# APPENDIX C – TECHNICAL MEMORANDUMS

Appendix C-1: Technical Memorandum 4

Appendix C-2: Technical Memorandum 4 Addendum

Appendix C-3: Technical Memorandum 5

## Appendix C-1 – Technical Memorandum 4

**Aquafor Beech File No.: 65319**

December 23, 2016

Revised November 10, 2017

# TECHNICAL MEMORANDUM NO.4

# LAWRENCE PARK NEIGHBOURHOOD STUDY AREA

Prepared for:
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## Introduction

Over the last 20 years, the City of Toronto has experienced four major rainfall events that triggered incidents of basement flooding in northern areas of the City. The last major rainfall event occurred on August 19, 2005 with up to 150 mm of rain falling over a period of three hours. The rainfall was concentrated north of the Highway 401 from Highway 400 to Highway 404. There was significant damage to private and public property with flooding, road overtopping due to limited hydraulic capacity of bridges and culverts, and a road washout.

## Objectives

The purpose of the Technical Memorandum 4 (TM4) is to combine the findings from Technical Memorandum 1 to 3. Sections below provided updated findings and information for Technical Memorandum 1 to 3. The brief objectives of the Technical Memorandum 1, 2 and 3 are summarized below.

### Technical Memorandum No. 1 (TM#1)

- To provide a list of information /data collected including sources and quality of the information/data.

### Technical Memorandum No. 2 (TM#2)

- To discuss and provide conclusions regarding the suitability of the available rainfall and flow monitoring data for calibration and validation of the InfoWorks H&H model, and include the above analyses of any new data that may be collected.

### Technical Memorandum No. 3 (TM#3)

- To discuss the methodology and findings of the InfoWorks Hydrologic & Hydraulic model assessment.

# TECHNICAL MEMORANDUM NO.1

## 1.0 PROJECT BACKGROUND

Periodically, the City has experienced both surface and basement flooding in response to relatively infrequent rainfall events. The most recent was the storm of August 19, 2005, an event in excess of 100 years return frequency that resulted in over 3,600 reported basement flooding occurrences across the City. In April 2006, City Council approved a work plan designed to focus on prevention, to the highest economical degree possible of surface flooding and reducing the amount of stormwater entering all sewer systems. The work plan identified 34 basement flooding areas throughout the City.

The City of Toronto has developed a city-wide Wet Weather Flow Master Plan (WWFMP) to address adverse impacts of Wet Weather Flow (WWF) and to protect the environment and improve the ecosystem health of the watersheds. The WWFMP recognizes that wet weather flow will be managed on watershed basis starting with source, conveyance, and end of pipe solutions. The WWFMP is focused on addressing issues related to controlling and reducing the impacts of Combined Sewer Overflow (CSO), Stormwater (SW) discharges and Infiltration/Inflow (I/I). A hierarchical approach to stormwater management was adopted in the development of the WWFMP, which considered, in order of priority, source control measures, followed by conveyance control measures and lastly, end-of-pipe control measures.

The following Technical Memorandum 1 represents the preliminary assessment of basement flooding in the areas designated as Lawrence Park Neighbourhood Study Area in the former Cities of North York and Toronto as the next step in a program to provide a comprehensive solution to basement flooding.

The Lawrence Park Neighbourhood (LPN) study area is almost fully developed at present with about seventy percent (70%) of the area made up of single and multi-family residential land use. Therefore, at source, or lot-level stormwater control measures can be applied to a variety of land uses, including municipal and residential properties.

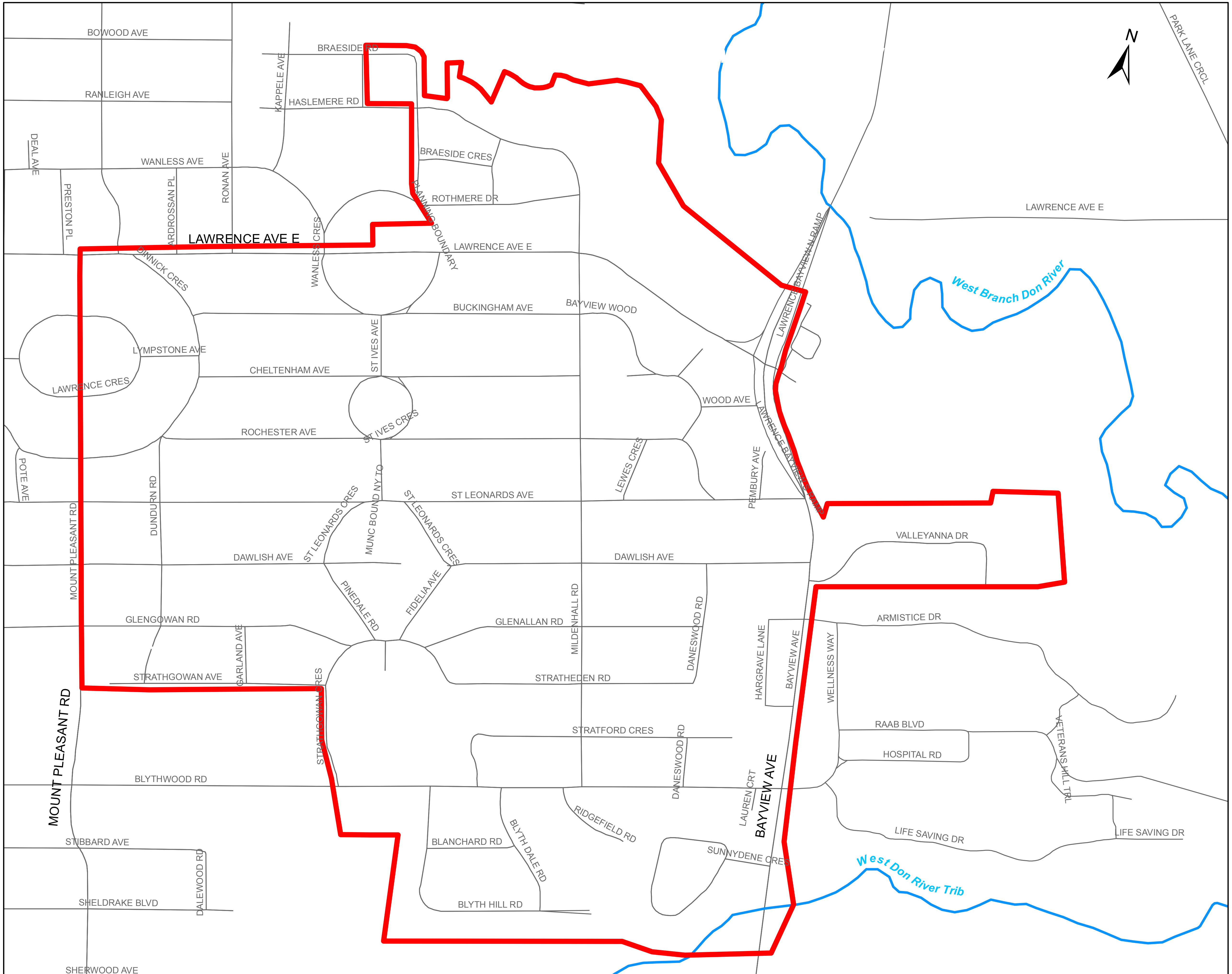
The success of lot-level stormwater control measures is dependent upon uptake by property owners. Given the extent of the study area comprised of residential land use, and in order to maximize the application of at source (first priority) control measures, it is necessary to secure residents' uptake and use of on-site control measures and practices on their properties, as well as their support for control measures on the municipal right-of-way and roadways in residential areas.

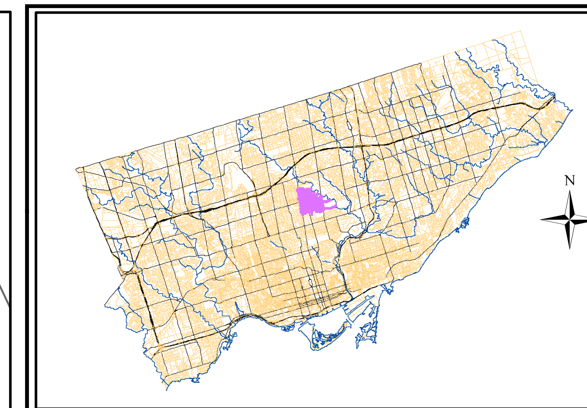
In order to properly evaluate the potential of at-source control measures for residential properties, the municipal right-of-way, and roadways, it is necessary to understand the opportunities and constraints to implementing such measures. In order to effectively evaluate options for lot-level stormwater control, it is necessary to understand the attitudes, opinions and practices of residents regarding such measures. Uptake of lot-level stormwater control measures in the residential sector is an important element of a comprehensive approach to stormwater control across the study area

## 1.1 Site Setting

Figure 1.1 shows the Lawrence Park Neighbourhood study area which is generally located in the central part of the City on Ward 25 – Don Valley West. The study area is roughly bounded by Blythwood Road, Ridgefield Road and Sunnydene Crescent to the south, Don River West Branch to the north, Mount Pleasant Road to the west, and Bayview Avenue in the east.

The study area is serviced by a mix of combined, sanitary and storm sewers as well as roadside ditches. The Lawrence Park Neighbourhood Sewershed has four (4) stormwater outfalls discharging into the tributary of West Branch Don River.



LEGEND:

- LPN Study Area
- Watercourses
- Roads

NOTES:

Base Mapping was provided by the City of Toronto

400 200 0 Meters

TORONTO

Aquafor Beech Limited

**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Lawrence Park Neighbourhood Survey Area**

**FIGURE No. 1.1**

**DATE: SEPTEMBER 2013**

The distribution of land use within the study area is approximately 70% single and multiple residential, approximately 10% institutional, commercial and industrial, and 23% park area and roadway. A majority of the commercial developments are located adjacent to Bayview Avenue.

A majority of the homes in this area (former City of Toronto) were initially serviced with combined sewers, which carry both wastewater and stormwater runoff. Throughout the 1960s until the mid 1980s, the City undertook sewer separation programs whereby stormwater runoff from public property was directed to a storm sewer. Subdivisions (former City of North York) within the study area that were constructed from the 1960's onward are serviced by a separate storm and sanitary system.

As of 2013, approximately 10.3% of the area is serviced by combined sewers, 20.5% with partially separated sewers (storm/combined) and 69.2% with separated sewers (storm/sanitary).

Topography of the study area is such that the water flows from northwest to the southeast and east end to the West branch of the Don River at the designated outfalls as shown in Figure 4.2. The high point in study area is located at northwest side where as the low point is located at the southeast boundary of the study area.

### 1.2 Objectives of Technical Memorandum #1

Technical Memorandum #1 is organized into the following sections:

1. Introduction
    a. Provides the background underlying the preparation of the Technical Memorandum.

2. Data Collection
    a. Presents the compilation of Group 1 and Group 2 data available from the City and other identifiable sources.

3. Field Survey
    a. Describes the field survey activities and presents the results.

4. Assessment of the Storm Sewer System
    a. Identifies data gaps for the storm sewer system and approach to address gaps in the data.

   b. Summarizes the characteristics and drainage areas of the storm system network.

5. Assessment of the Sanitary Sewer System
   a. Identifies data gaps for the Sanitary sewer system and approach to address gaps in the data.
   b. Summarizes the characteristics and drainage areas of the sanitary system network.

6. Assessment of the Combined Sewer System
   a. Identifies data gaps for the combined sewer system and approach to address gaps in the data.
   b. Summarizes the characteristics and drainage areas of the combined system network.

7. Summary
   a. A brief summary of the physical assessment is presented.

## 2.0 DATA COLLECTION

The City of Toronto identified two data groups for the study. Group 1 data was provided by the City and included physical information about the service areas and sewer systems. Group 2 data consists of historical information related to development practices, by-laws, system configuration, topography, hydrogeology, operations and maintenance, and basement flooding reports.

All identifiable information was compiled from City staff from various sources within the City and District offices.

Aquafor Beech Limited reviewed all the information provided by the City of Toronto. The review criteria was based on status, quality, and missing information in the data. The following sections summarize the findings of our review of all the provided information including various assumptions made to use and apply data in the development of the hydrologic and hydraulic model for the Lawrence Park Neighbourhood area.

### 2.1 Group 1 Data

Group 1 data was provided by the City and included information about the service areas and sewer systems.

### *2.1.1 Questionnaire*

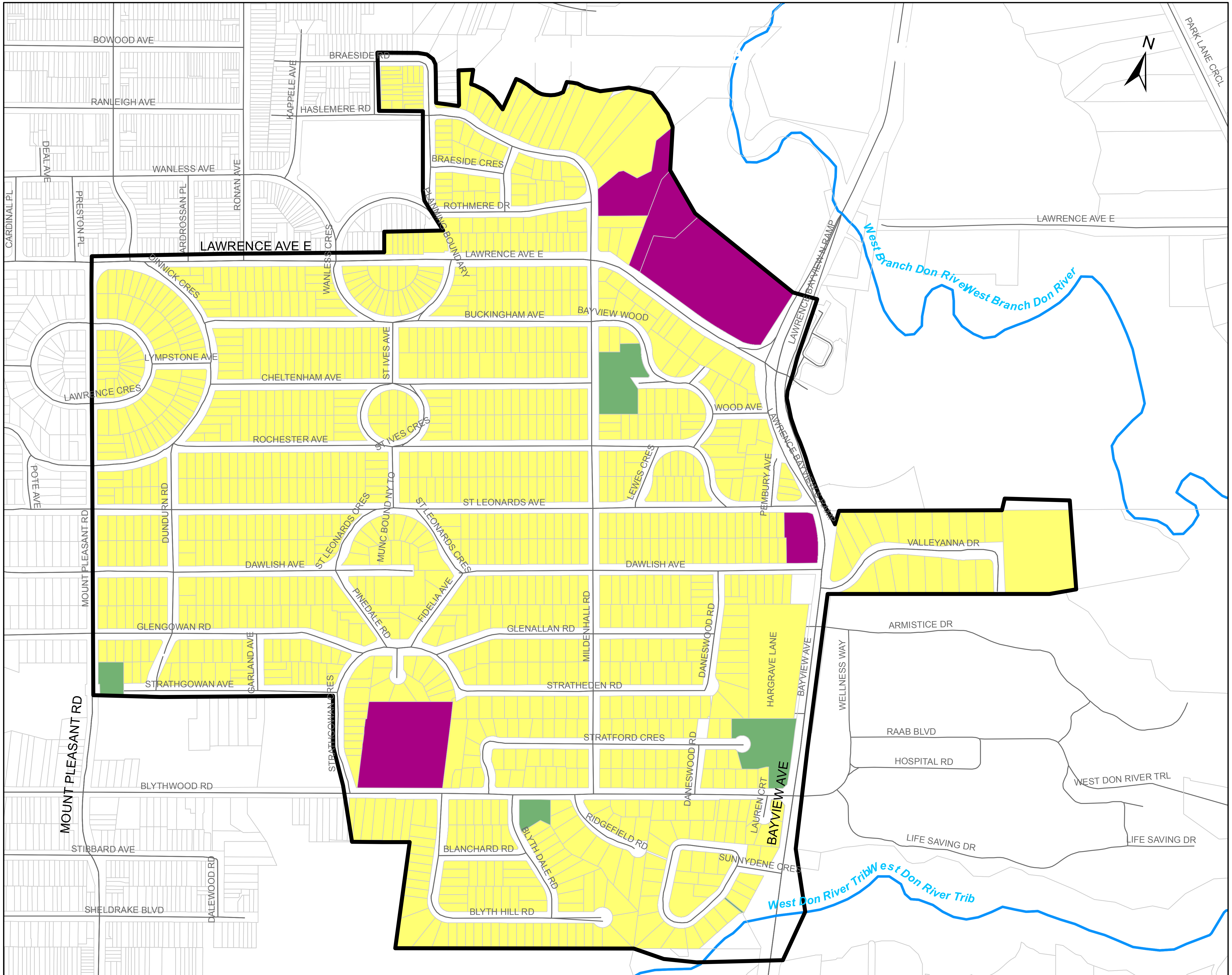
A questionnaire was distributed to all residents within the Lawrence Park Neighbourhood in late January. The submission deadline was February 28, 2013. Approximately 400 residents responded out of 2200 households (estimated). This response rate is considered high compared to other basement flooding studies in Toronto. The objective of the questionnaire was to gather input on flooding, road conditions, pedestrian safety, traffic issues, etc. A copy of the questionnaire is provided in Appendix B.

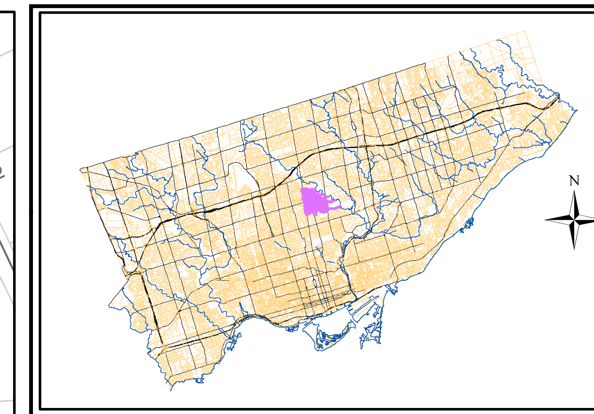
### *2.1.2 Land Use Classification*

Figure 2.1 presents the land use classification for LPN study area and Table 2.1 presents a summary of land use classifications. The land use has been processed based on the defined storm service boundary.

