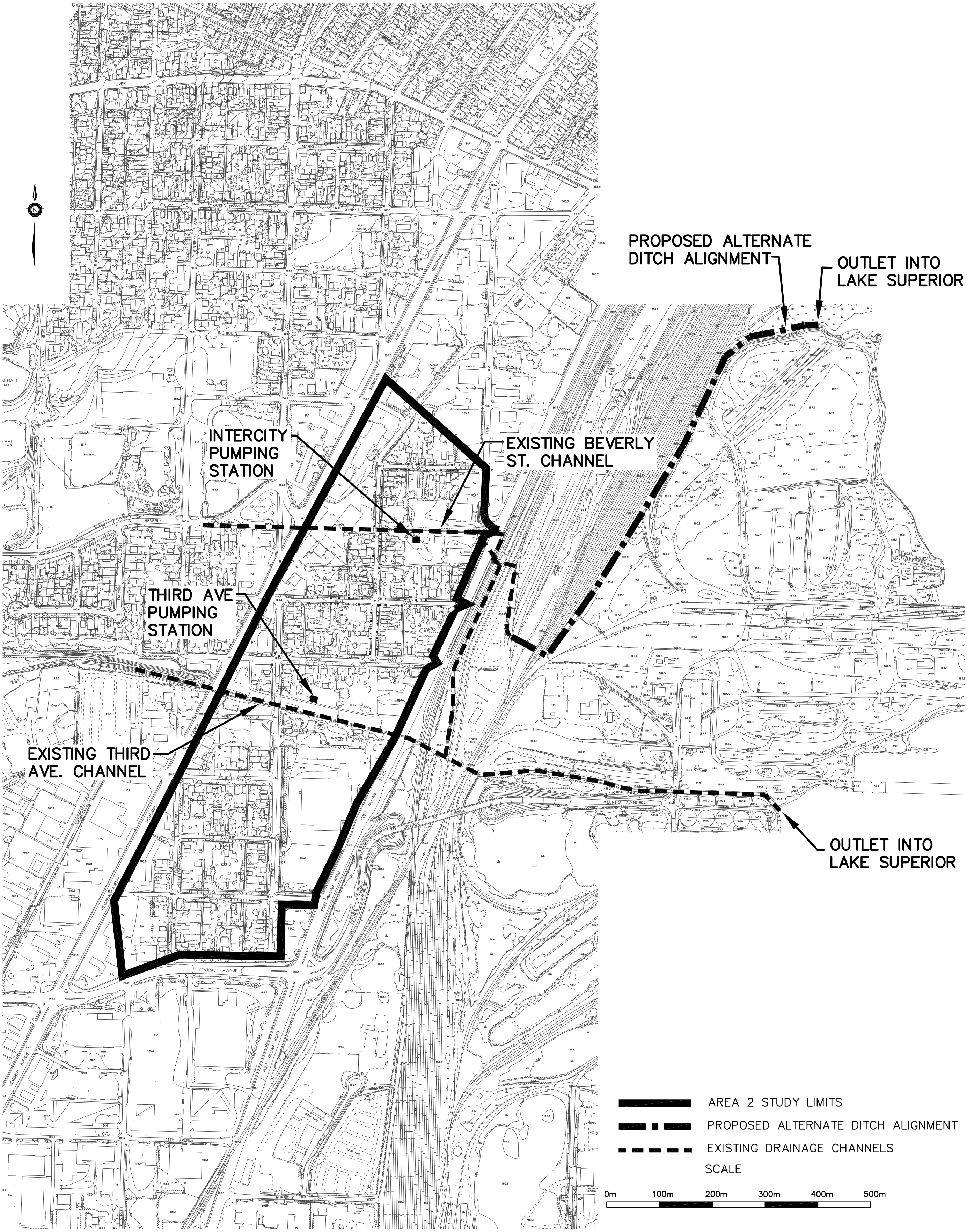
N

200 m

Hatch Mott MacDonald

AREA 2– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 25 YEAR DESIGN STORM CONDITIONS AND LOCAL SEWER IMPROVEMENTS IDENTIFIED UNDER 5 YEAR DESIGN STORM CONDITIONS

FIGURE 25



AREA 2 SURFACE DRAINAGE

Hatch Mott MacDonald

FIGURE 26

6.2.5 Recommended Improvements for Area 2

Table 2 contains a summary of proposed improvements to the minor storm sewer system for Area 2 under the various design storm conditions that were assessed.

The sewer sizes identified in the table as predicted by the model will provide the increase in capacity needed to reduce the surface flooding and basement flooding under the various design storm conditions.

In some cases, an increase in pipe size to provide additional capacity under a 5 year design storm will also provide a higher level of service.

The recommended improvements were identified based on the following rationale:

- The improvements will provide a level of service consistent with standards used by municipalities across the province.
- The improvements are consistent with current Ministry of the Environment Design Guidelines.
- The increase in capacity in the storm sewer system will provide a reduction in basement and surface flooding in the study areas.
- Some flooding can still be expected under severe storm conditions, such as a 50 or 100 year design storm. The provision of a minor storm system with capacity to convey a severe storm such as a 50 or 100 year storm is not practical nor is it standard practice throughout the Province. Extensive infrastructure including very large storm sewers, and/or storm water retention tanks and ponds would be required, and could create other downstream problems. The overland flow system is intended to accommodate the major storms conditions.
- Additional storage at the Third Ave. Pumping Station is also recommended, which can be achieved utilizing below grade tanks or a storm water pond. Either alternative will achieve a reduction in flooding. We recommend the higher capital cost option be carried forward for budget purposes, as further detailed engineering is required to confirm which alternative is more suitable at this location.

TABLE 2: Summary of Proposed Improvements in Area 2													
Pipe ID	Description	Existing Size (m)	Length (m)	Proposed Sewer Sizes (m) Under Varying Conditions								Estimated Cost $/m[1]	Total Estimated Cost
				Local 2-Y-S[2]	Local 5-Y-S	Trunk 10-Y-S	Trunk 25-Y-S	Trunk 10-Y-S Local 2-Y-S	Trunk 25-Y-S Local 2-Y-S	Trunk 10-Y-S Local 5-Y-S	Trunk 25-Y-S Local 5-Y-S		
HIGH ST. TRUNK													
49923	High St. North of Sixth	0.46	14.25		0.6	0.9	1.05	0.9	1.05	0.9	1.05	$1,308	$18,641.14
49924	High St. South of Fifth	0.53	96.26		0.6	0.9	1.05	0.9	1.05	0.9	1.05	$1,308	$125,922.52
49925	High St. North of Fifth	0.61	55.19		0.675	1.05	1.5	1.05	1.5	1.05	1.5	$1,694	$93,505.66
49926	High St. South of Fourth	0.61	56.7		0.675	1.05	1.5	1.05	1.5	1.05	1.5	$1,694	$96,063.98
49927	High St. North of Fourth	0.76	62.88			1.05	1.5	1.05	1.5	1.05	1.5	$1,694	$106,534.44
49928	High St. South of Third	0.76	55.19			1.05	1.5	1.05	1.5	1.05	1.5	$1,694	$93,505.66
49929	High St. North of Third	0.76	33.35			1.05	1.5	1.05	1.5	1.05	1.5	$1,694	$56,503.24

TABLE 2: Summary of Proposed Improvements in Area 2

Pipe ID	Description	Existing Size (m)	Length (m)	Proposed Sewer Sizes (m) Under Varying Conditions								Estimated Cost $/m[1]	Total Estimated Cost
				Local 2-Y-S[2]	Local 5-Y-S	Trunk 10-Y-S	Trunk 25-Y-S	Trunk 10-Y-S Local 2-Y-S	Trunk 25-Y-S Local 2-Y-S	Trunk 10-Y-S Local 5-Y-S	Trunk 25-Y-S Local 5-Y-S		
LOCAL SEWERS DISCHARGING TO HIGH ST. TRUNK													
49921	High St. South of Sixth	0.38	67.02		0.6								$0
49922	High St. South of Sixth	0.38	48.99		0.6								$0
Third Avenue Pumping Station Upgrades		Require additional storage of approx. 1,000 m3 if trunk sewers are upgraded to 10-year storm. Estimated cost for undergound storage is $1.5 million. Estimated cost for stormwater retention pond $100,000.											
MEMORIAL AVE.													
1437	South Memorial	0.46	46.5	0.6	0.675			0.6	0.6	0.675	0.675	$1,058	$49,215.60
1438	South Memorial	0.46	101.1	0.6	0.675			0.6	0.6	0.675	0.675	$1,058	$107,004.24
1979	South Memorial	0.46	104.2	0.6	0.675			0.6	0.6	0.675	0.675	$1,058	$110,285.28
858	South Memorial	0.46	73.8	0.6	0.675			0.6	0.6	0.675	0.675	$1,058	$78,109.92
3728	South Memorial	0.46	24.2	0.6	0.675			0.6	0.6	0.675	0.675	$1,058	$25,613.28
2562	South Memorial	0.46	13	0.6	0.675			0.6	0.6	0.675	0.675	$1,058	$13,759.20

Shading denotes recommended improvements to the storm sewer system

Notes:
[1] Estimated cost, $/m, includes surface restoration and 35% engineering and contingencies for the recommended improvements.
[2] 2-Y-S = 2 Year Design Storm (typ.)
[3] Refer to Figures 8 to 17 for illustrations of the improvements identified under varying conditions.
[4] If the cells are left blank there is no change to the existing sewer size identified under the varying conditions.

6.3 Area 3

The Area 3 study area is comprised of several tributary drainage areas, and 2 main trunk sewers. One of the trunk sewers is located on Alberta St. and flows north from Atlantic Ave. to the Neebing River. The second trunk sewer is located on McLeod St., flowing south from Christie St. beneath the CPR tracks to the Kaministiquia River.