**Table 2.1 Land Use Classification**

| Land Use Classification | | LPN Study Area | |
|---|---|---|---|
| | | Land Use Area (Ha) | Percentage of Total (%) |
| Residential | Single Family | 109 | 68% |
| | Multilevel Families | 0 | 0% |
| Industrial /Commercial /Institutional | Commercial | 0 | 0% |
| | Industrial | 0 | 0% |
| | Institutional | 14 | 9% |
| Open Area | Open Area | 6 | 4% |
| | Roadway | 31 | 19% |
| Total | | 160 | 100 |
| Note: Land use summary based on storm service area. | | | |



LEGEND:

- LPN Study Area
- Watercourses
- Roads

**Landuse Classification**

- Residential, Single Family
- Open Space
- Institutional
- Roadway

NOTES:

Base Mapping was provided by the City of Toronto

400 200 0 Meters

TORONTO

Aquafor Beech Limited

**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Land Use Classification**

**FIGURE No. 2.1**

**DATE: SEPTEMBER 2013**

The predominant land use for the area is residential representing approximately 70% of the service area. The residential development is currently single family with no multilevel developments. A condominium/apartment development located north east of Bayview Avenue and Blythwood Road is currently under construction. Approximately 10% of the service area is made up of industrial, commercial and institutional lands (ICI), and the remainder of the area is open space or public roadway.

### 2.1.3 *Population*

Population information was supplied by the City of Toronto from the 2011 census data. Table 2.2 presents the study area population based on the sanitary service boundary defined for the project.

Table 2.3 presents a summary of population density associated with the residential land use. The population density ranges between 35 and 40 persons/ha across the study area. In 2011, the City of Toronto had a population[1] of 2,615,060 representing a percentage change of 4.5% from 2006. This compares to the national average growth of 5.9%. Land area is 630.21[1] square kilometers with a population density of 4,149.5 persons[1] per square kilometer. The population density is approximately 40 persons/ha across the City.

[1] – Population data was adopted from the website of Statistics Canada "2011 Census, Statistics Canada".

The population density for the residential areas are similar to current density associated with residential land use classifications within the City of Toronto.

**Table 2.2 Lawrence Park Neighbourhood Study Area - Population**

| **Study Area** | **Population** |
|---|---|
| Lawrence Park Neighbourhood | 4094 |
| **Notes:** Population data source 2011 census. | |

**Table 2.3 Residential Per Capita Water Consumption**

| **Study Area** | **Population** | | **Area (ha)** | | Population Density (Pop/ha) | |
|---|---|---|---|---|---|---|
| LPN | Single Family | Multi-Family | Single Family | Multi-Family | Single Family | Multi-Family |
| | 4094 | 0 | 109 | 0 | 37.5 | 0 |

### *2.1.4 Water Consumption/Billing Records*

Lawrence Park Neighbourhood Area water consumption data was provided by the City for 2004. The water consumption information was overlapped with land use (residential and ICI) areas for assessment.

The residential water consumption data was used to establish a Theoretical Wastewater Production Rate (TWPR) based on the assumption that approximately 85% of water consumed is returned to the sanitary collection system. For LPN study area, the TWPR is determined as follows:

- Define the contributing population in each study area. 2011 population data is considered to be representative of 2004 population conditions.
- Intersect the population information from residential areas with the water consumption records associated with residential land use.
- Sum the water consumption in each service area and calculate the TWPR by taking 85% of the water consumption and divide by the contributing population.

Table 2.4 presents a summary of TWPR for residential land in LPN study area. The TWPR from the study area is 1131 lpcd significantly higher for the study area.

The TWPR for single family residential land use from LPN study area was compared with the Toronto Water Efficiency Plan, Works and Emergency Services, 2002. This report identifies that for the City of Toronto it is expected that 70% of the annual average day demand supplied to the community is returned to the wastewater system. For this analysis 85% return was adopted as a conservative assessment. Table 2.5 presents a summary of residential per capita water consumption in the City of Toronto based on 85% of the water consumed being returned to the system as wastewater.

**Table 2.4 Residential Per Capita Water Consumption in City of Toronto, 2011**

| Area | Residential Population | Residential Water Consumption (m3/d) | TWPR (lpcd) |
|---|---|---|---|
| LPN study area | 4094 | 5448 | 1131 |

**Table 2.5 Industrial/Commercial/Institutional (ICI) Water Consumption Assessment**

| Land Use | 2001 Population[2] | Average Daily Demand[2] (L) | TWPR ([1,2]) (lpcd) |
|---|---|---|---|
| Single Family | 1,340,000 | 427,720,000 | 272 |
| Multi-Unit | 1,250,000 | 239,020,000 | 162 |
| Residential | 2,590,000 | 666,740,000 | 219 |
| Notes:<br>1. TWPR – Theoretical Wastewater Production Rate base on 85% of 2001 water consumption values.<br>2. City of Toronto Water Efficiency Plan, 2002 – Table 2.2 | | | |

The TWPR determined for LPN study areas of 1131 lpcd compares significantly high with the City wide residential TWPR of 219 lpcd.

An average per capita sanitary flow of 240 L/cap/day is identified for all the residential areas and 250 L/cap/day is identified for all the Industrial/Commercial/Institutional areas.

These values are identified from a study entitled "*Don, Humber & Highland Creek Sanitary Trunk Sewer Capacity Analysis, Phase 1 – Existing (2001) Trunk Sewer Spare Capacity, June 2004*",

The per capita flow rates based on the monitored DWF will be compared with the TWPR, and the appropriate flow rates will be used in the InfoWorks model for the dry weather flow generations.

### *2.1.5 Physical Sewer Network Data*

The City of Toronto provided the study team with the physical system data for the combined, sanitary and storm systems. The information provided defines the collection system networks including pipe geometry such as size, invert, length and slope, as well as other relevant information such as material and construction date. In addition manhole data was provided and included data such as ground elevation and depth to invert. The information available from the collection system datasets (line and point) forms the basis for developing storm, combined and sanitary collection system models providing much of the necessary physical information.

The data (with the exception of 2 combined diversion weirs) provided does not identify special structures that may exist in the network. Examples of special structures include flow control structures such as super pipes for storage, and stormwater management facilities (SWMF). Figure 4.4 shows the locations of the diversion weirs/structures. (one weir is located within the LPN study area and the other one is located within the upstream drainage area north of the LPN study area.

### *2.1.6 Aerial/Ortho Photography*

The aerial photography provided includes the 2012 colour ortho images for the study area. The aerial information was found to be consistent with current land use. Reviewing the aerial information with current uses shows little identifiable change in the area that would have a material impact on the study. The aerial information is used as reference to assist in defining land use, particularly for parcels identified as unknown and for open space areas. This information, will be used to support model development and in the development of alternatives

### *2.1.7 Digital Elevation Model (DEM) and Topographical Mapping*

The City provided the following digital elevation model (DEM) information:

15-m grid point spacing with 16-bit pixel depth derived from 1:10,000 aerial ortho-photography.

The DEM has sufficient resolution to discriminate major drainage features such as surface ponding areas, high points, flow path and to define surface drainage area boundaries.

## 2.2 Group 2 Data

The City undertook to identify other relevant data for the LPN study area that may reside with District Staff or other agencies such as the Toronto Region Conservation Authority (TRCA) or Ministry of Natural Resources (MNR). The following sub-section presents a summary of Group 2 identified data which was compiled and reviewed.

### *2.2.1 Previous Studies*

Table 2.6 presents a summary of reference documents which were identified and are relevant to the LPN study area.

**Table 2.6 Previous Studies Relevant to Lawrence Park Neighbourhood Study Area**

| No. | Reports |
|---|---|
| 1 | Lawrence Study Area Findings & Recommendations Report, DM Robichaud Associates Limited, February 2008 |
| 2 | Wet Weather Flow Management Guidelines, City of Toronto, February 2006 |

The following is a brief summary of reports which related to LPN study area.

***Lawrence Study Area Findings & Recommendations Report, DM Robichaud Associated Limited, February 2008***

The objective of the Lawrence Study Area Findings & Recommendations Report was to provide recommended actions for existing storm and sanitary sewer infrastructure (i.e., manholes, sewers, catchbasins, and laterals). Provided below is a summary of existing infrastructure findings from the report.

- 4 Fog tests were conducted.
- 122 sanitary and 114 storm manholes were inspected;
- A total of 216 catchbasins were GPS'ed and basic inventory information were recorded;
- The field surveys/inspections found 1178 downspout discharge below grade;
- The sewer CCTV inspections summary stated that all the storm and sanitary sewers were cleaned and inspected with a CCTV inspection unit;
- A range from 200mm to 600mm concrete of main line storm sewers were notified;
- A range from 250mm to 300mm diameter concrete of main line sanitary sewers were notified;
- storm sewer laterals were not inspected; and
- 38 sanitary lateral inspections were attempted; the 26 laterals were fully inspected and the remainder were obstructed in some manner during the inspection.

The recommended actions are summarized in the following:

1. Repair all potential loss of service items;
2. Perform maintenance work to remove protrusions and calcite build-ups;
3. Perform other infiltration related repairs based on quantity of infiltration;
4. Follow the repair of the loss of service and structural issues identified in the sewer CCTV reports; and
5. Perform a review of the stormwater management system in the Lawrence area.

***Toronto Wet Weather Flow Master Plan, Area 4 - Don River Watershed, MMM Group, July 2003***

The goal of the Wet Weather Flow Management Master Plan was to develop a preferred strategy for managing wet weather flows in the City of Toronto. The Wet Weather Flow Master Plan recognizes rainwater as a potential resource to be used to improve the health of Toronto's water courses and near shore zones of Lake Ontario and to protect and enhance the natural environment of Toronto's watersheds. The goal of the Master Plan is to reduce and ultimately eliminate the adverse impacts of wet weather flow on built and natural environment in a timely and sustainable manner and to achieve a measurable improvement in the ecosystem health of the watershed.

The Master Planning process satisfies the Planning and Design Process of the Class Environmental Assessment for Municipal Water and Wastewater Projects. The study process included a systematic approach consisting of data collection to describe the existing conditions, target setting, a methodology for developing and evaluating alternatives, development and assessment of strategies, extensive public consultation, selection of preferred strategy and a description of the long term preferred strategy as well as the description of a 25 year implementation plan.

The Wet Weather Flow Master Plan for Area 4 affects Basement Blooding Area 20. Area 20 discharges directly to Don River. The Master Plan identified the several basement flooding areas in North York.

The Master Plan recommended strategy was Strategy 5 – Striving to Meet Enhanced Targets. The strategy includes a range of controls associated with source controls, conveyance, operations, channel improvements, public education, environmental monitoring and review, and end of pipe facilities. A more focused 25-year implementation strategy was adopted by the City in July 2003. In Basement Flooding Area 20 the 25-year implementation plan shows voluntary source control, conveyance controls in the vicinity of the basement flooding, a number end-of-pipe stormwater management ponds and infiltration devices, and stream restoration in Don River. The overall Wet Weather Master Plan 25-year implementation plan has allocated approximately $172 million[1] for Don River separated areas.

Recommendations associated with other end-of-pipe features will be considered when developing alternatives to identify where the City goals overlap in Basement Flooding Area 20.

[1] – Cost was adopted from "Wet Weather Flow Management Master Plan Study Area #4 - Don River – Presentation of Long Term Preferred Strategy & 25 Year Implementation Plan."

### *2.2.2 Historical Basement Flooding*

Figure 2.2 shows the locations of basement flooding reported to the City for two historical storm events in LPN study area. The events include May 12, 2000 and August 19, 2005. Out of approximately 1,300 properties in LPN study area, there were 16 reported basements flooded for the May 2000 event and a total of two reported flooded during the August 2005 event. There were no properties that reported flooding on both the May 2000 and August 2005 events. The centre of the August 19, 2005 event passed north of the LPN study area resulting in few reported flooding cases in the area in comparison to other parts of the City.

### *2.2.3 Historical Operation/Maintenance Records*

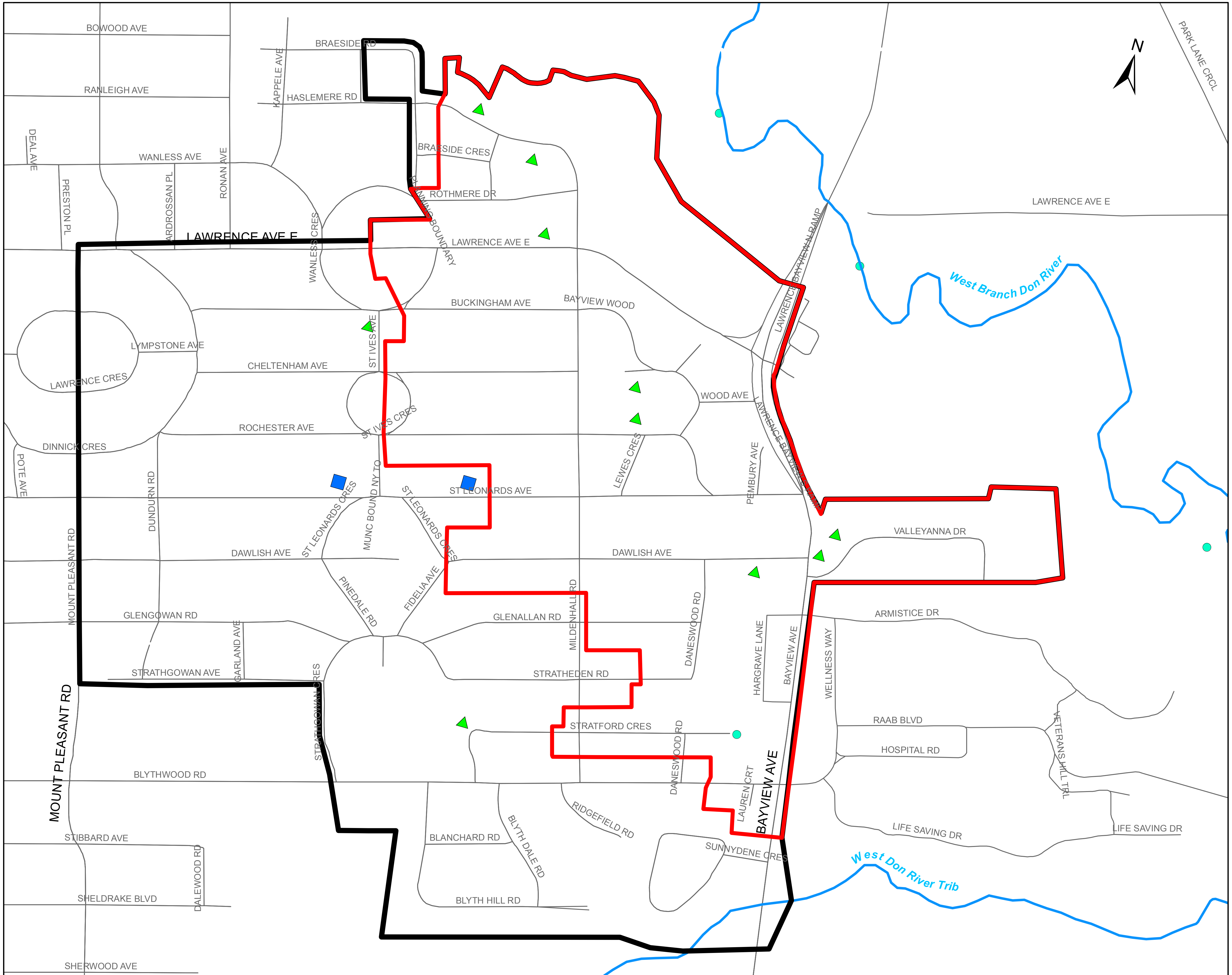
The operations and maintenance records within the LPN study area were provided by the City – Transportation Services. Based on the review of the records, the summary is provided in below.

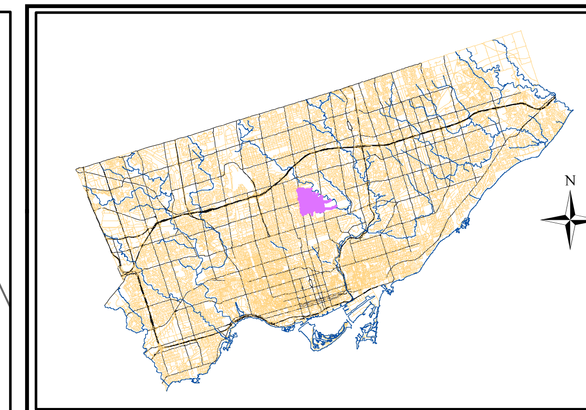
- Historical operations and maintenance records are summarized on a street by street basis.
- The types, drainage directions and construction dates of roads are recorded.
- The dates of maintenance and rehabilitation are also documented.

The operations and maintenance records are presented in Appendix C.

### *2.2.4 CCTV Records for the Past 10 Years*

District/City staff were contacted regarding CCTV inspection programs. Staff identified CCTV inspection as an ongoing program for the City. City crews and private contractors undertake CCTV inspections continuously. The frequency of CCTV inspection is typically driven by a complaint from residents, field observations from City staff that indicate a potential problem (i.e. blockage, grease build up), as part of a sewer investigation, in advance of road resurfacing, or when other utility work is being done in the area. It is the goal of District staff to have the entire sewer network surveyed citywide on a 15 year cycle. CCTV records are archived on tape.




LEGEND:

- Study Area 20 Sanitary Sewer Network Area
- LPN Study Area
- Flooding Incidents 12 MAY 2000
- Flooding Incidents 19 AUGUST 2005
- Watercourses
- Roads
- Storm Sewer Outfalls

NOTES:

Base Mapping was provided by the City of Toronto

400 200 0 Meters

TORONTO

Aquafor Beech Limited

**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Basement Flooding Historical Records**

**FIGURE No. 2.2**

**DATE: SEPTEMBER 2013**

Figure 2.3 shows the available CCTV records in 2008 for the sanitary system for LPN study area. In addition, figure 2.4 shows the available CCTV records (City's Sewer Asset Planning Unit's database) for the storm, combined and sanitary systems for LPN study area.

The CCTV documentation/reports were available for review within Lawrence Park Neighbourhood area. The reports were generated from CCTV conducted as part of a 2008 study as well as from the City's Sewer Asset Unit's database.

### *2.2.5 Smoke-Test/Dye Test Results*

Historically Smoke/Dye testing has been undertaken by the City to address operation and maintenance issues as required. This investigation technique has been used in response to basement flooding events in the area and in support of engineering reports prepared by staff or consultants on behalf of the City. This investigative technique is also used by the City to identify cross connections if they are suspected.

There is no program of routine smoke testing while historical downspout dye testing records (2003 – 2004) are available for Basement Flooding Area 20 within the LPN study area Figure 2.5 (provided by the City in PDF file format) shows the locations and results of dye testing for Area 20.

### *2.2.6 Sewer System Design Criteria at the Time of Construction*

Historical design criteria for the former cities of Toronto and North York were not available.

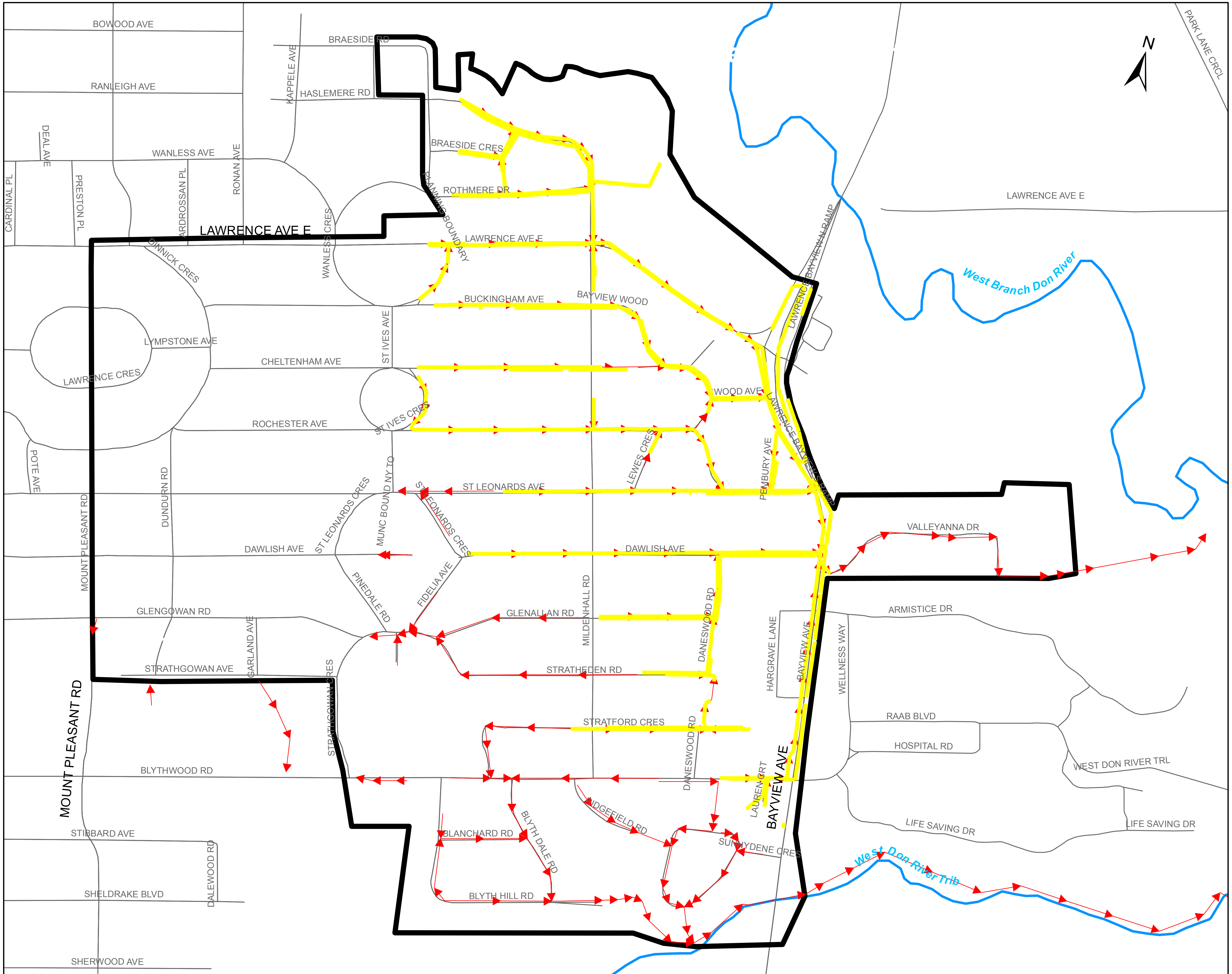
### *2.2.7 Sewer Use By-Law at the Time of Construction (House Connection)*

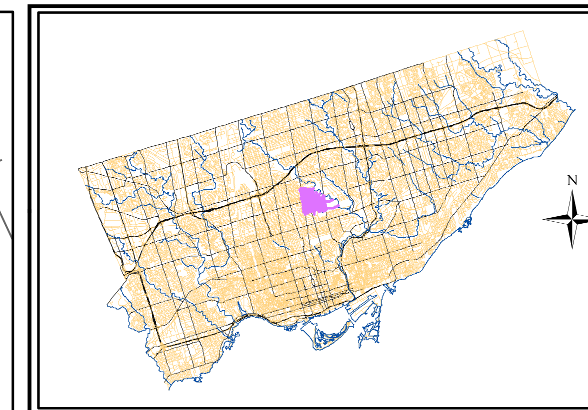
A memorandum dated September 12, 1991 from the former city of North York indicated that the connection policy for house foundation drains was to connect them to the sanitary sewer prior to 1991. The memo also stated that "Effective September 1, 1991 the Ontario Plumbing Code (O. Reg. 401/91) requires that all foundation drains be connected to the storm sewer system, if this is available. If a storm sewer is not available on the street, the foundation drains are to be pumped above ground, on private property."

**Foundation Drains**

Over 90 plumbing records/drain cards were provided by the City for the LPN study area. Table 2.7 presents a summary of the connections cards requested from the City for review of 14 properties within the Area 20. The properties were selected to provide a cross section of connection types associated with proposed borehole locations within the LPN study area. Figure 2.6 shows the proposed 6.0m depth borehole locations associated with available drain plan/cards and CCTV reports information.

Properties developed prior to 1991 appear to have weeping tiles/foundation drains connected to the sanitary system. Some of the connection cards do not show clearly storm connections.



LEGEND:

- LPN Study Area
- Watercourses
- Roads
- CCTVed in 2008
- Sanitary Sewer

NOTES:

Base Mapping was provided by the City of Toronto

400 200 0 Meters

TORONTO

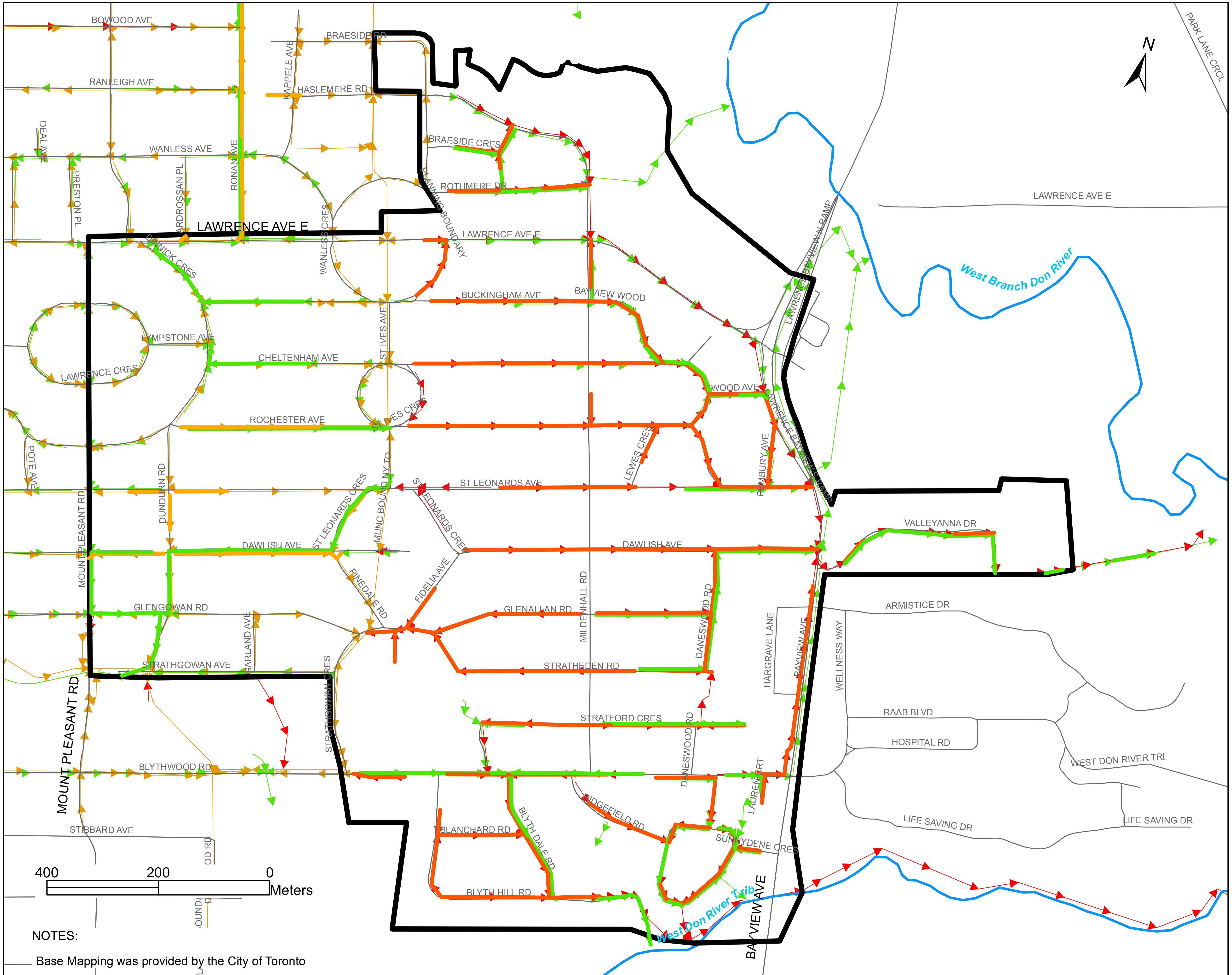
Aquafor Beech Limited

**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**HISTORICAL CCTV INSPECTIONS SANITARY SEWERS (2008)**

**FIGURE No. 2.3**

**DATE: SEPTEMBER 2013**

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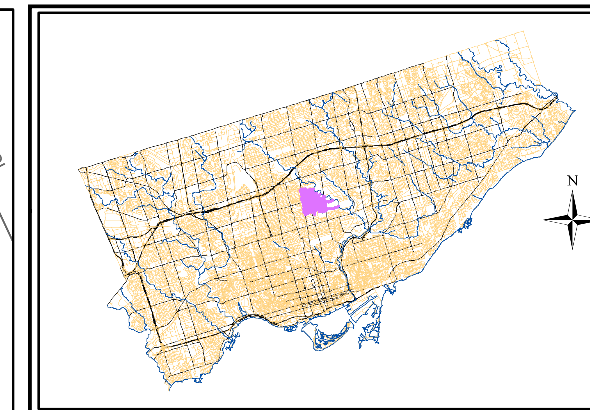


LEGEND:

- LPN Study Area
- Watercourses
- Roads

**CCTVed Sewer**

**FLOW_TYPE**

- Combined Sewer
- Sanitary Sewer
- Storm Sewer
- Sewer_Move

**Sewers**

**FLOW_TYPE**

- Combined Sewer
- Sanitary Sewer
- Storm Sewer

TORONTO

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**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA HISTORICAL CCTV INSPECTIONS STORM/COMBINED/SANITARY RECORDS**

**FIGURE No. 2.4**

**DATE: SEPTEMBER 2013**

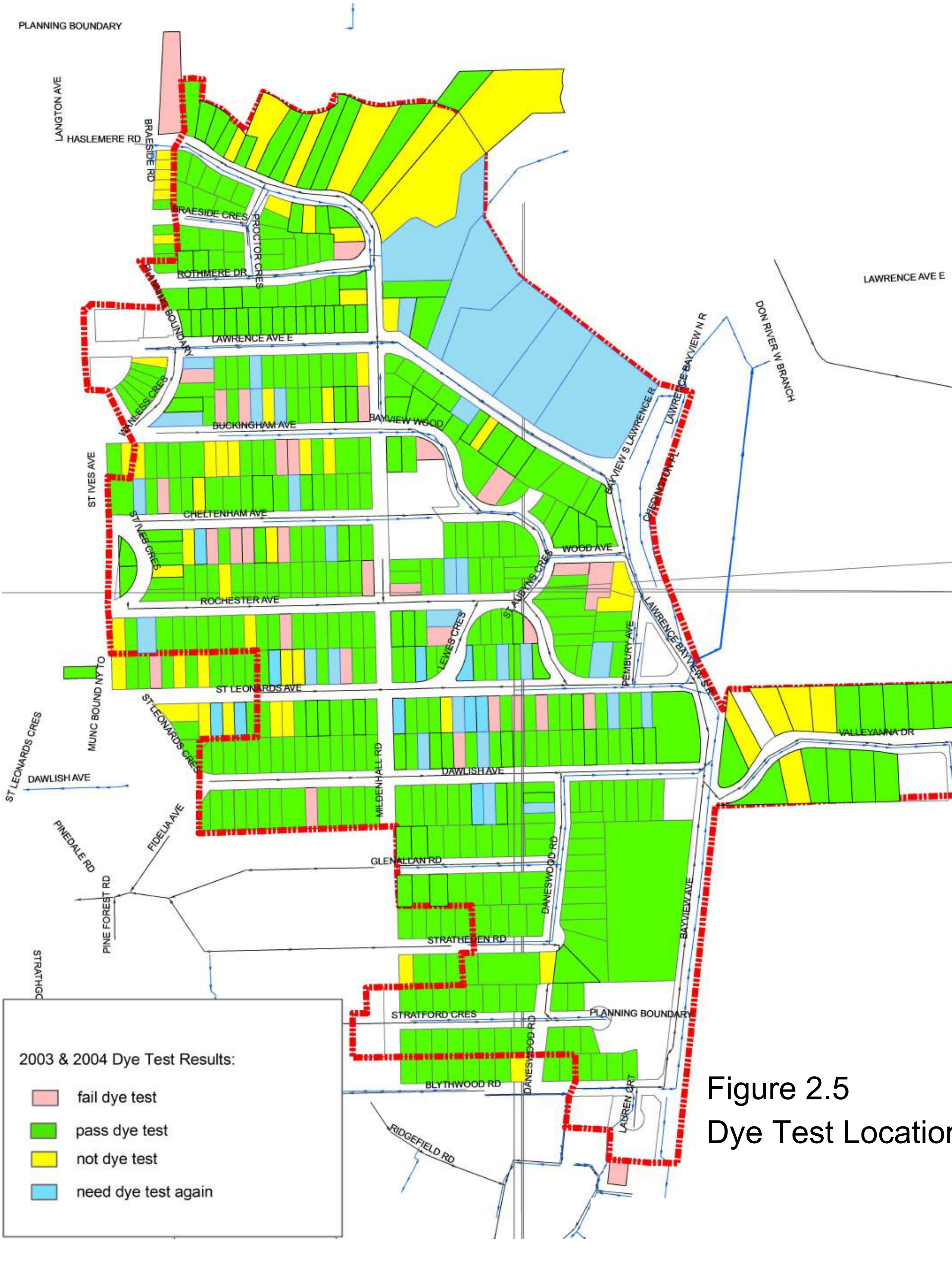



Figure 2.5
Dye Test Locations

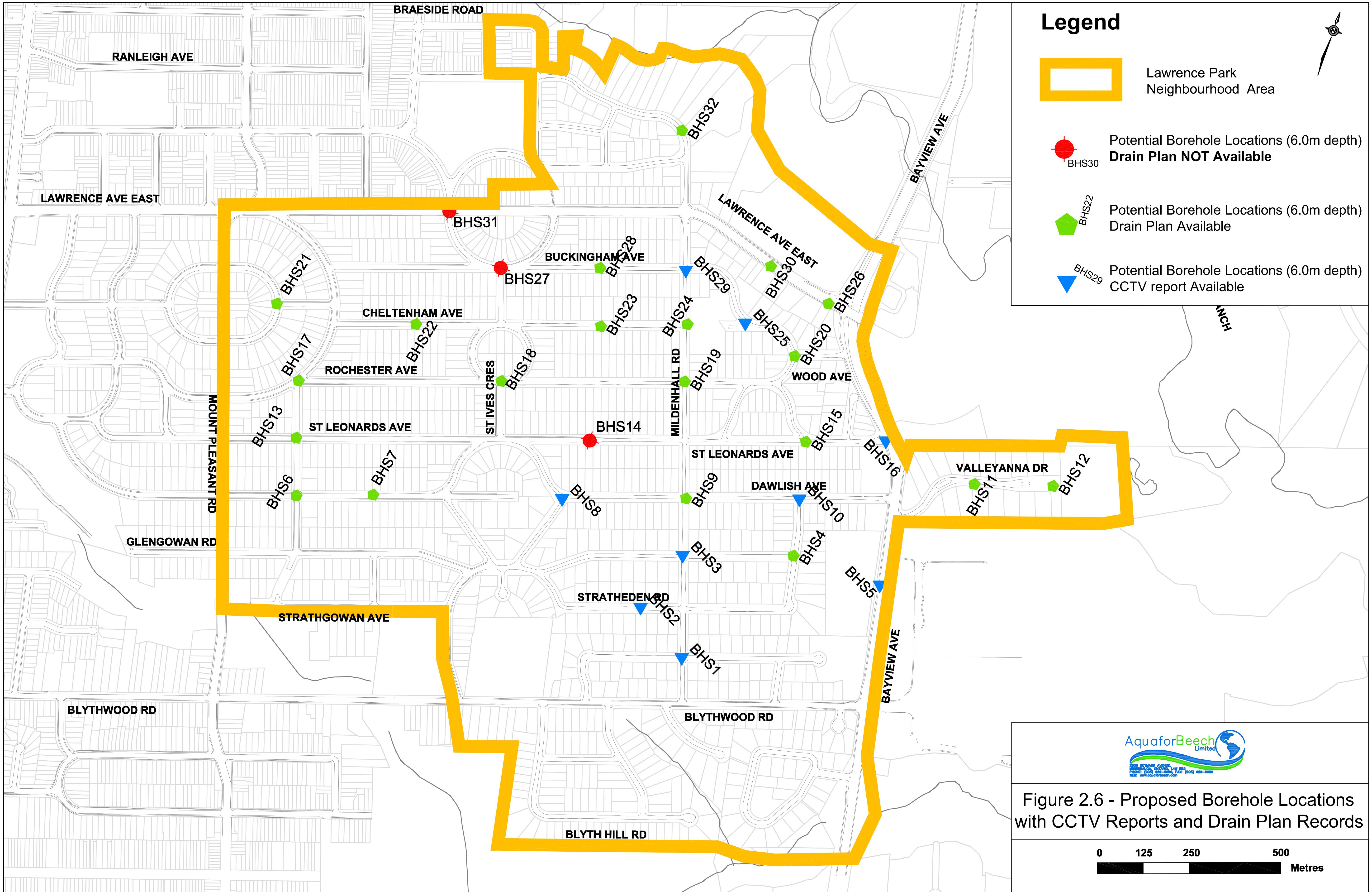



Figure 2.6 - Proposed Borehole Locations with CCTV Reports and Drain Plan Records

Some of the connection cards included historical service calls and the actions taken.