6.3.1 Alberta St. Area

There are no improvements identified in the Alberta St. catchment area under a 2, 5, or 10 year storm event. The trunk sewer in this area has sufficient capacity under the 25 year storm condition.

6.3.2 McLeod St. Area

There are improvements identified on Pacific Ave. between Hargrave and McBain St. under a 2 year storm event. Improvements are identified to sewers on McIntosh St., McLeod St. and McPherson St. north of Pacific Ave., on McBain St., on Hargrave between Christie St. and Pacific Ave., and on McLaughlin St. south of Christie St. under a 5 year storm event.

The trunk sewer in this area has sufficient capacity under both the 10 and 25 year storm condition.

The sewer capacity in all of Area 3 is restricted by the river levels at the point of discharge. Most of the sewers will always have water in them, as the outlet elevation is below normal river level.

The figures illustrating the above analysis are enclosed as Figures 27 to 32.

6.3.3 Other Improvements

The existing sewer outfalls have gates on them which are normally open. As river levels fluctuate, the level of water in the sewers will also fluctuate. The gates are closed and the sewers pumped out if maintenance is required to the sewers.

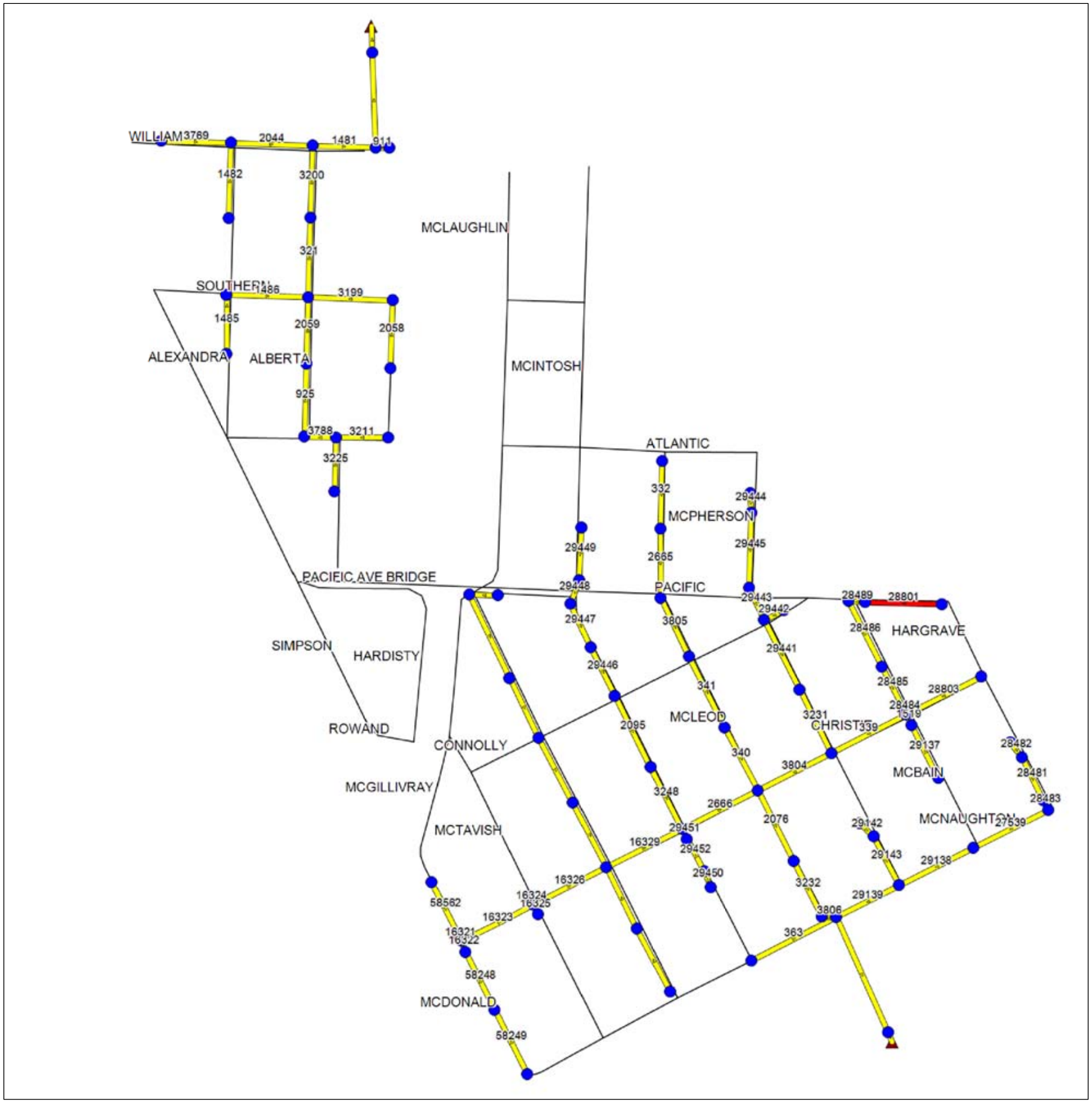
Replacement of the existing gates with a flexible rubber check valve designed to open with a minimum specified head and to close with back pressure is an alternative to be considered. This will allow the storm sewers to drain as much as possible, and keep river water from backing into the sewers, maintaining the maximum amount of available storage in the sewers. In the scenario where the outlets are always submerged as is the case in Area 3, there is not much benefit to changing the gates to check valves as the volume of additional storage gained is minimal. There is additional maintenance associated with the check valves as well. As a result, it is recommended to retain the use of the existing gates.

The City could also consider the construction of storm water pumping stations at the storm sewer system outlets at the Neebing and Kaministiquia Rivers. The pumping stations would be designed to accept storm drainage from the sewers and pump it up and into the rivers. Property would be required for construction of the pumping stations.

The benefit is that the sewer system would no longer be storing river water and be available to accept storm runoff from the study area thereby increasing the capacity of the storm sewer system. The capital cost and ongoing maintenance costs of two new pumping stations, however, is significant, and is not recommended at this time.

The City is also prioritizing the separation of the remaining portions of the combined sewer system on McIntosh/McPherson that will involve construction of a new outfall to the Neebing/McIntyre Floodway. The costs and details for the combined sewer separation project are not included in the estimates presented in this study.