The majority of service calls involved blockage of service laterals. Other investigative work was noted where dye testing was done and recorded (See Section 2.2.5).
Based on the review of available records it is assumed the former city of North York connection policy for house foundation drains being connected to the sanitary sewer prior to 1991 reflects the actual connection practice of the time. After 1991 it has been assumed that reconstructed homes are such that only the domestic sewage component discharges to the sanitary sewer system (i.e. the foundation drain & any directly connected downspouts, are not connected to the sanitary sewer).

### Table 2.7 Connection Cards Requested

| Map Id | Address | System Age | Connection Record Review |
|---|---|---|---|
| Former city of North York | | | |
| BHS4 | 44 Glenallan Rd. | N/A | W to Sanitary, storm lateral shown |
| BHS9 | 263 Dawlish Ave. | N/A | W to Sanitary, No storm lateral shown |
| BHS11 | 5 Valleyanna Dr. | 1960 | W to Sanitary, storm lateral shown |
| BHS12 | 12 Valleyanna Dr. | 1961 | W to Sanitary, storm lateral shown |
| BHS15 | 275 St. Leonards Ave. | N/A | W to Sanitary, no storm lateral shown |
| BHS18 | 2 St Ives Cres. | 1924 | Inconclusive Appears W to Sanitary, Originally Septic tank shown at the back of dwelling |
| BHS19 | 154 Rochester Ave. | 1961 | Inconclusive Appears W to Sanitary, No storm lateral shown |
| BHS20 | 9 Wood Ave. | 1960 | Inconclusive Appears W to Sanitary, No storm lateral shown |
| BHS23 | 118 Cheltenham Ave. | N/A | Inconclusive Appears W to Sanitary and Storm |
| BHS24 | 138 Cheltenham Ave. | 1960 | Inconclusive Appears W to Sanitary, No storm lateral shown |
| BHS26 | 321 Lawrence Ave East | N/A | Inconclusive Appears W to Sanitary, No storm lateral shown |
| BHS28 | 124 Buckingham Ave. | N/A | Inconclusive Appears W to Sanitary, No storm lateral shown |
| BHS30 | 299 Lawrence Ave East | 1984 | W to Sanitary, no storm lateral shown |
| BHS32 | 111 Mildenhall Rd. | 2006 | Permit Renewed. W to Sanitary, no storm lateral shown |
| **Notes:**<br>W = Weeping Tile/Foundation Drains | | | |

### 2.2.8 Natural Surface Water Drainage before Development

Lawrence Park Neighbourhood (LPN) study area drains toward the West Don River. Bayview Avenue is a physical barrier to the natural drainage which was overcome by piping stormwater under the road east to the West Don River. The drainage area south of Blythwood Road drains to Burke Brook which is a tributary of West Don River.

### 2.2.9 Hydrogeotechnical Report for Groundwater Conditions

Terraprobe Limited was retained to conduct a desktop hydrogeological assessment of LPN study area.

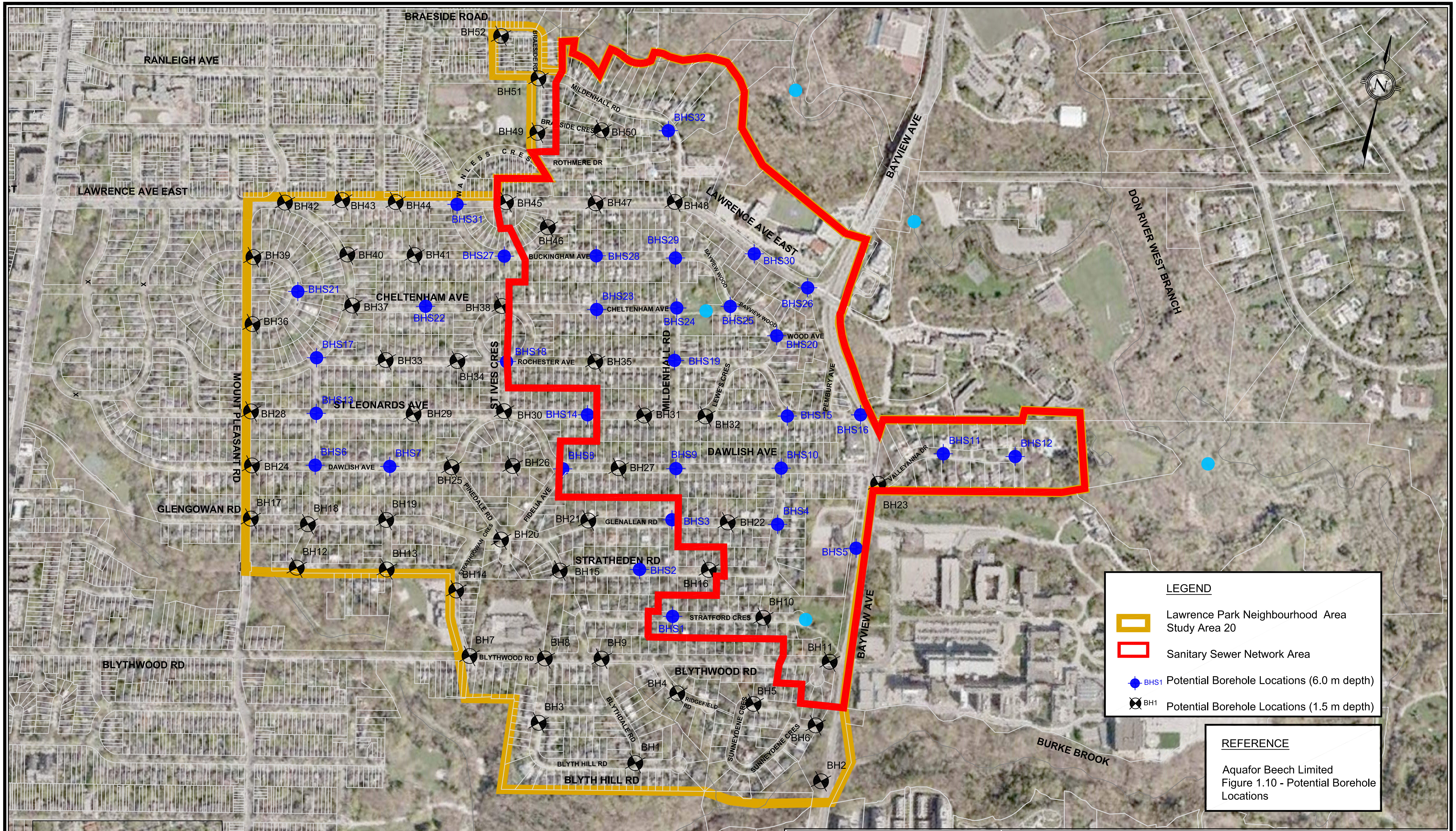
There are 52 (1.5m depth) and 33 (6.0m depth) proposed boreholes to be undertaken for LPN study area. Figure 2.7 shows the locations of the proposed boreholes. From discussion with Terraprobe staff, their assessment/final report was available in December 2013.

Groundwater elevations based on the City's borehole database indicate that the elevations range from approximately 175 m above mean sea level (AMSL) to 110 m AMSL. Overall, the direction of horizontal groundwater flow is towards the east, with some flow towards the West Don River.

### 2.2.10 Sewer System Improvements

Improvements to the combined, sanitary and storm systems are defined as any modifications or additions to the system since the original systems were installed. System changes were identified by comparing the neighbourhood age with infrastructure age (sanitary, combined and/or storm) to identify where the systems have been altered.

Based on the past 10 years of records/drawings it would not seem that any combined/sanitary/storm sewer improvements have been made.




Terraprobe
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title: BOREHOLE LOCATION PLAN

File No. 11-12-2126

FIGURE : 2.7

# 3.0 FIELD SURVEY

A field survey of the study area was conducted in the fall/winter of 2012. The object of the survey was to visually inspect each property from the street to determine where the roof downspouts discharge (underground or surface). The survey was also used to identify properties with reverse sloping driveways and document catchbasin types. The survey identified any features in the study area that may be important to overland flow paths as well as opportunities to manage surface flows.

## 3.1 Methodology

Aquafor staff undertook a field survey for the LPN Study Area by walking and driving the entire area. The area surveyed included all houses located within the study area boundaries as presented in the RFP. The field survey was completed by January 2013.

The purpose of the field survey was to confirm the characteristics of the study area which will assist in the development and calibration of the InfoWorks hydraulic models that will be used to assess the wastewater collection system and storm drainage system.
The field survey comprised of a walkthrough of the neighbourhoods to document observations and to compile statistics on the following:

- Downspout connections
    - Connected (all downspouts discharge into the ground),
    - Partially connected (some of the downspouts discharge to the surface while others discharge into the ground),
    - Disconnected (all downspouts discharge to surface),
- Low points where surface ponding may occur,
- Reverse Slope driveways, and
- Catchbasin types and location of double CBs.

## 3.2 Downspout Connections

Table 3.1 presents a summary of the field surveys identifying the percentage of connected, partially connected and disconnected properties for LPN study area.

**Table 3.1 Downspout Connection Statistics**

| Parameter | LPN Study Area (# of Units) | Percentage of Total (%) |
|---|---|---|
| 100% Connected Downspouts | 615 | 48 |
| 100% Disconnected onto Ground | 368 | 29 |
| 100% Disconnected to Driveway | 126 | 10 |
| 100% Disconnected to Backyard | 40 | 3 |
| Partially Disconnected onto Ground | 60 | 5 |
| Partially Disconnected to Driveway | 29 | 2 |
| Partially Disconnected to Backyard | 3 | 0 |
| Unknown | 48 | 4 |
| Total Units Observed | 1289 | 100 |

A review of Table 3.1 indicates that approximately 55% of the households are still connected or partially connected to the sewer system. Figure 3.1 summarizes the downspout connectivity for LPN study area.

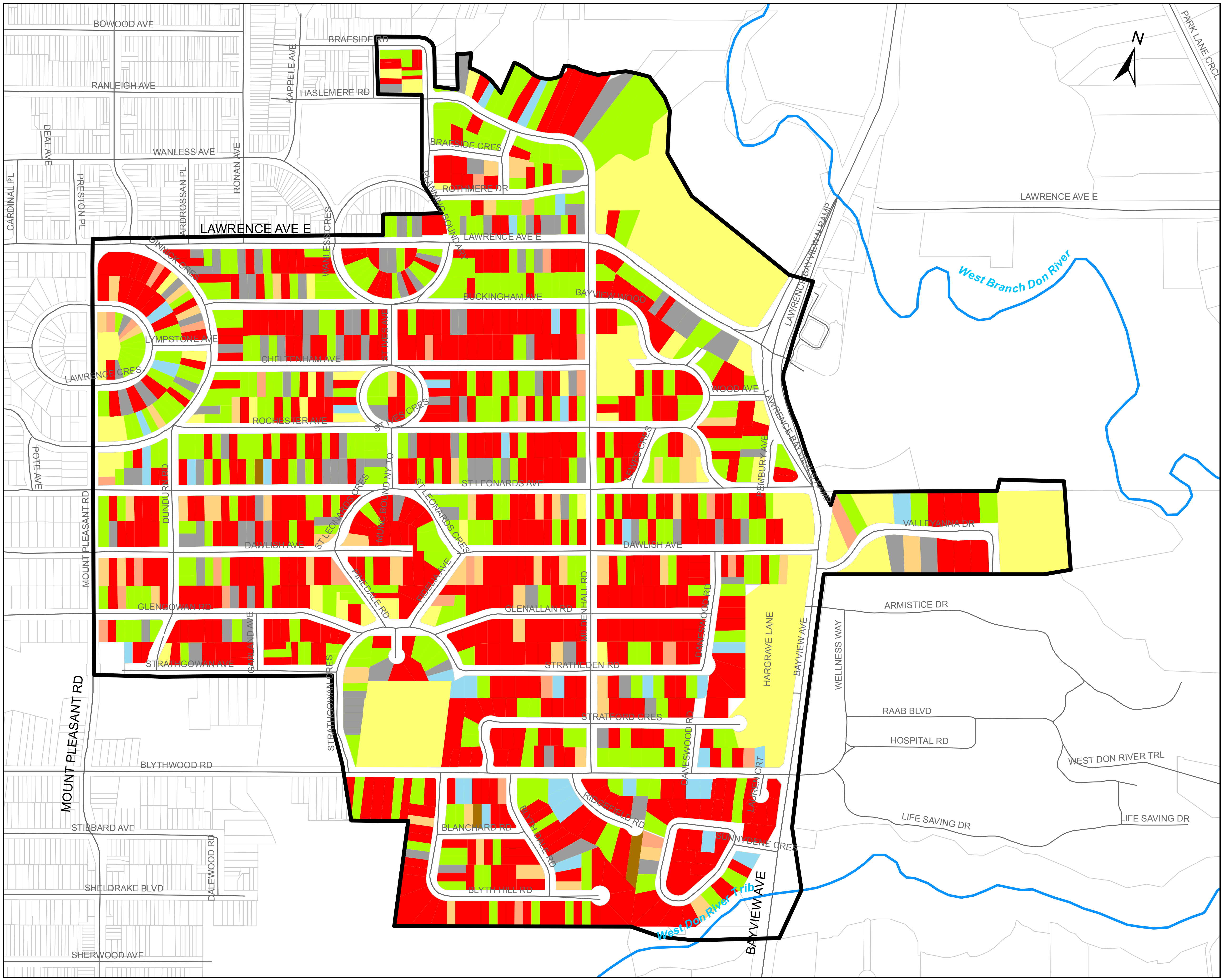
## 3.3 Surface Drainage

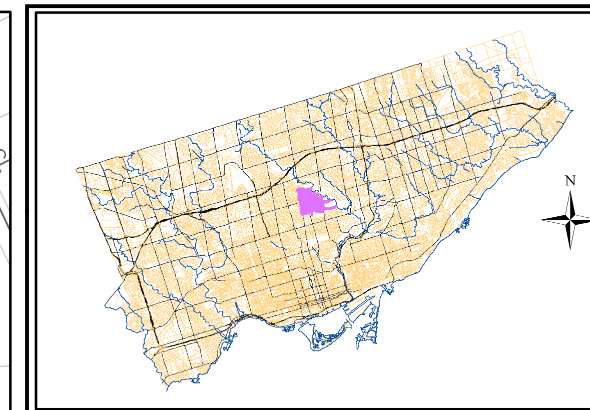
Topography across the study area group generally dips from the northwest to the southeast and towards the West Don River. Based on the digital elevation model for the LPN study area, the ground surface elevation ranges from approximately 176 m to 126 m above mean sea level, with the exception of areas near the West Don River which are situated at elevations of approximately 110 m AMSL.

Generally, the majority of the study area group flows toward the West Don River, with Area 20 entering from the west side. Area 20 is tributary to West Don River, with approximately the whole of Area 20 entering West Don River directly via the drainage network running parallel to Lawrence Avenue East.

From the field survey, low lying areas were identified as well as low points within the roadway where there may be potential for ponding. Direction of flow for the overland system was determined as best as possible. Any special drainage features were documented such as roadside ditches that are located within the LPN study area.

The locations of roadside ditches are shown in Figures 4.2 as part of the storm sewer system.



LEGEND:

- LPN Study Area
- Watercourses
- Roads

**Surveyed Parcels**

**CONNECTION**

- 100% Connection
- 100% Disconnected onto Ground
- 100% Disconnected to Driveway
- 100% Disconnected to Backyard
- Partially Disconnected onto Ground
- Partially Disconnected to Driveway
- Partially Disconnected to Backyard
- Unknown

NOTES:

Base Mapping was provided by the City of Toronto

400 200 0 Meters

TORONTO

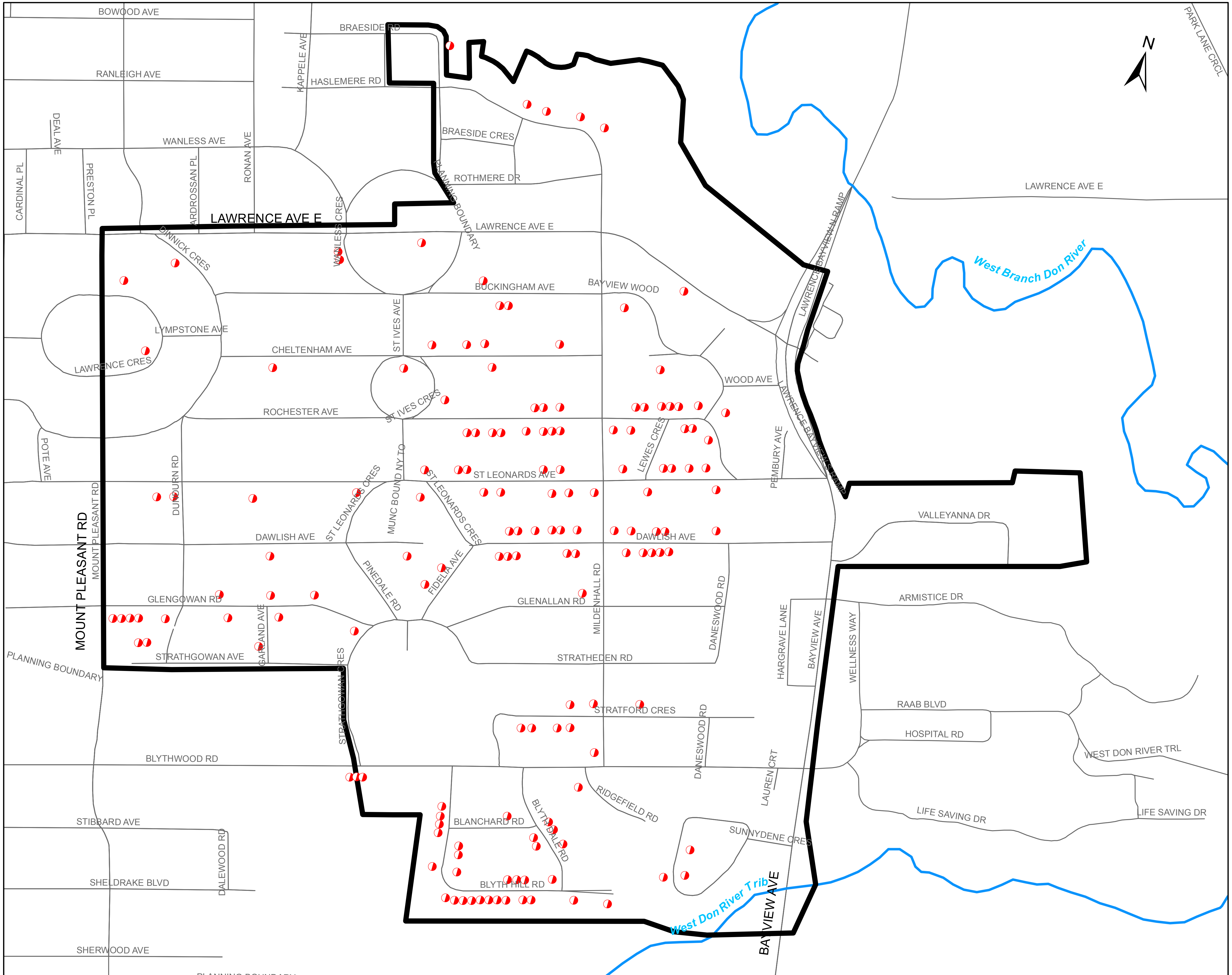
Aquafor Beech Limited

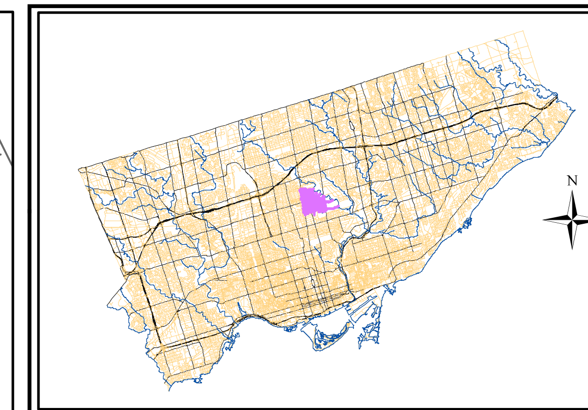
**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Downspout Connectivity**

**FIGURE No. 3.1**

**DATE: SEPTEMBER 2013**



LEGEND:

- LPN Study Area
- Reverse Slope Driveways
- Watercourses
- Roads

NOTES:

Base Mapping was provided by the City of Toronto

400 200 0 Meters

TORONTO

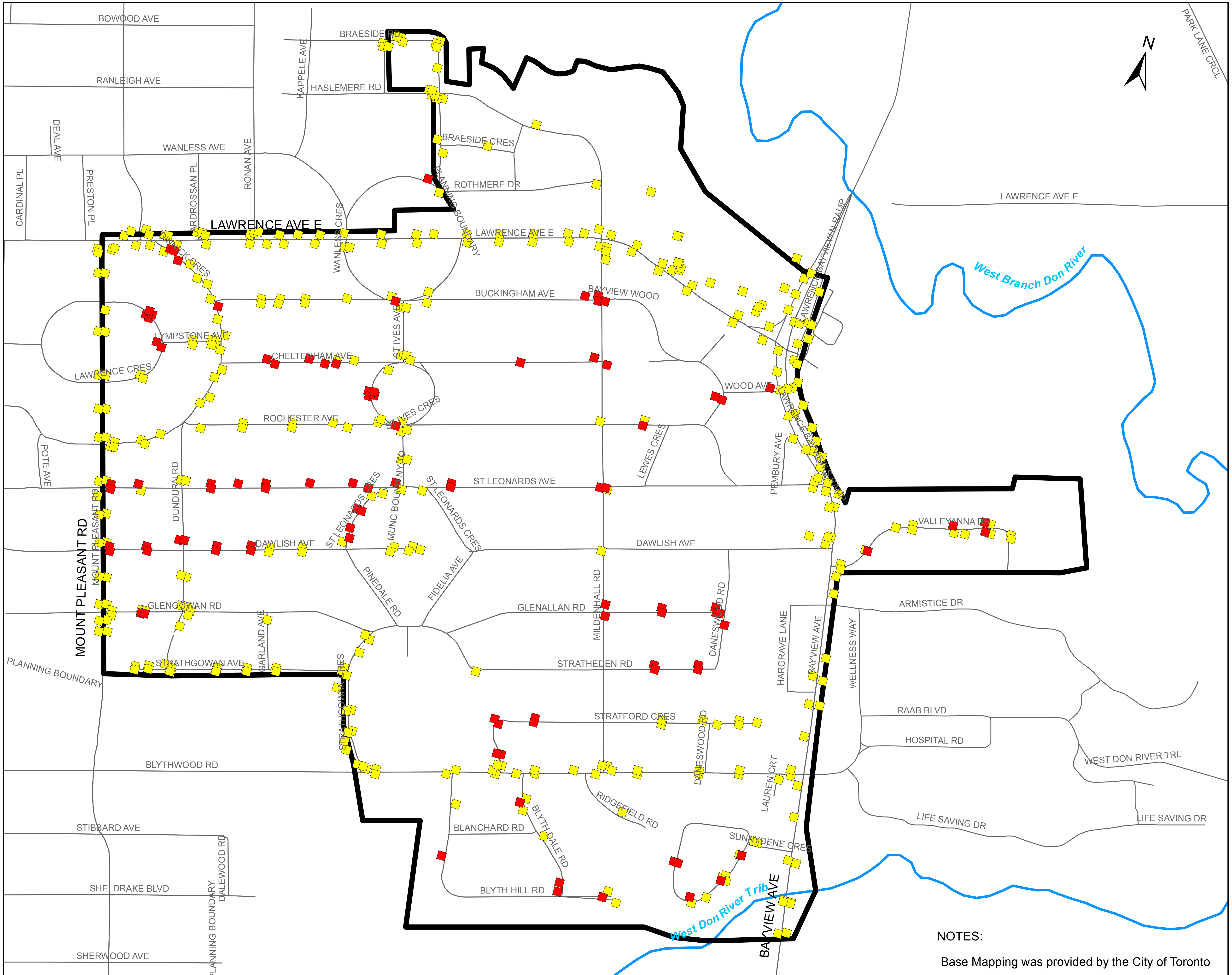
Aquafor Beech Limited

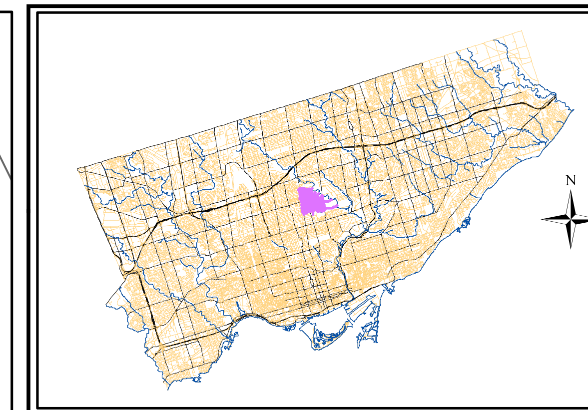
**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Properties with Reverse Slope Driveways**

**FIGURE No. 3.2**

**DATE: SEPTEMBER 2013**



LEGEND:

- LPN Study Area
- Watercourses
- Roads

**CatchBasin**

**Type**

- Herring Bone
- Bird Cage
- Parallel Slot

400 200 0 Meters

TORONTO

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**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Catchbasin Locations**

**FIGURE No. 3.3**

**DATE: SEPTEMBER 2013**

## 3.4 Reverse Slope Driveways

Table 3.2 presents a summary of the statistics for reverse slope driveways within LPN study area.

### Table 3.2 Reverse Slope Driveway Statistics

| Parameter | LPN study area (# of Units) | Percentage of Total (%) |
|---|---|---|
| Number of Reverse Driveways | 155 | 11.3 |
| Total Units Observed | 1369 | 100 |

Figure 3.2 identifies the locations of properties with reverse slope driveways within the study area.

## 3.5 Catchbasins

Table 3.3 presents a summary of the statistics related to the catchbasin types observed in the study area.

### Table 3.3 Catchbasin Type Statistics

| (Parallel Slot Grate) | OPSD 400.01 (Herring Bone Grate) | OPSD 400.121 (Bird Cage Grate) |
|---|---|---|
|  |  |  |
| **99** | **367** | **1** |
| 21% | 79% | 0% |

Figure 3.3 shows the catchbasin locations for the LPN study area based on the field survey.

# 4.0 ASSESSMENT OF THE STORM SEWER SYSTEM

## 4.1 Data Gaps

The database of the storm sewer system provided by the City was reviewed in detail. Data gaps were identified, which could be classified into the following categories:

- Isolated manholes not connected to the network;
- Isolated storm sewers not connected to the system;
- Missing manhole ground surface elevations; and
- Missing pipe information such as pipe geometry, diameter and/or invert elevations.

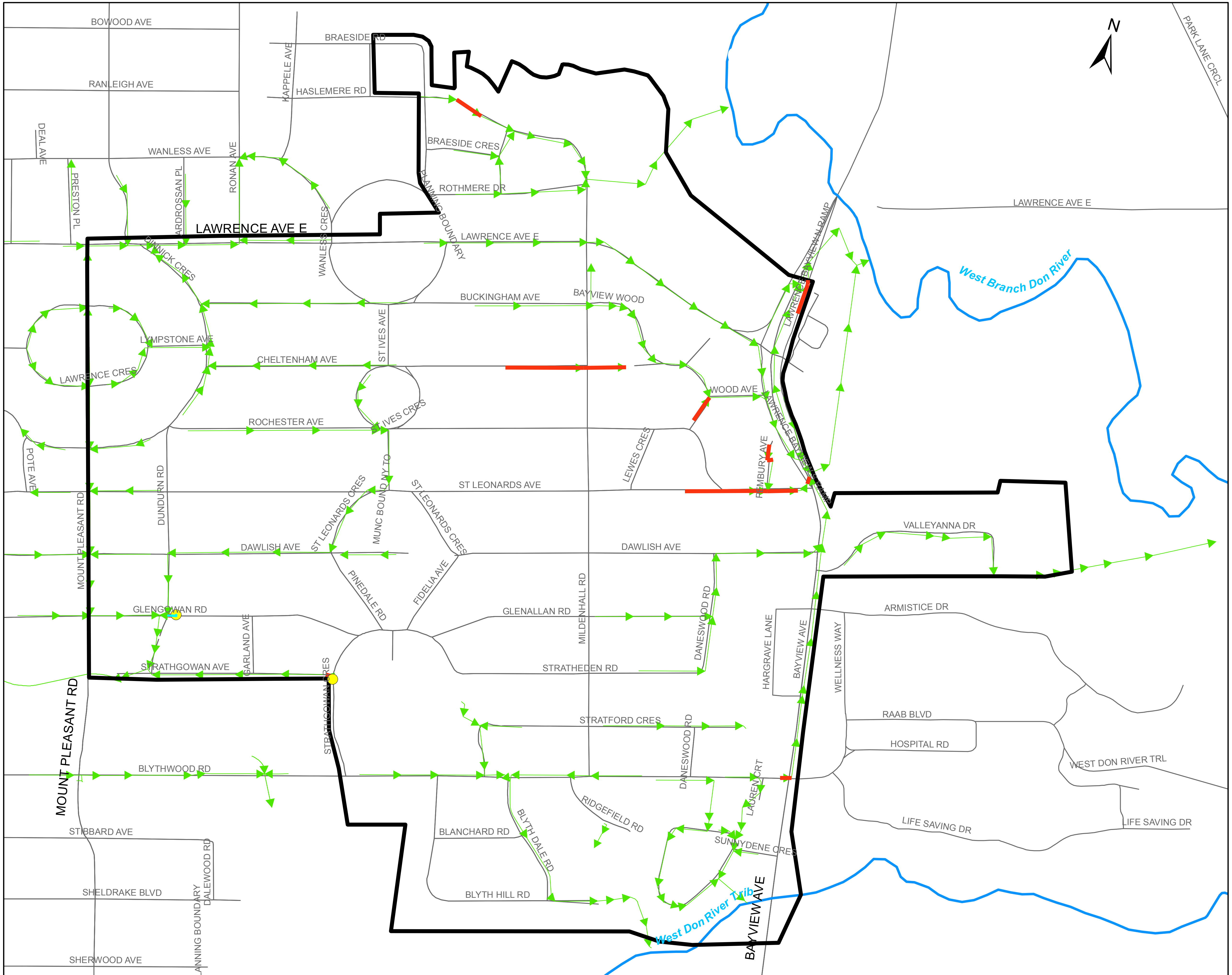
Figure 4.1 presents the missing information identified in the database for the storm sewer system.

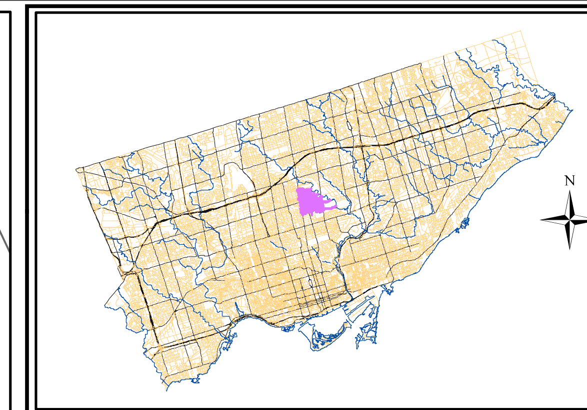
Most of all manhole elevations for the study areas were provided. However, 16 pipes in the storm sewer network were affected by the gaps in the database.

Most of the gaps were filled using the digital sewer plan and profile drawings available provided by the City. When no information was available, the missing information was inferred using the InfoWorks model inference tool. The following assumptions were also considered to complete the sewer network model:

- Missing pipe inverts that could not be inferred by the InfoWorks inference tool were assigned inverts based on the average slope of pipe up and downstream of the missing inverts.
- Physical sewer connections that did not have a manhole at the connection point (i.e. private property sewers or laterals connected to collectors) were connected in the model using a dummy manhole.
- Connection of backyard, and private property catchbasins was considered by modelling a 250 mm sewer with 1% slope and catchbasin at the upstream end.

The data gap analysis associated with link information, such as missing pipe inverts for the storm system is summarized in Appendix A.