Created: Dec 02' 2009 - 11:20am
Last Saved: Jul 22' 2014 - 12:44pm



LEGEND

SEWER IMPROVEMENTS
EXISTING SEWERS
EXISTING MANHOLES
3250 SEWER ID
OUTFALL

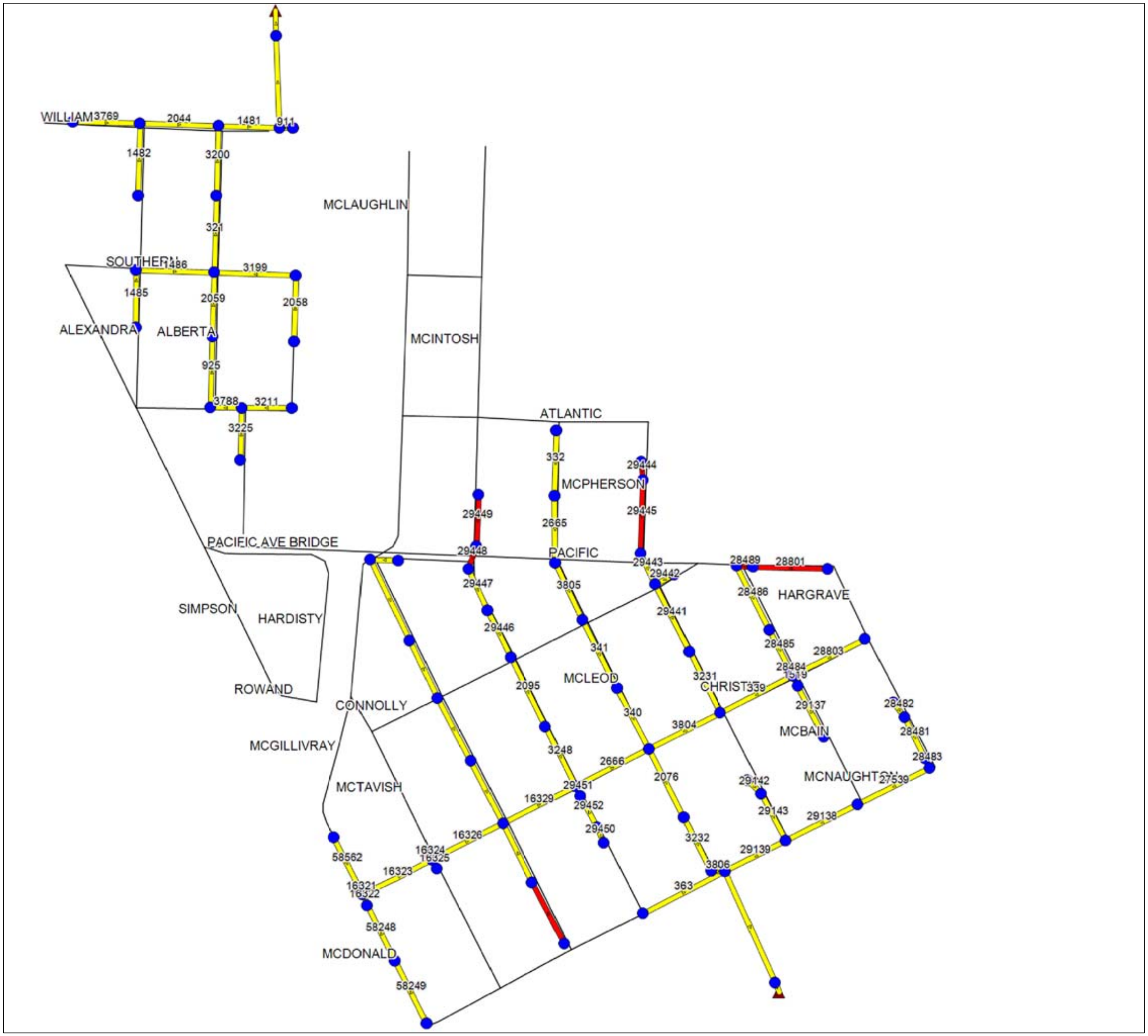
N

250 m

Hatch Mott MacDonald

AREA 3– IMPROVEMENTS IDENTIFIED UNDER 2 YEAR DESIGN STORM CONDITIONS

FIGURE 27



AREA 3– IMPROVEMENTS IDENTIFIED UNDER 5 YEAR DESIGN STORM CONDITIONS

LEGEND

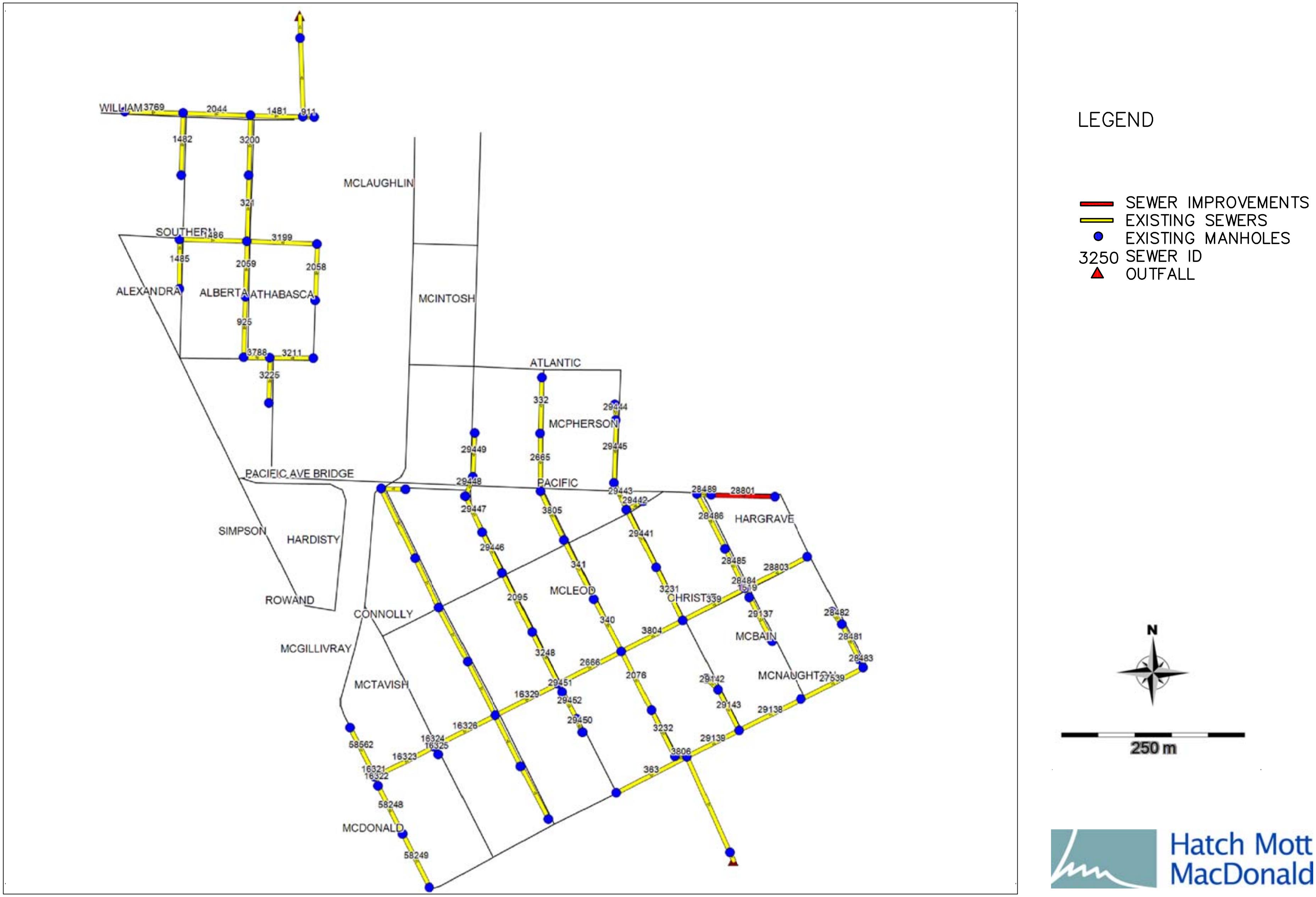
SEWER IMPROVEMENTS
EXISTING SEWERS
EXISTING MANHOLES
3250 SEWER ID
OUTFALL

N

250 m

Hatch Mott MacDonald

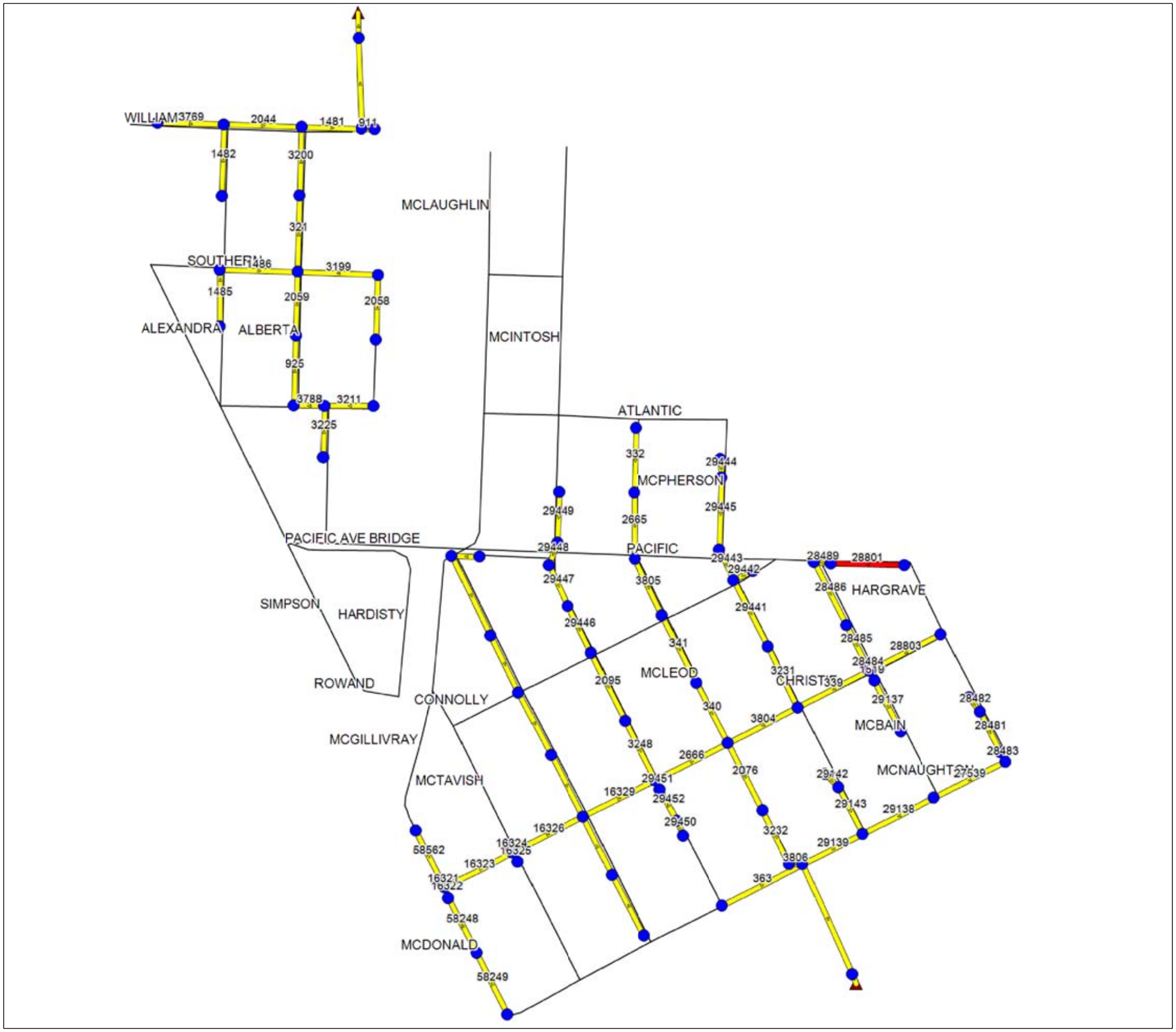
FIGURE 28



Hatch Mott MacDonald

AREA 3– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 10 YEAR DESIGN STORM CONDITIONS AND LOCAL SEWER IMPROVEMENTS IDENTIFIED UNDER 2 YEAR DESIGN STORM CONDITIONS