LEGEND:

- LPN Study Area
- Watercourses
- Roads
- Missing Manhole Ground Elevation
- Missing Pipe Information
- Storm Sewer

NOTES:

Base Mapping was provided by the City of Toronto

400 200 0 Meters

TORONTO

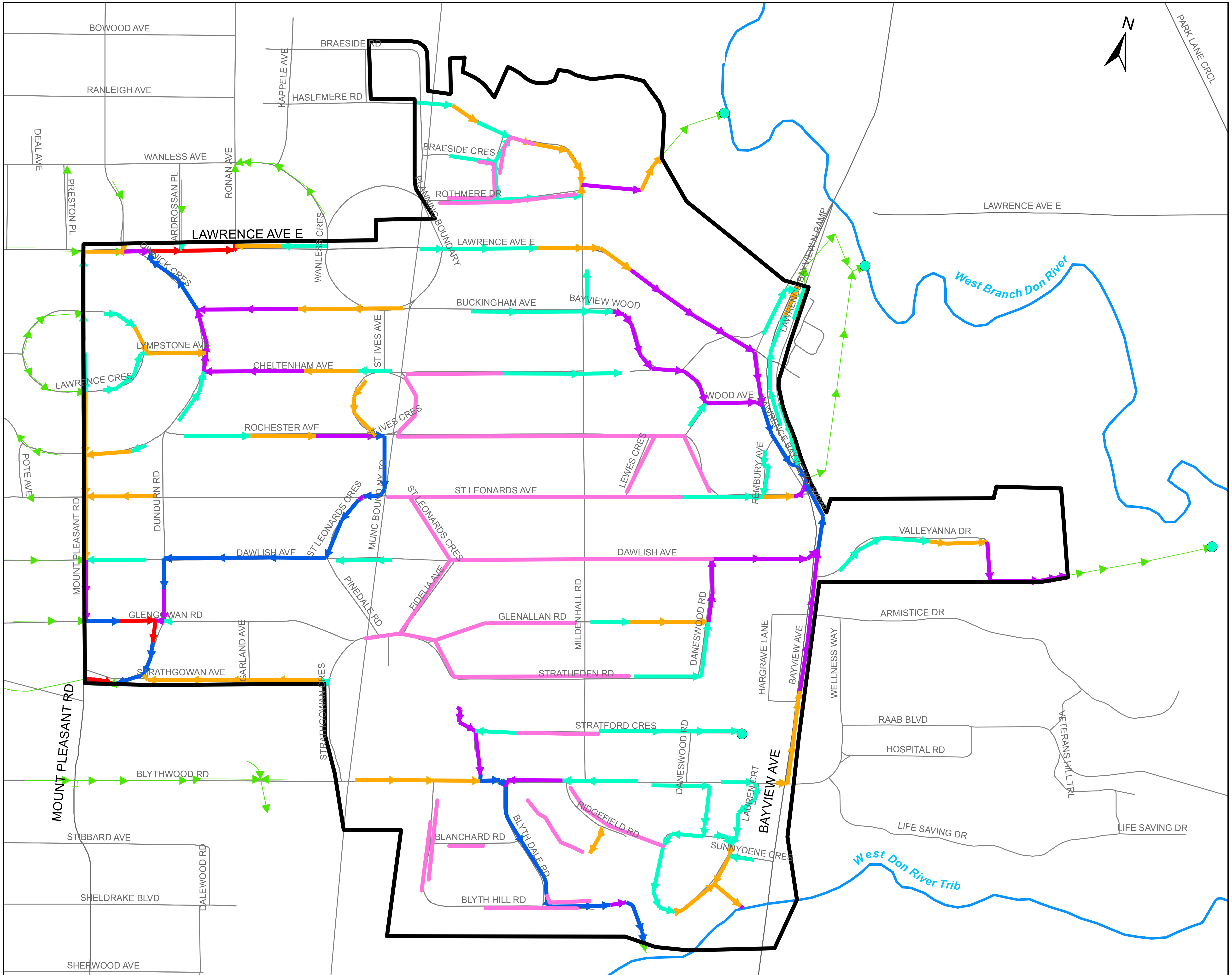
Aquafor Beech Limited

**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Storm Data Gaps**

**FIGURE No. 4.1**

**DATE: SEPTEMBER 2013**




LEGEND:

- LPN Study Area
- Storm Sewer Outfall
- Storm Sewer
- Watercourses
- Roads

**Storm Pipe Diameter (mm)**

- 200 - 300
- 300 - 450
- 450 - 750
- 750 - 1200
- 1200 - 2100
- Ditches

NOTES:

Base Mapping was provided by the City of Toronto

TORONTO

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**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Storm Drainage Minor System and Pipe Sizes**

**FIGURE No. 4.2**

**DATE: SEPTEMBER 2013**

### 4.2 System Characteristics and Storm Drainage Area Boundary

Figure 4.2 presents the service boundary of the storm service area. The figure also shows the range of pipe sizes identified in the LPN study area as well as outfall locations. The figure also indicates the ditch locations within the road right-of-way in the study area. The 160 ha LPN study area consists of approximately 1300 properties. The LPN study area is primarily single-family detached residential landuse developed in the 1920's to 1940's. A significant percentage of the houses have been renovated or torn down and rebuilt. The storm drainage system for the study area drains to the West Don River.

There are approximately 240 storm pipes within the storm service boundary of the LPN study area. All the pipes are either circular or rectangular and range in diameter from 200 mm to 2100 mm. A majority of the streets in the study area are serviced by a storm sewer system. These storm sewers discharge to the receiving watercourses via storm sewer outfalls.

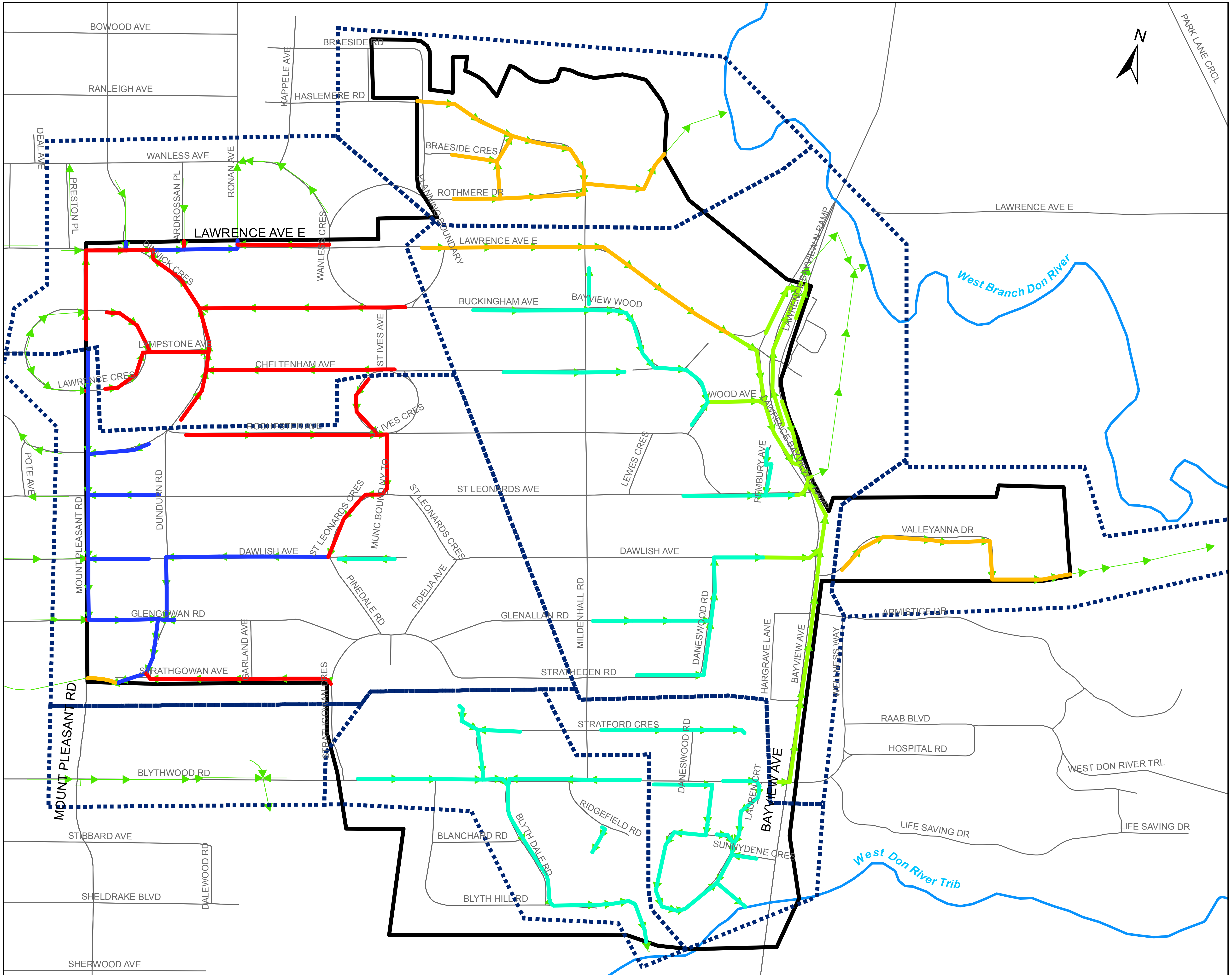
A portion of the LPN study area has ditch drainage along the road right-of-way instead of standard curb and gutter which is typically found in urban residential neighbourhoods. There is approximately 5 kilometres of ditches which collect storm flow, discharge to several common ditch inlets, and ultimately into the City's storm system. Table 4.1 presents information on the storm system characteristics for the LPN study area. Figure 4.3 presents the age of the storm sewer system for the LPN study area.

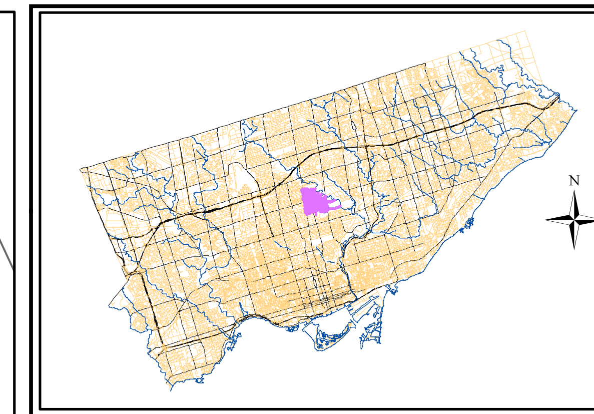
The DEM with break lines was used to define major system (overland) flow drainage features such as surface drainage flow paths and drainage area boundaries. Figure 4.4 presents the overland flow paths for the LPN study area.

There are no stormwater management facilities in the study area as indicated in the sewer infrastructure data.

**Table 4.1 Storm System Characteristics**

| Study Area | Service Area (ha) | Number of Storm Pipes | Pipe Length by Size | Pipe Age | Length of Ditches (km) | Number of Outlets |
|---|---|---|---|---|---|---|
| Lawrence Park Neighbourhood | 160 | 238<br>(14,094.9 m) | 200-300: 84 (4,888.6 m)<br>301-450: 58 (3,552.4 m)<br>451-750: 35 (3,166.6 m)<br>751-1200: 52 (1,542.4 m)<br>1201-2100: 9 (945.9m) | 1946-1949: 81 (4,365.3m)<br>1950-1952: 17(1,068.8m)<br>1953-1961: 55 (3,432.0m)<br>1962-1979: 30(1,943.4m)<br>1980-1983: 55(3,285.4m) | 5 | 7 |




LEGEND:

- LPN Study Area
- Watercourses
- Roads
- Storm Sewer
- Boundaries of Storm Service

**Storm Pipe Age**

- 1946 - 1949
- 1950 - 1959
- 1960 - 1969
- 1970 - 1979
- 1980 - 1989

NOTES:

Base Mapping was provided by the City of Toronto

400 200 0 Meters

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Aquafor Beech Limited

**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Storm System Age**

**FIGURE No. 4.3**

**DATE: SEPTEMBER 2013**

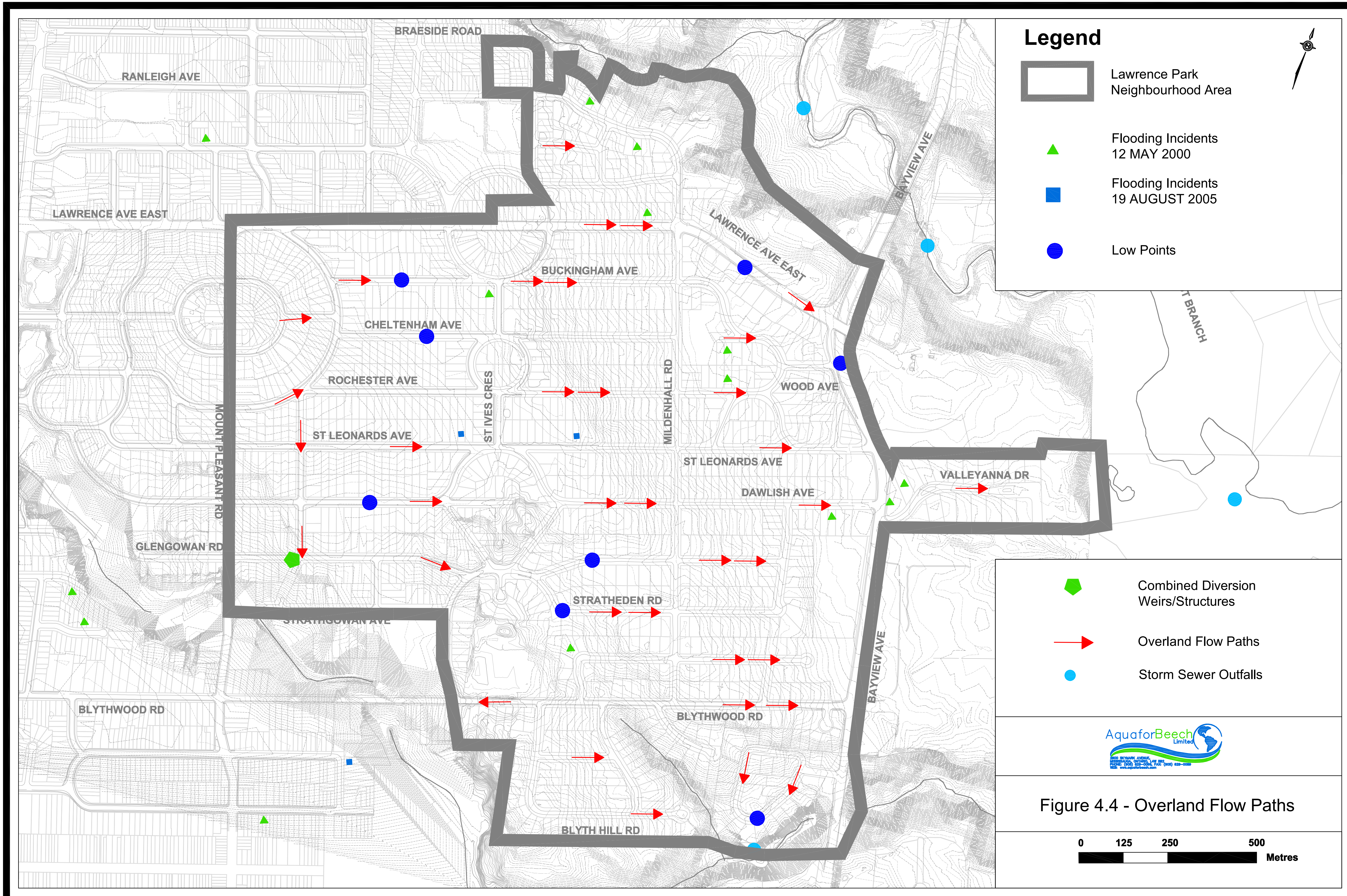



Figure 4.4 - Overland Flow Paths

# 5.0 ASSESSMENT OF SANITARY SEWER SYSTEM

## 5.1 Data Gaps

The database of the sanitary sewer system provided by the City was reviewed in detail. Data gaps were identified, which could be classified into the following categories:

- Isolated manholes not connected to the network;
- Isolated sanitary sewers not connected to the system;
- Missing manhole ground surface elevations; and
- Missing pipe information such as pipe geometry, diameter and/or invert elevations.

Figure 5.1 presents the missing information identified in the database for the sanitary sewer system.

Most of all manhole elevations for the study areas were provided. However, 6 pipes in the sanitary sewer network were affected by the gaps in the database. Most of the gaps were filled using the digital sewer plan and profile drawings provided by the City. Similar to the storm system when no information was available, the missing information was inferred using the InfoWorks model inference tool.

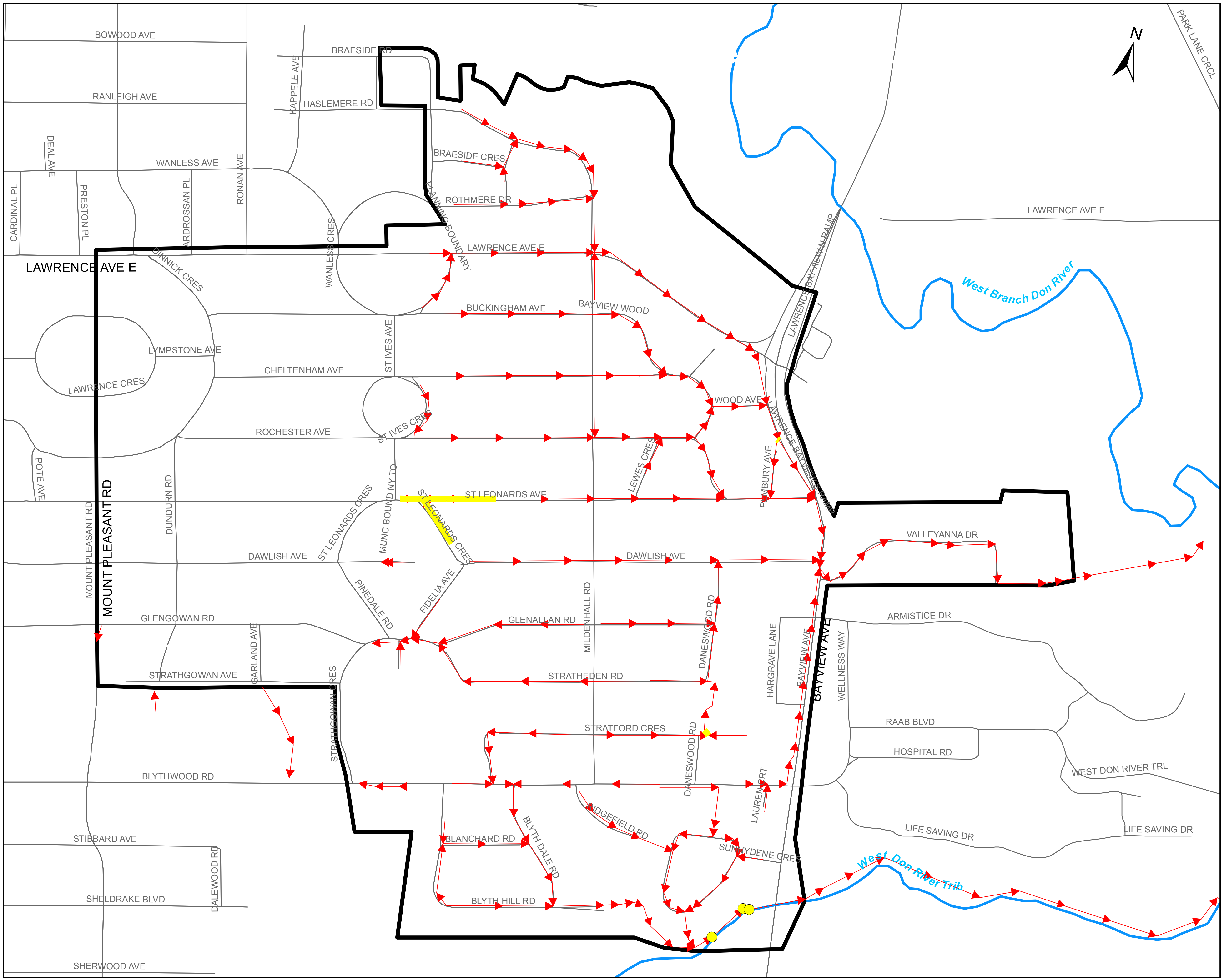
The data gap analysis associated with link information such as missing pipe inverts for the sanitary system is summarized in Appendix A.

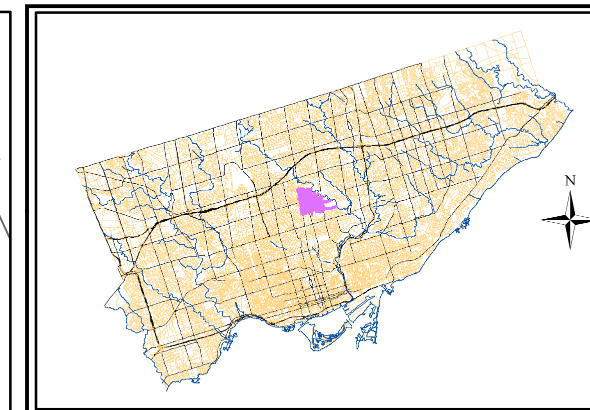
## 5.2 Sanitary Sewer Characteristics and Sanitary Drainage Area

Figure 5.2 presents the service boundary of the sanitary service area. The figure also shows the range of pipe sizes identified in the LPN study area. The 75 ha sanitary service area consists of 610 properties. The area is primarily single-family detached residential landuse which was initially developed in the 1920’s to 1940’s. The sanitary sewer system drains to the  West Don Sanitary Trunk Sewer. This sewer trunk flows easterly and combines with the Wilket Creek Sanitary Trunk Sewer that ultimately discharge to the Ashbridges Bay Wastewater Treatment Plant.

House foundation drains constructed prior to 1991 based on the policy, are connected to the sanitary sewer.

There are approximately 200 sanitary pipes within the sanitary service boundaries of the LPN study area. All the pipes are circular and range in diameter from 200 mm to 300 mm. Table 5.1 presents information on the sanitary system characteristics for the individual areas. Figure 5.3 presents the sanitary system age for the LPN study area.




LEGEND:

- LPN Area
- Watercourses
- Roads
- Missing Pipe Information
- Missing Manhole Ground Elevation
- Sanitary Sewer

NOTES:

Base Mapping was provided by the City of Toronto

400 200 0 Meters

TORONTO

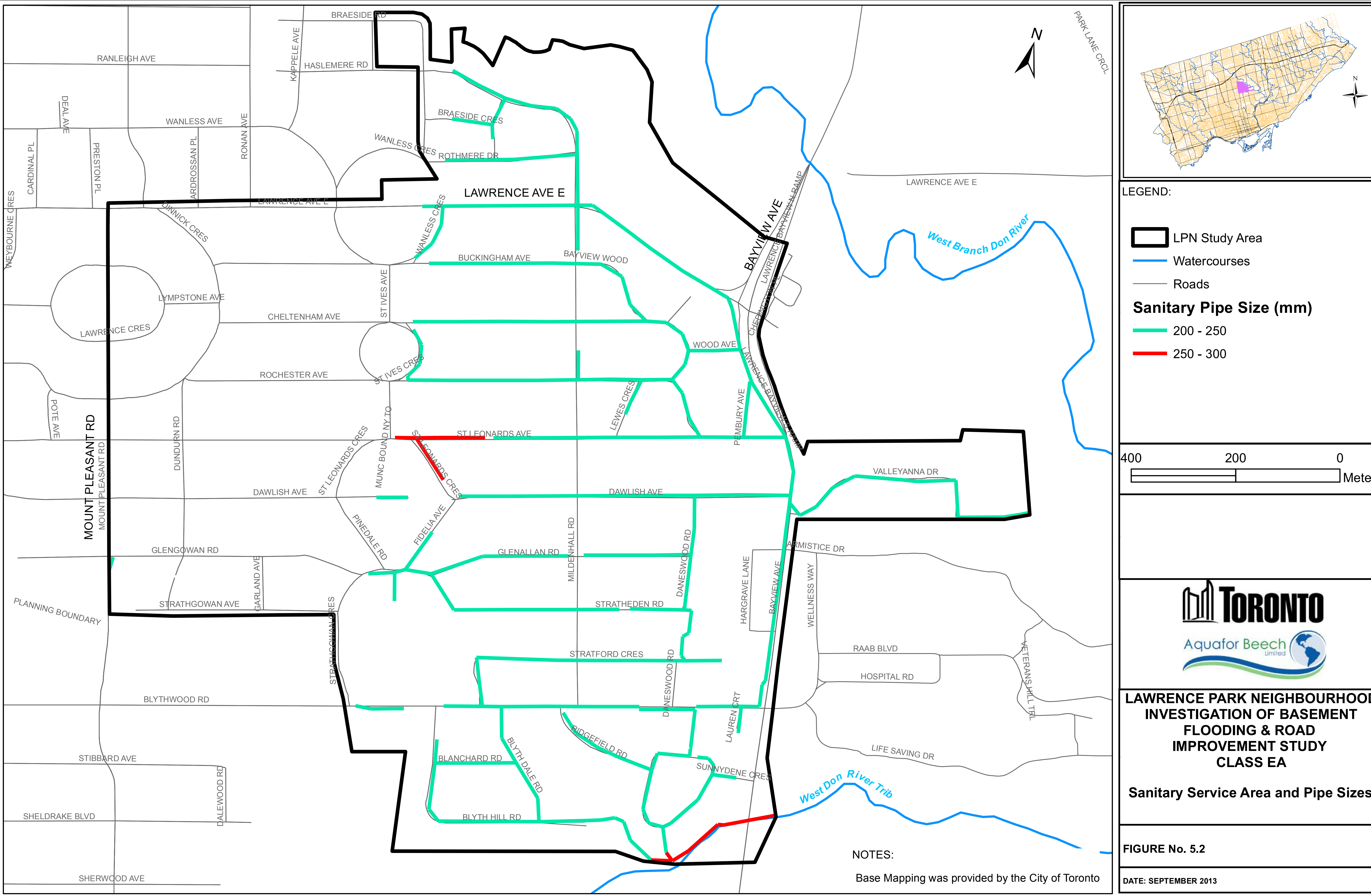
Aquafor Beech Limited

**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Sanitary Data Gaps**

**FIGURE No. 5.1**

**DATE: SEPTEMBER 2013**

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**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Sanitary Service Area and Pipe Sizes**

NOTES:

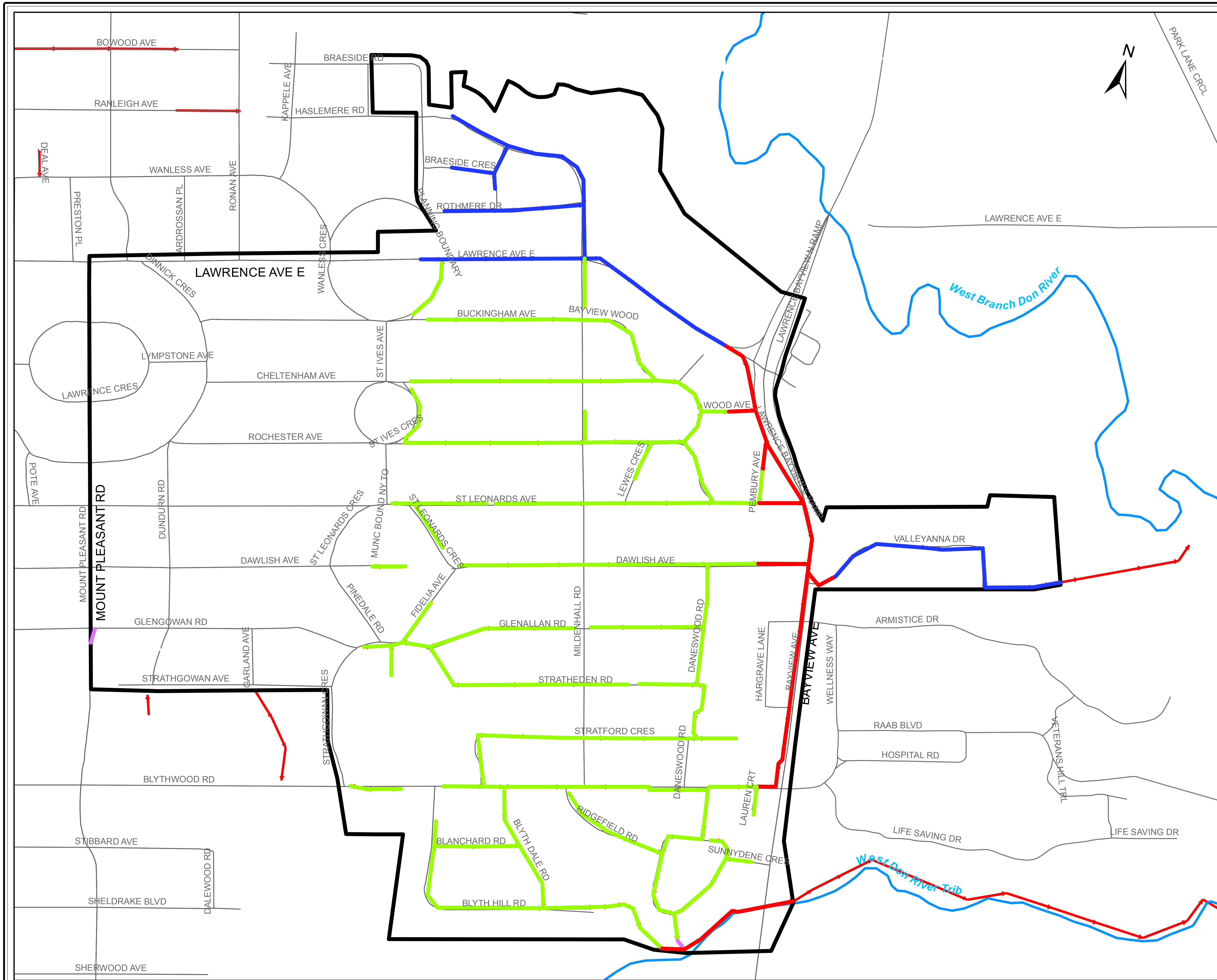
Base Mapping was provided by the City of Toronto

**FIGURE No. 5.2**

**DATE: SEPTEMBER 2013**

## Table 5-1 Sanitary System Characteristics

| Study Area | Service Area (ha) | Property | Number of Sanitary Pipes | Pipe Length by Size | Pipe Age | Number of Outlets |
|---|---|---|---|---|---|---|
| Sanitary Service Area | 75 | 611 | 204 (11,868.7 m) | 200-250: 194(11,312 m)<br>251-300: 10 (556.1 m) | 1922-1949: 139(8,401.2 m)<br>1950-1952: 15(832.1 m)<br>1953-1958: 18(1,133.9m)<br>1959-1963: 31(1,502.5m)<br>Unknown: 1 (20m) | 2 |




LEGEND:

- LPN Study Area
- Watercourses
- Roads
- Sanitary Sewer

**Sanitary Pipe Age**

- Unknown
- 1930 - 1939
- 1940 - 1949
- 1950 - 1959
- 1960 - 1969

400 200 0 Meters

NOTES:

Base Mapping was provided by the City of Toronto

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Aquafor Beech Limited

**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Sanitary System Age**

**FIGURE No. 5.3**

**DATE: SEPTEMBER 2013**

# 6.0 ASSESSMENT OF COMBINED SEWER SYSTEM

## 6.1 Data Gaps

The database of the combined sewer system provided by the City was reviewed in detail. Data gaps were identified, which could be classified into the following categories:

- Isolated manholes not connected to the network;
- Isolated combined sewers not connected to the system;
- Missing manhole ground surface elevations; and
- Missing pipe information such as pipe geometry, diameter and/or invert elevations.

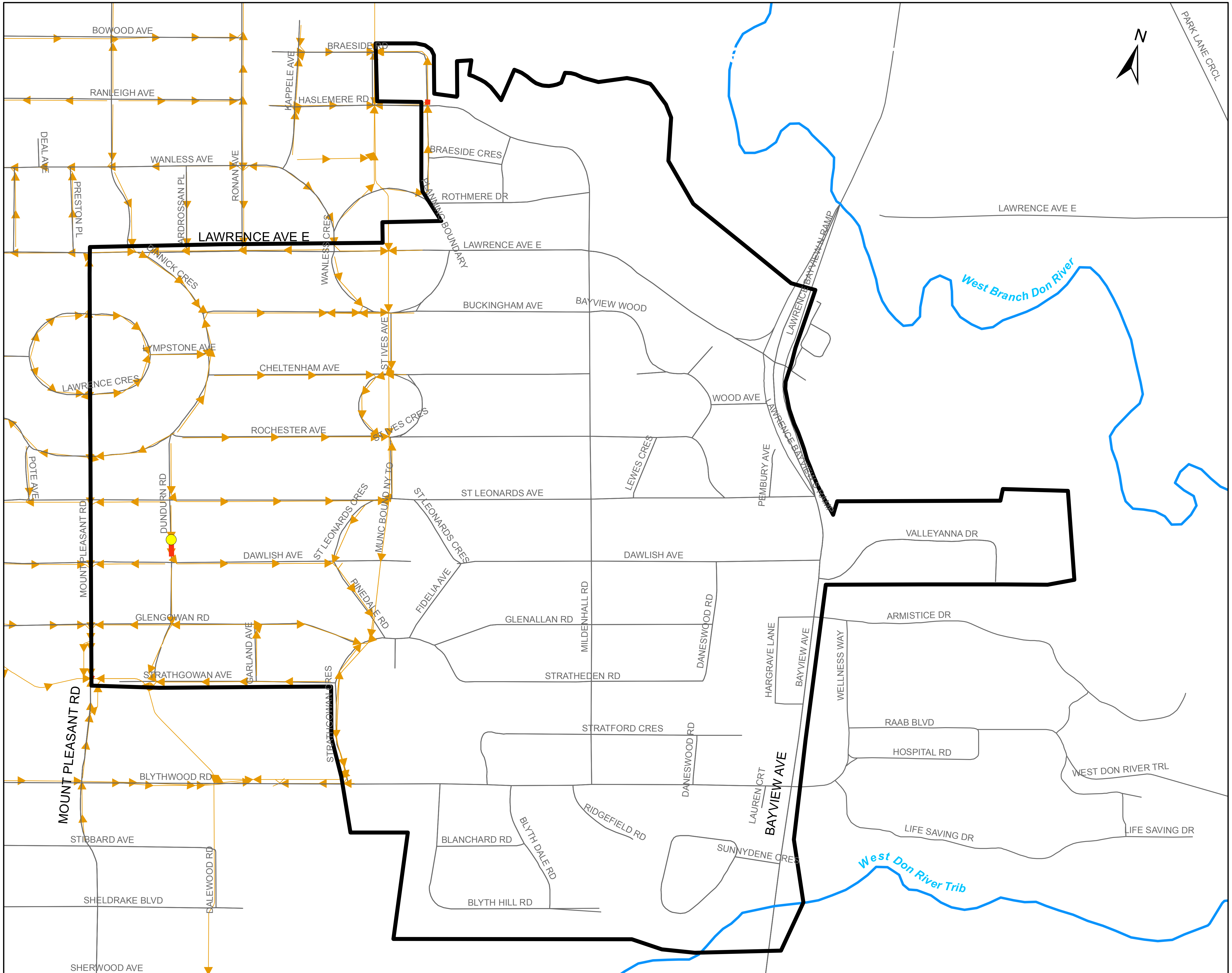
Figure 6.1 presents the missing information identified in the database for the combined sewer system.

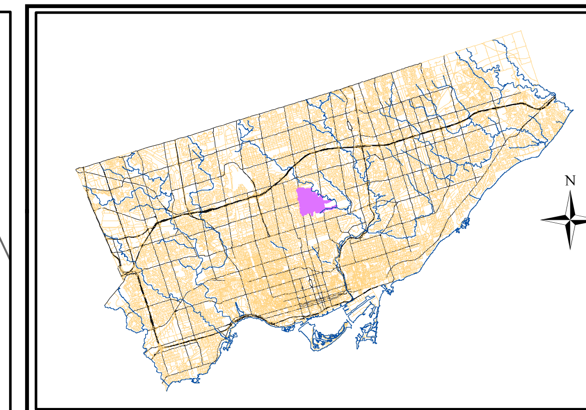
Most of all manhole elevations for the study areas were provided. However, 3 pipes in the combined sewer network were affected by the gaps in the database. Most of the gaps were filled using the digital sewer plan and profile drawings provided by the City. Similar to the storm system when no information was available, the missing information was inferred using the InfoWorks model inference tool.

The data gap analysis associated with link information such as missing pipe inverts for the combined sewer system is summarized in Appendix A.

## 6.2 Combined Sewer Characteristics and Combined Drainage Area

Figure 6.2 presents the service boundary of the combined service area. The figure also shows the range of pipe sizes identified in the LPN study area. The 45 ha combined service area consists of 352 properties. The area is primarily single-family detached residential landuse which was initially developed in the 1920's to 1940's.
There are approximately 130 combined pipes within the combined service boundaries of LPN study area. All the pipes are either circular or rectangular and range in diameter from 200 mm to 2100 mm.. Table 6.1 presents information on the combined system characteristics for the individual areas. Figure 6.3 presents the combined system age for the LPN study area.