FIGURE 29



LEGEND

- SEWER IMPROVEMENTS
- EXISTING SEWERS
- EXISTING MANHOLES
- 3250 SEWER ID
- OUTFALL

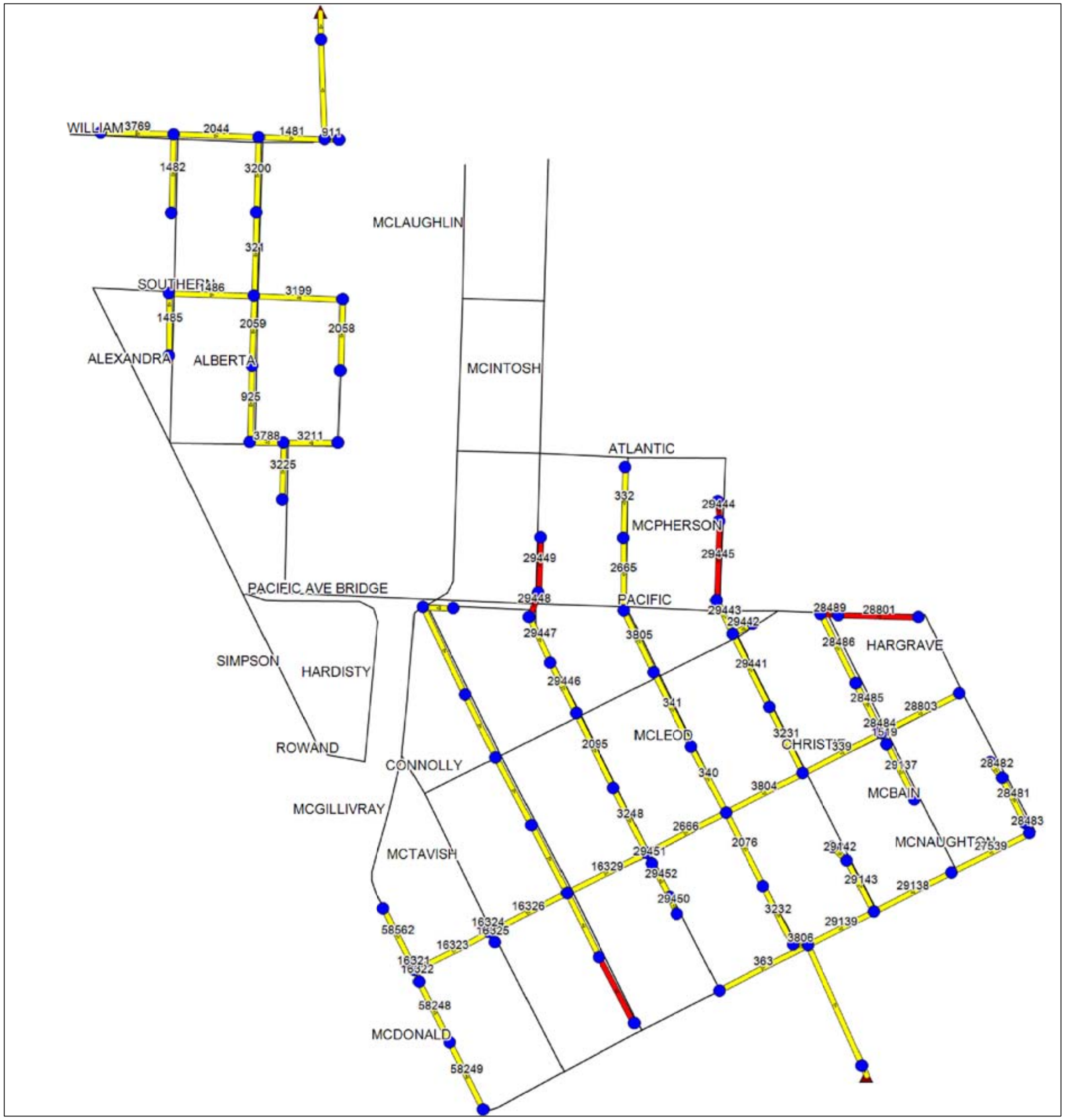
N

250 m

Hatch Mott MacDonald

AREA 3– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 25 YEAR DESIGN STORM CONDITIONS AND LOCAL SEWER IMPROVEMENTS IDENTIFIED UNDER 2 YEAR DESIGN STORM CONDITIONS

FIGURE 30



LEGEND

SEWER IMPROVEMENTS
EXISTING SEWERS
EXISTING MANHOLES
3250 SEWER ID
OUTFALL

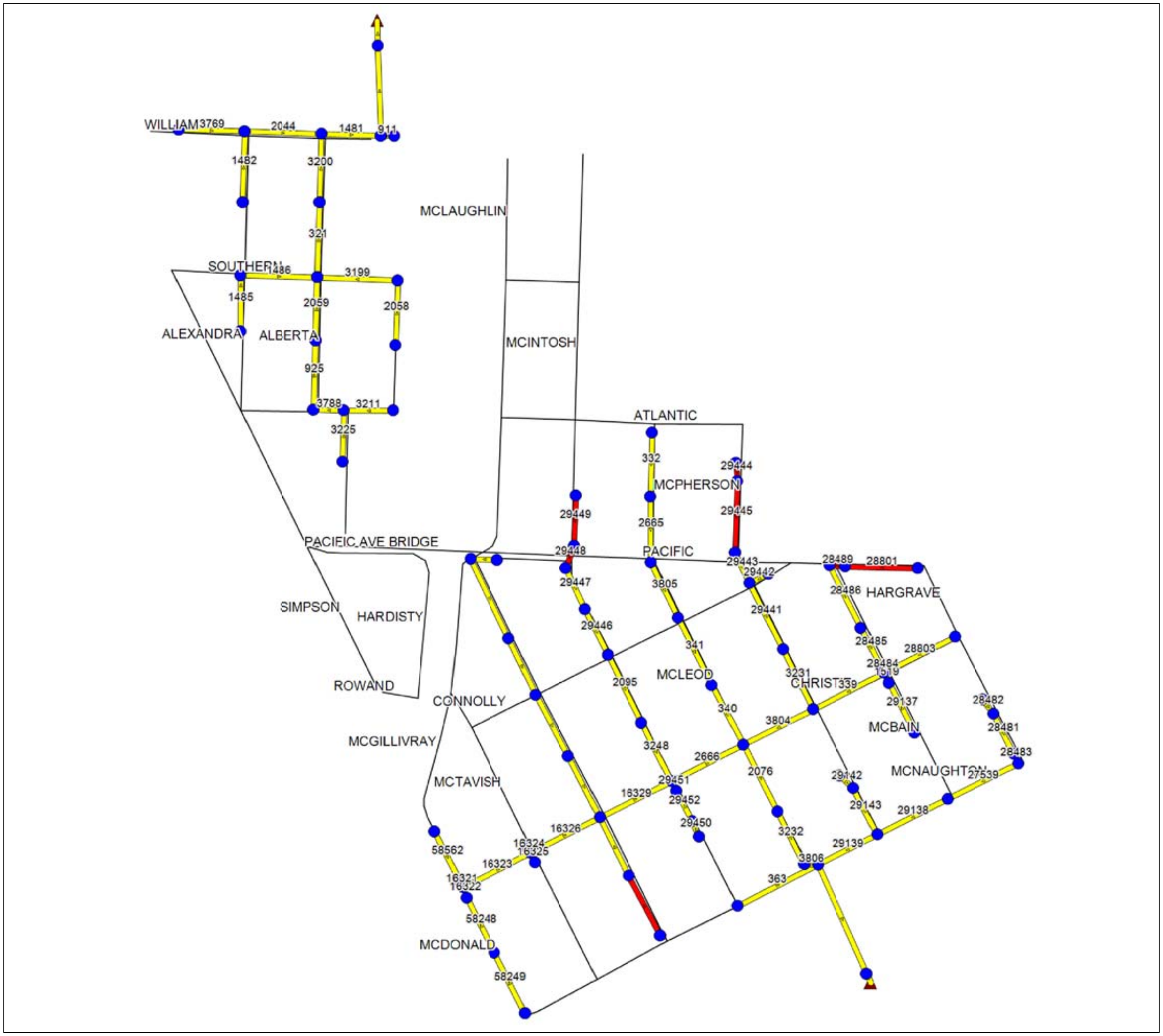
N

250 m

Hatch Mott MacDonald

AREA 3– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 10 YEAR DESIGN STORM CONDITIONS AND LOCAL SEWER IMPROVEMENTS IDENTIFIED UNDER 5 YEAR DESIGN STORM CONDITIONS

FIGURE 31



LEGEND

SEWER IMPROVEMENTS
EXISTING SEWERS
EXISTING MANHOLES
3250 SEWER ID
OUTFALL

Hatch Mott MacDonald

AREA 3– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 25 YEAR DESIGN STORM CONDITIONS AND LOCAL SEWER IMPROVEMENTS IDENTIFIED UNDER 5 YEAR DESIGN STORM CONDITIONS

FIGURE 32

6.3.4 Recommended Improvements for Area 3

Table 3 contains a summary of proposed improvements to the minor storm sewer system in Area 3 under the various design storm conditions that were assessed.

The sewer sizes identified in the table as predicted by the model will provide the increase in capacity needed to reduce the surface flooding and basement flooding under the various design storm conditions.

In some cases, an increase in pipe size to provide additional capacity under a 5 year design storm will also provide a higher level of service.

The recommended improvements were identified based on the following rationale:

- The improvements will provide a level of service consistent with standards used by municipalities across the province.
- The improvements are consistent with current Ministry of the Environment Design Guidelines.
- The increase in capacity in the storm sewer system will provide a reduction in basement and surface flooding in the study areas.
- Some flooding can still be expected under severe storm conditions, such as a 50 or 100 year design storm. The provision of a minor storm system with capacity to convey a severe storm such as a 50 or 100 year storm is not practical nor is it standard practice throughout the Province. Extensive infrastructure including very large storm sewers, and/or storm water retention tanks and ponds would be required, and could create other downstream problems. The overland flow system is intended to accommodate the major storms conditions.
- An increase in sewer sizes to increase capacity is less costly and provides additional storage, and is therefore preferred over the construction of pumping stations.

TABLE 3: Summary of Proposed Improvements in Area 3

Pipe ID	Description	Existing Size (m)	Length (m)	Proposed Sewer Sizes (m) Under Varying Conditions								Estimated Cost $/m[1]	Total Estimated Cost
				Local 2-Y-S[2]	**Local 5-Y-S**	**Trunk 10-Y-S**	**Trunk 25-Y-S**	**Trunk 10-Y-S Local 2-Y-S**	**Trunk 25-Y-S Local 2-Y-S**	**Trunk 10-Y-S Local 5-Y-S**	**Trunk 25-Y-S Local 5-Y-S**		
28801	Pacific East of McBain	0.3	87	0.375	0.375			0.375	0.375		0.375	$659	$57,316
29444	North McPherson	0.3	20		0.45					0.45	0.45	$714	$14,283
29445	McPherson North of Pacific	0.3	86		0.375					0.375	0.375	$659	$56,657
29448	McIntosh @ Pacific	0.3	29		0.6					0.6	0.6	$744	$21,572
29449	North McIntosh	0.3	60		0.525					0.525	0.525	$702	$42,120
28489	Pacific East of McBain	0.3	19		0.525					0.525	0.525	$702	$13,338
	McLaughlin South	0.3	81		0.375					0.375	0.375	$659	$53,363

Shading denotes recommended improvements to the storm sewer system

Notes:
[1] Estimated cost, $/m, includes surface restoration and 35% engineering and contingencies.
[2] 2-Y-S = 2 Year Design Storm (typ.)
[3] Refer to Figures 27 to 32 for illustrations of the improvements identified under varying conditions.
[4] If the cells are left blank there is no change to the existing sewer size identified under the varying conditions.

6.4 Area 4

The Area 4 study area is situated on both sides of the Neebing River, and has several tributary drainage areas. Syndicate Ave. north of the river was considered to be the location of one trunk sewer. The trunk sewers on the south side of the river are located on Prince Arthur Blvd. between Finlayson St, and the Neebing River, and on Minnestoa St. between Pacific Ave. and the Neebing River.

6.4.1 Syndicate Ave. Area

There are no improvements identified in the Syndicate Ave. catchment area under a 2 year storm event. Improvements on Syndicate Ave. from Durban St. to the Neebing River, and on Durban St. west of Syndicate Ave. were identified under a 5 year storm event.

The Syndicate Ave. trunk sewer has sufficient capacity under a 10 and 25 year storm event if the local sewers are assessed against a 2 year storm event. If the local sewers are assessed under a 5 year storm, then improvements are identified similar to that discussed above on Syndicate Ave. and Durban St.

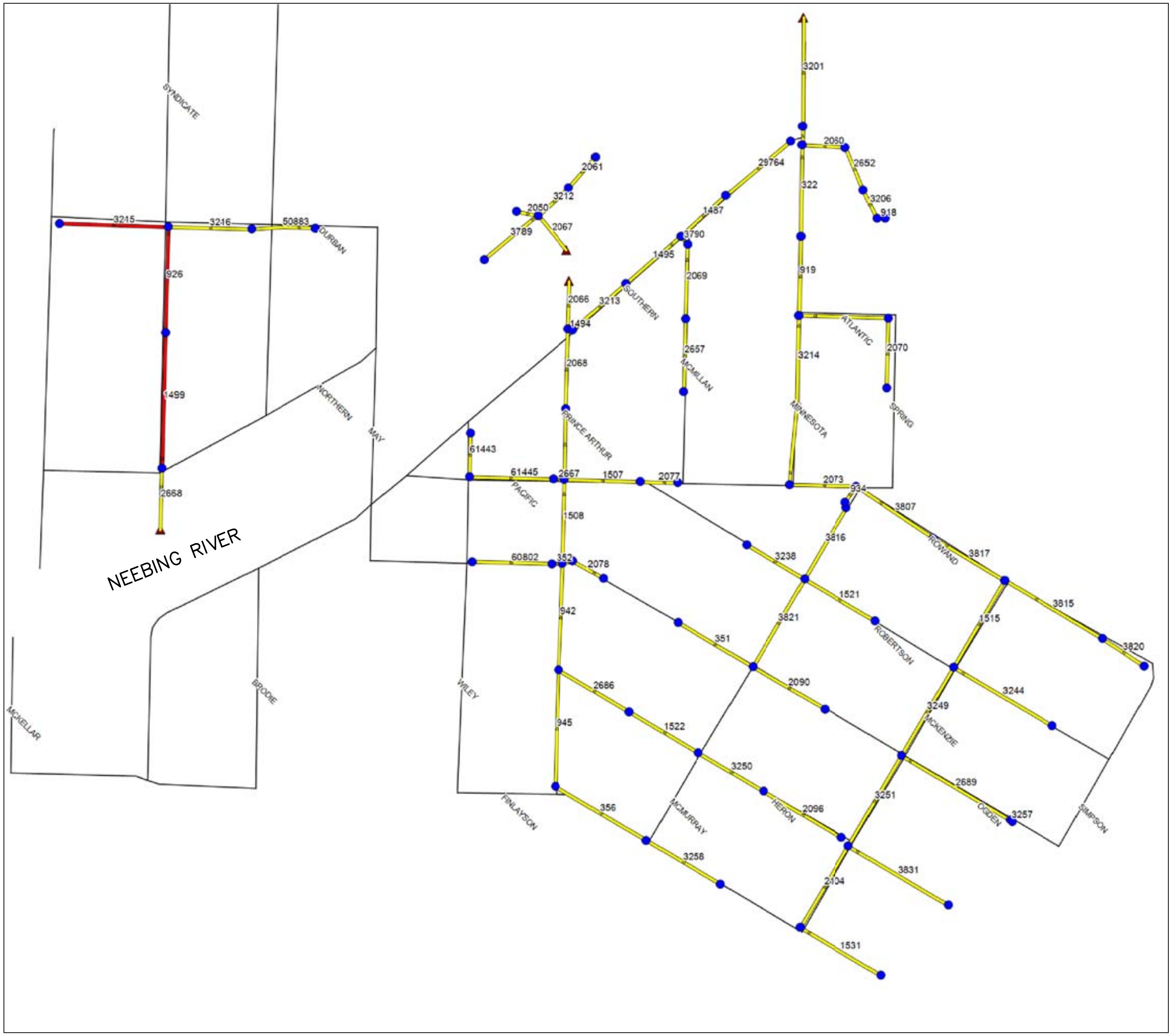
6.4.2 Prince Arthur Blvd. Area

There are no improvements identified in the Prince Arthur Blvd. catchment area under a 2 or 5 year storm event. The trunk sewer in this area also has sufficient capacity under the 10 and 25 year storm conditions.

6.4.3 Minnesota St. Area

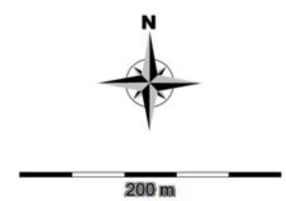
There are no improvements identified in the Minnesota St. catchment area under a 2, 5, 10 or 25 year storm event. The trunk sewer in this area also has sufficient capacity under the 10 and 25 year storm conditions.

The figures illustrating the above analysis are enclosed as Figures 33 to 35 and are summarized on Table 4.



LEGEND

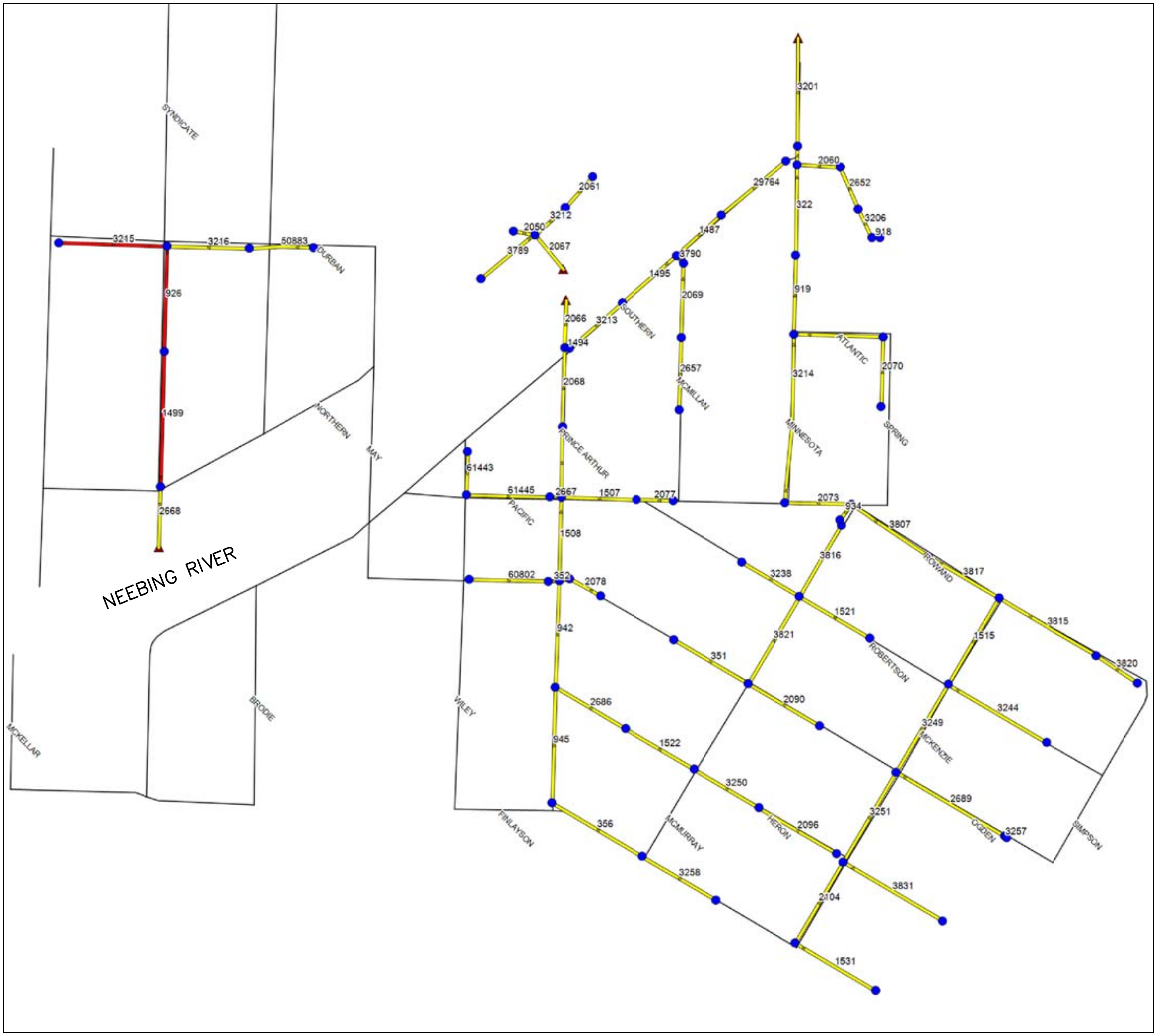
SEWER IMPROVEMENTS
EXISTING SEWERS
EXISTING MANHOLES
3250 SEWER ID
OUTFALL



Hatch Mott MacDonald

AREA 4– IMPROVEMENTS IDENTIFIED UNDER 5 YEAR DESIGN STORM CONDITIONS

FIGURE 33



LEGEND

SEWER IMPROVEMENTS
EXISTING SEWERS
EXISTING MANHOLES
3250 SEWER ID
OUTFALL

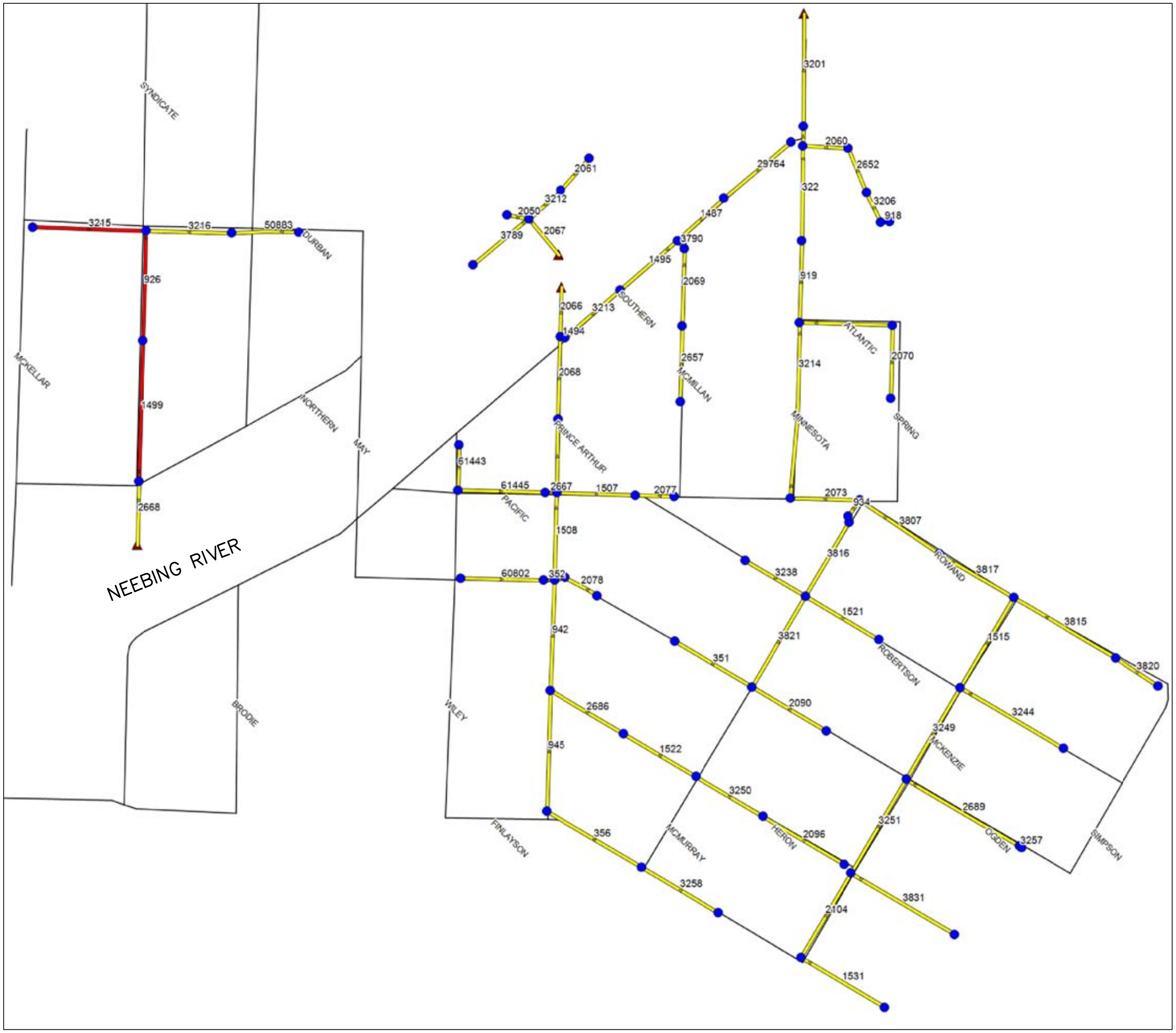
N

200 m

Hatch Mott MacDonald

AREA 4– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 10 YEAR DESIGN STORM CONDITIONS AND LOCAL SEWER IMPROVEMENTS IDENTIFIED UNDER 5 YEAR DESIGN STORM CONDITIONS

FIGURE 34



LEGEND

- SEWER IMPROVEMENTS
- EXISTING SEWERS
- EXISTING MANHOLES
- 3250 SEWER ID
- OUTFALL

Hatch Mott MacDonald

AREA 4– TRUNK SEWER IMPROVEMENTS IDENTIFIED UNDER 25 YEAR DESIGN STORM CONDITIONS AND LOCAL SEWER IMPROVEMENTS IDENTIFIED UNDER 5 YEAR DESIGN STORM CONDITIONS

FIGURE 35

6.4.4 Recommended Improvements for Area 4

Table 4 contains a summary of proposed improvements to the minor storm sewer system in Area 4 under the various design storm conditions that were assessed.

The sewer sizes identified in the table as predicted by the model will provide the increase in capacity needed to reduce the surface flooding and basement flooding under the various design storm conditions.

In some cases, an increase in pipe size to provide additional capacity under a 5 year design storm will also provide a higher level of service.

The recommended improvements were identified based on the following rationale:

- The improvements will provide a level of service consistent with standards used by municipalities across the province.
- The improvements are consistent with current Ministry of the Environment Design Guidelines.
- The increase in capacity in the storm sewer system will provide a reduction in basement and surface flooding in the study areas.
- Some flooding can still be expected under severe storm conditions, such as a 50 or 100 year design storm. The provision of a minor storm system with capacity to convey a severe storm such as a 50 or 100 year storm is not practical nor is it standard practice throughout the Province. Extensive infrastructure including very large storm sewers, and/or storm water retention tanks and ponds would be required, and could create other downstream problems. The overland flow system is intended to accommodate the major storms conditions.
- There is additional benefit to the proposed improvements on Syndicate Ave. and Durban St. The increase in pipe size provides capacity for the trunk sewers to accommodate a 25 year design storm, and the local sewers to accommodate a 5 year design storm.

TABLE 4: Summary of Proposed Improvements in Area 4

Pipe ID	Description	Existing Size (m)	Length (m)	Proposed Sewer Sizes (m) Under Varying Conditions								Estimated Cost $/m[1]	Total Estimated Cost
				Local 2-Y-S[2]	Local 5-Y-S	Trunk 10-Y-S	Trunk 25-Y-S	Trunk Local 10-Y-S 2-Y-S	Trunk 10-Y-S Local 5-Y-S	Trunk 10-Y-S Local 5-Y-S	Trunk 25-Y-S Local 5-Y-S		
926	Syndicate South of Durban	0.46	100		0.525				0.525		0.525	$702	$70,200
1499	Syndicate North of Northern	0.46	129		0.525				0.525		0.525	$702	$90,558
3215	Durban West of Syndicate	0.38	103		0.525				0.525		0.525	$702	$72,306

Shading denotes recommended improvements to the storm sewer system

Notes:
[1] Estimated cost, $/m, includes surface restoration and 35% engineering and contingencies.
[2] 2-Y-S = 2 Year Design Storm (typ.)
[3] Refer to Figures 33 to 35 for illustrations of the improvements identified under varying conditions.
[4] If the cells are left blank there is no change to the existing sewer size identified under the varying conditions.

6.5 Public Education and Outreach

Educating the public on alternative ways to improve storm drainage on and around their properties is a valuable component of any storm drainage system.

6.5.1 Roof Downspout Extension / Rain Barrels

Building rooftops provide large surface areas that are completely impermeable to rainfall. Eaves troughs and downspouts are designed to quickly collect runoff and channel it from the roof. Discharging roof downspouts to pervious surfaces away from the foundation walls such as lawns, or rain gardens provides an opportunity for the runoff to infiltrate into the ground and away from basements. Extensions on the downspouts is a simple upgrade that can result in significant drainage improvements.

Capturing the runoff in a rain barrel has a dual purpose. The runoff is stored for future use in irrigating gardens and this reduces water consumption from the community water supply. This in turn reduces flows in the sewer system, which can reduce surcharging.

6.5.2 Foundation Drain Disconnection

Disconnecting foundation drains from the sanitary sewer system, and disconnecting gravity weeping tile connections from the storm sewers are discussed further in Section 7.

6.6 Engineering Standards and General Improvements

Several recommendations for changes to the City's existing Engineering and Development Standards are summarized below:

g) Incorporate the most recent Environment Canada data into revised Intensity Duration Frequency curves for use on future City projects;

h) For minor storm sewer systems, review the level of enhancement identified (if any) to utilize a 5 year design storm vs. a 2 year design storm;

i) Increase the use of curb inlet or double catchbasins to allow the storm water to enter the sewer system on the roadways faster;

j) Consider catchbasin restrictors on catchbasins located on publically owned parklands to provide storage to reduce peak flows to the sewer system;

k) Consider increasing the size of storm sewer laterals between the catchbasins and the storm sewers to a minimum of 250mm to improve the ability of the sewer system to remove the surface water;

l) Review the existing Site Plan Control Bylaw and the Stormwater Bylaw to address storm drainage requirements between pre and post development conditions.

7.0 IMPLEMENTATION PLAN

7.1 Overview

The following section provides a summary of the recommendations for improvements. The objectives discussed at the outset of the study were to improve the storm system to reduce:

- Consumer complaints;
- Operation and Maintenance Activities;
- Infiltration / Inflow;
- Overflows, flood damage and basement flooding;
- Service interruptions.

The Plan will change and evolve throughout the implementation period as more and better information becomes available, and as budgets become available.

7.2 Prioritization and Schedule

The recommendations have been summarized and prioritized based on the cost, the sequence of upgrades necessary from an operational perspective, the need for additional studies to address downstream impacts, and the benefits of the projects. To prioritize programs, four levels of priorities have been established, 1 being the highest and 4 being the lowest. Projects that are lower cost providing immediate results are given higher priority. For example, areas identified for improvements under a 2 year design storm are given a higher priority. Projects that provide improvements to trunk sewers that have exhibited an additional benefit to the respective upstream local sewers are also given a higher priority.

The suggested timing for the various works is shown on Table 5, and the recommended improvements are illustrated on Figures 36 to 39.

7.3 Cost Estimates

Cost estimations for the recommended projects and programs have been prepared and are also summarized on Table 5, indicating the total costs for the improvements. There are no costs shown for some programs, which indicate that program funding should come from private property owners.

It should be noted that in some areas, further engineering analysis is required to confirm the extent of improvements in downstream sewer systems.

The Implementation Schedule has been developed to assist the City with the planning and establishment of budgets for the various recommendations. It should be noted that funding for each project will have to be confirmed annually as the capital budgets are approved by City Council. As a result, the timing of the various works may vary from that presented.

None of the recommendations require additional property purchases.

It should also be noted that costs for stormwater retention ponds/tanks in Area 1 have not been included in the costs.

7.4 Municipal Class Environmental Assessment & Environmental Compliance Approval Requirements

The Municipal Class Environmental Assessment (MCEA) provides a streamlined decision making framework that enables the requirements of the Ontario Environmental Assessment Act to be met in an effective manner. A description of the project classifications is found in Section 1.3.

In addition to the EA requirements, approval from the Ministry of the Environment is required through the application for an Environmental Compliance Approval (ECA),formerly known as a Certificate of Approval, for most upgrades and installation of new equipment regarding the collection and/or treatment of sewage.

The following is a summary of the various types of recommended projects/upgrades and the requirements for Environmental Assessment (EA) and Environmental Compliance Approvals (ECA):

Schedule A – The following improvements may be considered as Schedule A activities:

- Establish new stormwater detention/retention ponds or tanks provided all facilities are in either an existing utility corridor or an existing road allowance where no additional property is required. This might include a stormwater pond or tanks in Areas 1 or 2.
- Increase in pumping station capacity by adding or replacing equipment where new equipment is located within an existing building or structure and where the existing rated capacity is not exceeded. This might include the following upgrades:
    - Intercity Pumping Station Upgrades;
    - Third Ave. Pumping Station upgrades;

  These improvements would also be subject to an Environmental Compliance Approval through the Ministry of the Environment.

Schedule A+ - The following improvements may be considered as Schedule A+ activities:

- Increase in pumping station capacity by adding or replacing equipment where new equipment is located within an existing building or structure and where the existing rated capacity is exceeded. This might include the following upgrades:
    - Intercity Pumping Station Upgrades;
    - Third Ave. Pumping Station upgrades

  These improvements would also be subject to an Environmental Compliance Approval through the Ministry of the Environment.

- Establish, extend or enlarge a sewage collection system and all necessary works to connect the system to an existing sewage or natural drainage outlet, provided all such facilities are in either an existing road allowance or an existing utility corridor. This might include the following upgrades:

    - Installation of new and/or larger storm sewers and appurtenances provided they are in existing utility corridors.

  These improvements would also be subject to an Environmental Compliance Approval through the Ministry of the Environment.

Schedule B - The following improvements may be considered as Schedule B activities:

- Establish, extend or enlarge a sewage collection system and all necessary works to connect the system to an existing sewage or natural drainage outlet, where such facilities are not in either an existing road allowance or an existing utility corridor;

- Establish new stormwater detention/retention ponds or tanks where additional property is required;

- Establish new Sewage flow equalization tankage in existing sewer systems or at existing pumping stations for influent and/or effluent control. This might include the following upgrades:

    - Intercity Pumping Station equalization tankage;
    - Third Avenue Pumping Station equalization tankage;

  These improvements would also be subject to an Environmental Compliance Approval through the Ministry of the Environment.

- Increase pumping station capacity by adding or replacing equipment and appurtenances, where new equipment is located in a new building or structure. This might include the following upgrades:

    - All pump capacity upgrades outlined under Schedule A+ could potentially be Schedule B projects if a new building or structure is planned;

  These improvements would also be subject to an Environmental Compliance Approval through the Ministry of the Environment.

There are no anticipated Schedule C projects currently recommended.

Generally, the following upgrades are not subject to EA or ECA processes:

- manhole upgrades/repairs;
- installation of new catchbasins;
- roadside ditches, culverts and other stormwater works for the purposes of servicing municipal road works;
- disconnection of downspouts and weeping tiles;
- operation and maintenance activities;
- flood mitigation programs such as rain barrels, etc.

7.5 Residential Drainage Rebate Program

The City of Thunder Bay through EcoSuperior has initiated a Drainage Rebate Program to provide financial assistance to homeowners to take flood protection measures. When excess storm water enters the sanitary sewer system, it can cause the sewer to overload and water levels to rise above normal levels, and this condition is referred to as "surcharging". If the home has sanitary fixtures or floor drains below the surcharge levels, basement flooding can occur.

Items that are eligible for financial assistance include backflow preventer installations, sump pump/dry well installations, and weeping tile disconnections. The rebate program is available to all property owners within the City of Thunder Bay.

In order to ensure the public is aware of this Rebate Program, and the importance of directing storm water away from the home and the sanitary sewer system, advertisements have been placed in the Chronicle Journal, on EcoSuperior's website, and in the City of Thunder Bay's online document "MYTbay Newsletter to Citizens", dated Feb/March 2013.

Further details of the Rebate Program are enclosed in Appendix C, and can also be found at www.ecosuperior.org.

7.6 Other Rebate and Grant Programs

The City currently promotes the use of rain barrels as a method to capture run-off from the rooftop for use in gardens and on lawns. They are easy to install and a simple, inexpensive way to meet outdoor water needs. The installation of a rain barrel provides plants with non-chlorinated soft rainwater and also helps reduce the load on storm sewers.

The City also has a Rain Garden Rebate Program. A Rain Garden is a landscaped depression that will soak up rainwater runoff from the hard surface areas (i.e. driveway, roofs). Rain Gardens are normally planted with wildflowers or other plants and they provide habitat and food for birds and insects.

Additional details with respect to these programs can be found in Appendix C or at www.ecosuperior.org.

TABLE 5: IMPLEMENTATION PLAN

Description	Estimated Cost[1]	Priority	Implementation Period	Comments
AREA 1 - NORTHWOOD				
James St. East Trunk Conestoga to Edward	$635,000	1	2014	As an alternative to upgrading to a 1050 mm dia. pipe, the estimated cost to twin the existing 910 mm dia. trunk sewer is $490,000
James St. Trunk East of Edward to Outfall Ditch	$620,000	1	2014	Potential upgrades east of Study Area[2]
Kensington South of Ironwood	$120,000	2	2015	
Ironwood	$145,000	2	2015	
Edward St. Trunk - Ironwood to Redwood	$505,000	2	2015	
Redwood East of Edward to Floodway	$2,040,000	2	2015	Potential upgrades East of Study Area[2]
Ryerson Pl	$30,000	3	2016	
Fanshaw Trunk - East of Conestoga	$105,000	3	2016	
Conestoga	$65,000	3	2016	
James St. South Trunk (Redwood to Neebing River)	$1,510,000	3	2016	Potential upgrades south of Study Area[2]
Huntington/University/Vale	$375,000	3	2016	
James St. South Trunk (North of Redwood)	$850,000	3	2016	
Fanshaw Trunk - West of Conestoga	$250,000	3	2016	
Trinity Cres.	$140,000	3	2016	
Redwood/Kinsmen Park West of James	$395,000	4	2017	Drainage improvements for McMaster/Dalhousie Area
Edward South of Redwood to Neebing River	$1,345,000	4	2017	Potential upgrades South of Study Area[2]
Sherbrooke North of Kensington	$330,000	4	2017	
AREA 2 - INTERCITY				
Third Ave. PS Storage	$1,500,000	3	2016	Stormwater retention pond alternative estimated cost $100,000
High St. Trunk	$595,000	4	2017	
Memorial Ave. South	$385,000	4	2017	Potential upgrades[3]
AREA 3 - EAST END (East of Simpson)				
McIntosh/McLaughlin/McPherson/Pacific	$205,000	3	2016	
AREA 4 - EAST END (West of Simpson)				
Syndicate Ave. and Durban St.	$235,000	2	2015	

TABLE 5: IMPLEMENTATION PLAN

GENERAL

Description	Estimated Cost[1]	Implementation Period	Comments
Roof Downspout Extension	$ -		No Cost to City
Rain Barrels	$ 2,000	2014-2017	$20 subsidy per household. Assume 100 households participate
Foundation Drain Disconnection	$ 50,000	2014-2017	$500 subsidy per household. Assume 100 households participate
Sump Pump Installation	$ 125,000	2014-2017	$1,250 subsidy per household. Assume 100 households participate
Backflow Prevention Valve Installation	$ 175,000	2014-2017	$1,750 subsidy per household. Assume 100 households participate
Rain Garden Rebate Program	$ 25,000	2014-2017	$500 subsidy per household. Assume 50 households participate

Average General Cost per year (2014-2017)	**$ 94,250**
SubTotal Priority 1 (2014)	**$1,349,250**
SubTotal Priority 2 (2015)	**$3,139,250**
SubTotal Priority 3 (2016)	**$5,124,250**
SubTotal Priority 4 (2017 & future)	**$3,144,250**
Total	**$12,757,000**

Notes:
[1]Estimated costs include surface restoration and 35% Egineering and Contingencies rounded up to the next $5,000, taxes not included.
[2]Further engineering analysis is required to confirm improvements in the downstream sewer system.

AREA 1— RECOMMENDED UPGRADES

PRIORITIES

1
2
3
4

LEGEND

SEWER IMPROVEMENTS
EXISTING SEWERS
EXISTING MANHOLES
3250 SEWER ID
OUTFALL

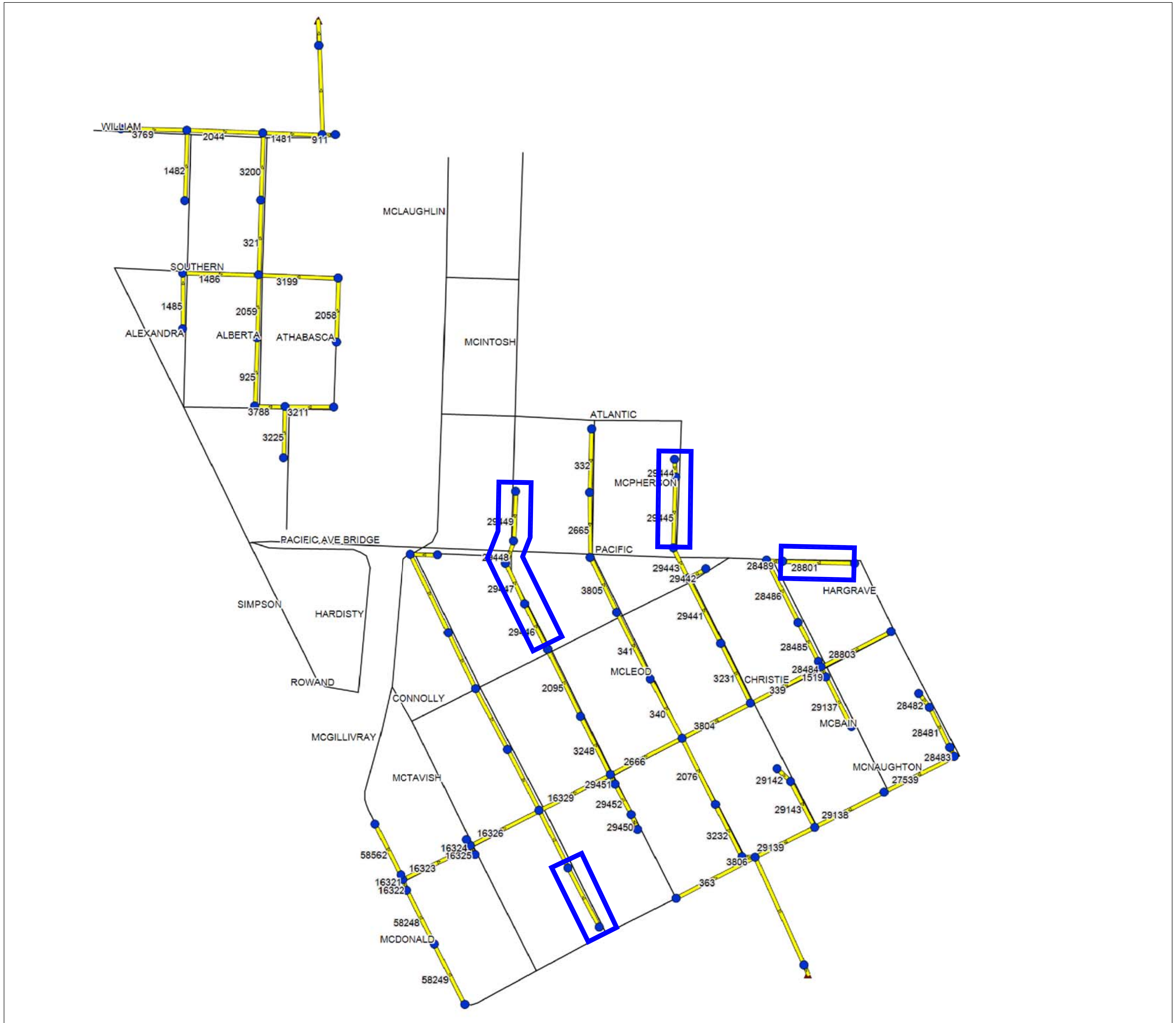
Hatch Mott MacDonald

FIGURE 36

AREA 2– RECOMMENDED UPGRADES

Hatch Mott MacDonald

FIGURE 37



AREA 3– RECOMMENDED UPGRADES

PRIORITIES

1
2
3
4

LEGEND

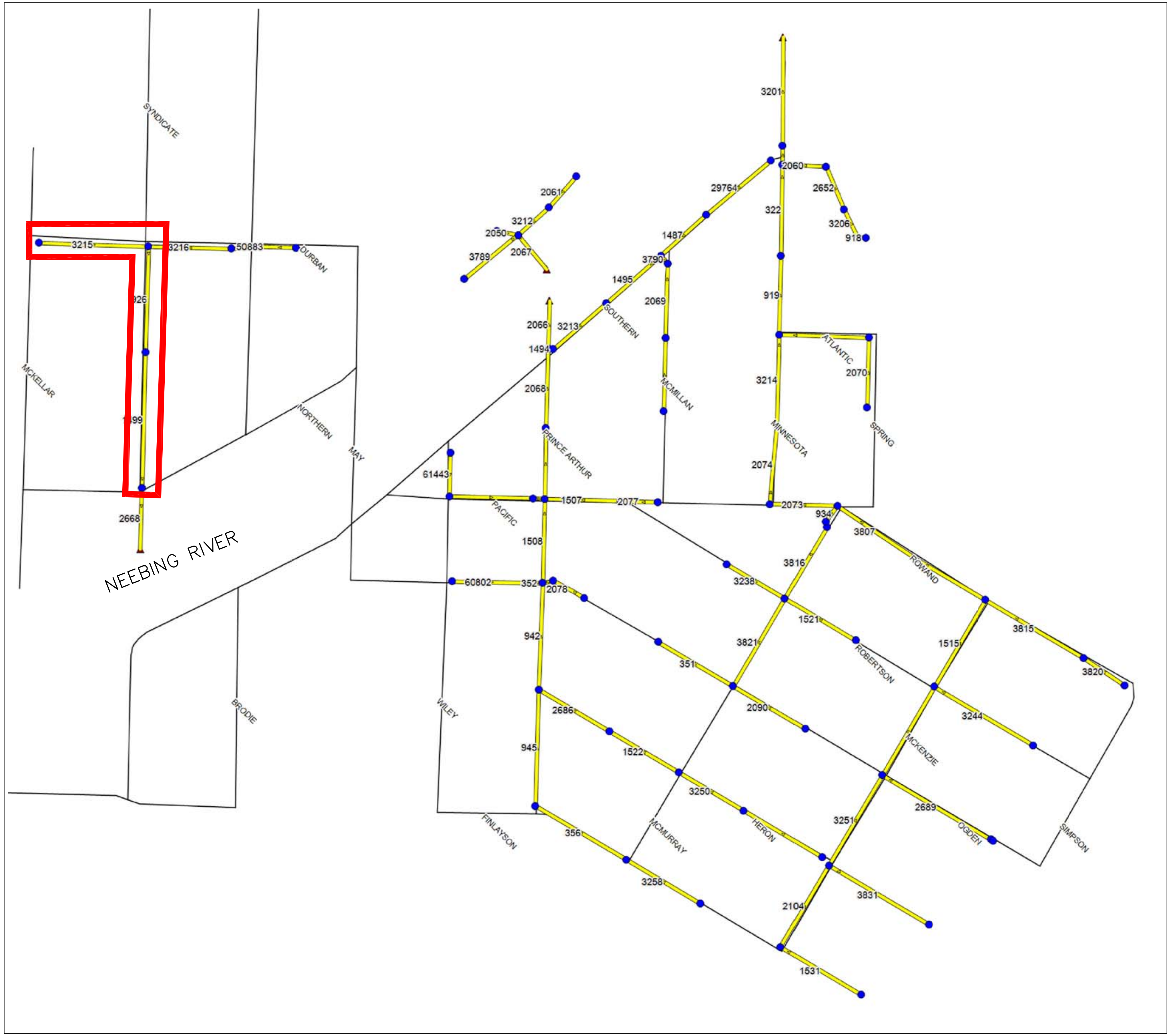
SEWER IMPROVEMENTS
EXISTING SEWERS
EXISTING MANHOLES
3250 SEWER ID
OUTFALL
FLOODED MANHOLE (≥ 0.02hr)

N

250 m

Hatch Mott MacDonald

FIGURE 38



AREA 4— RECOMMENDED UPGRADES

FIGURE 39