LEGEND:

- LPN Study Area
- Watercourses
- Roads
- Missing Manhole Ground Elevation
- Missing Pipe Information
- Combined Sewer

NOTES:

Base Mapping was provided by the City of Toronto

400 200 0 Meters

TORONTO

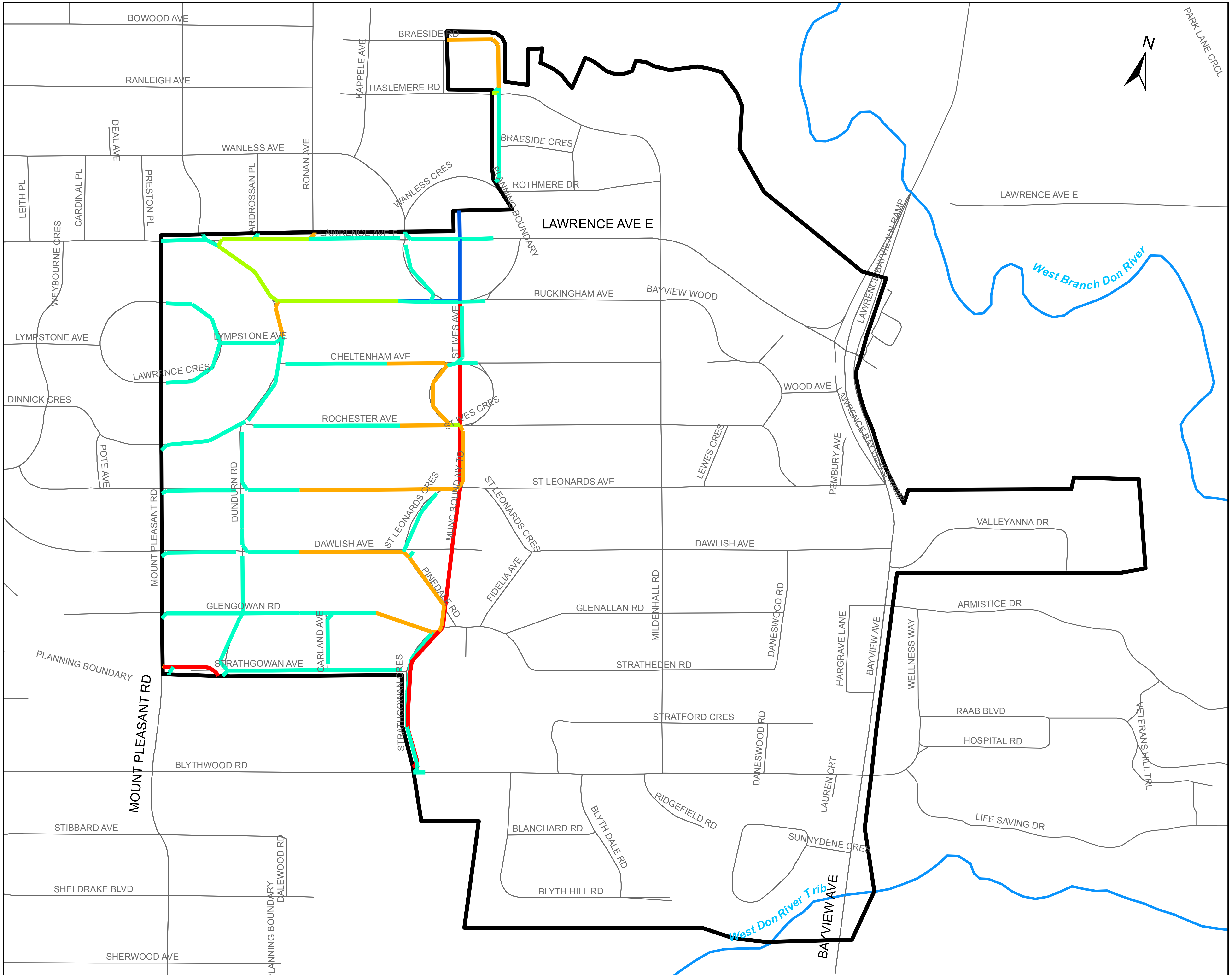
Aquafor Beech Limited

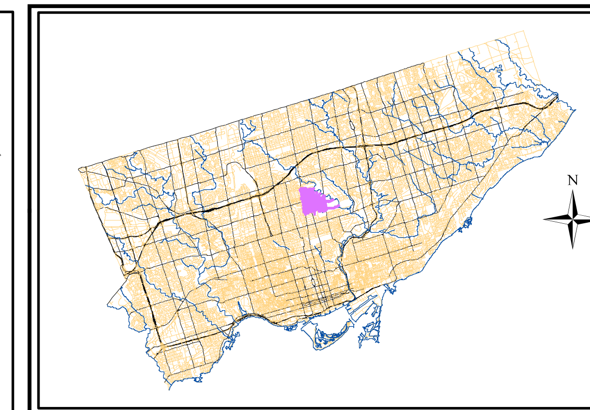
**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Combined Data Gaps**

**FIGURE No. 6.1**

**DATE: SEPTEMBER 2013**




LEGEND:

- LPN Study Area
- Watercourses
- Roads

**Combined Pipe Size (mm)**

- 225 - 300
- 300 - 450
- 450 - 750
- 750 - 1350
- 1350 - 2100

NOTES:
Base Mapping was provided by the City of Toronto

400 200 0 Meters

TORONTO

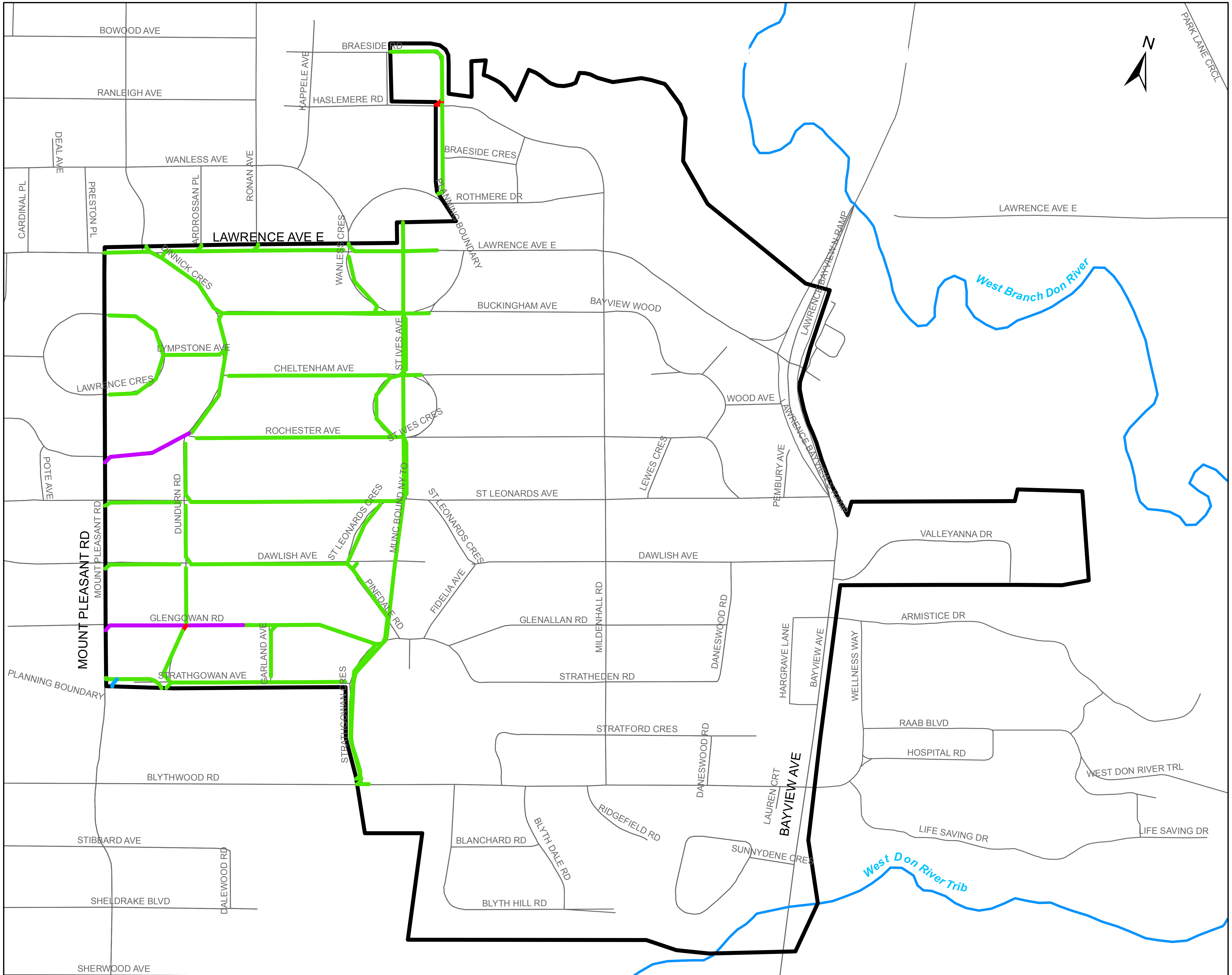
Aquafor Beech Limited

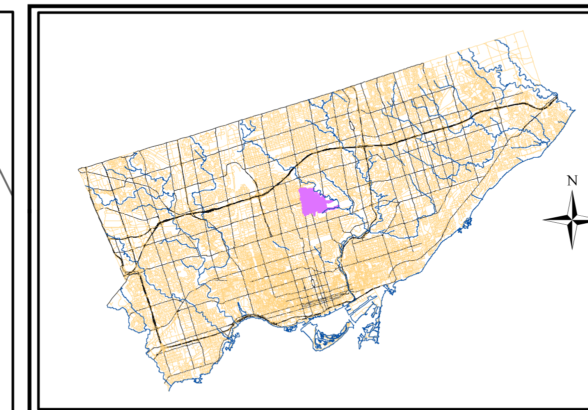
**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Combined Service Area and Pipe Sizes**

**FIGURE No. 6.2**

**DATE: SEPTEMBER 2013**




LEGEND:

LPN Study Area

Watercourses

Roads

**Combined Pipe Age**

1914 - 1922

1923 - 1928

1929 - 1934

1935 - 1984

NOTES:

Base Mapping was provided by the City of Toronto

400 200 0 Meters

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**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Combined System Age**

**FIGURE No. 6.3**

**DATE: SEPTEMBER 2013**

## Table 6-1 Combined System Characteristics

| Study Area | Service Area (ha) | Property | Number of Combined Pipes | Pipe Length by Size | Pipe Age | Number of Outlets |
|---|---|---|---|---|---|---|
| Combined Service Area | 45 | 352 | 134 (8,478.2 m) | 225-300: 86 (4,672.3m)<br>301-450: 29 (1,530.0m)<br>451-750: 10 (647.2m)<br>750-1350: 3(490.6m)<br>1351-2100: 6 (1,138.1m) | 1914-1922: 7(416.5m)<br>1923-1928:121 (7,881.0m)<br>1929-1934: 2 (53.9m)<br>1929-1934: 4(126.7m) | 1 |

## 7.0 SUMMARY

Technical Memorandum #1 presents a summary of the data collection and field work activities. The following section summarizes the information compiled and overlays the information to establish possible connections between the existing information, system characteristics and basement flooding. The interpretation of available information is intended to assist in defining the primary cause(s) of basement flooding and guide the modelling and assessment process in the LPN study area. The following information has been collected and reviewed:

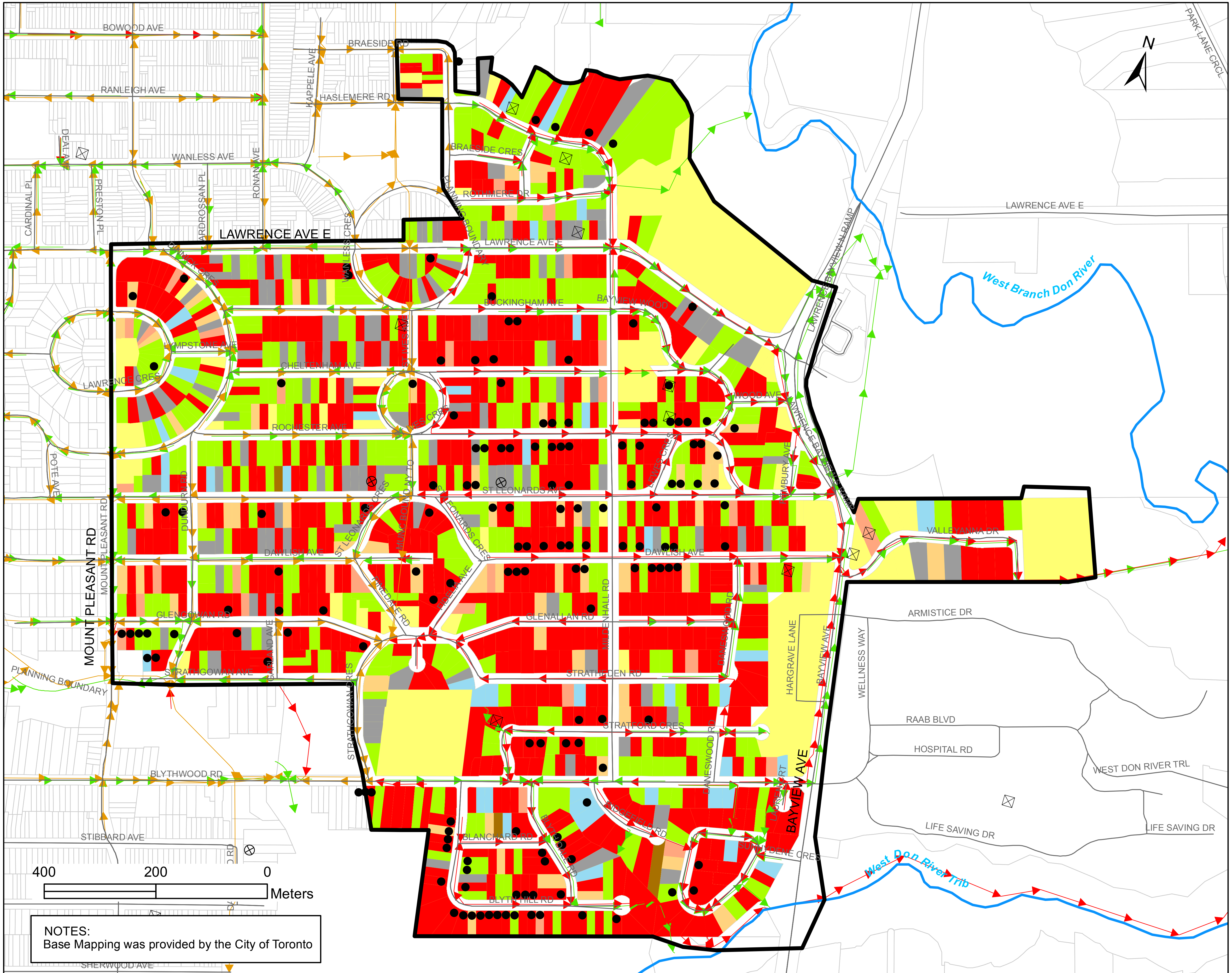
- Physical information of the combined, sanitary and storm sewer networks (minor systems);
- Hydrogeotechnical review;
- Historical CCTV inspection record;
- Historical reports and investigations;
- Historical connection practice;
- Historical flooding records; and
- Field survey – roof leader connection, reverse slope driveways and other features.

### 7.1 Lawrence Park Neighbourhood Study Area Summary

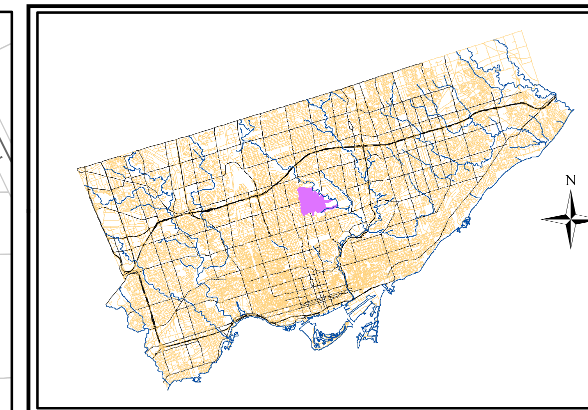
Figure 7.1 presents a composite map of the LPN study area information based on the available information.

The following findings are made based on the information reviewed:

- The area is comprised primarily of single family residential development. No sewer system improvements have been identified in the area.
- The storm and sanitary outlet from the area goes under Bayview Avenue towards the West Don River. The primary outlet for the combined system is south towards Eglinton Avenue. Outlet assumptions for system modelling need to be established for subsequent modelling activities.




NOTES:
Base Mapping was provided by the City of Toronto



LEGEND:

- LPN Study Area
- Reverse Slope Driveways

**HistoricalFlooding**

- Aug 19, 2005
- May 12, 2000
- Watercourses
- Roads
- Combined Sewer
- Sanitary Sewer
- Storm Sewer

**Surveyed Parcels**

**CONNECTION**

- 100% Connection
- 100% Disconnected onto Ground
- 100% Disconnected to Driveway
- 100% Disconnected to Backyard
- Partially Disconnected onto Ground
- Partially Disconnected to Driveway
- Partially Disconnected to Backyard
- Unknown

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**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Study Area Summary**

**FIGURE No. 7.1**

**DATE: SEPTEMBER 2013**

- Sanitary sewer condition and debris build up may be a factor in maintaining pipe capacity. During the installation of flow meters grease build up was identified forcing the monitoring site to be flushed periodically.
- There are reverse slope driveways in the area, and there are a few of them associated with basement flooding.
- The storm system includes an extensive roadside ditch network combined with a storm pipe network.
- The combined, sanitary and storm networks have in-system diversion/overflow points where flow direction is dependent on the depth of flow.
- Weeping tile drainage is assumed to be connected to the sanitary system for properties built before 1991. After 1991 roof leaders and weeping tile appear to be connected to the storm sewer.

Preliminary conclusions include:

- The primary source of basement flooding is identified to be from the sanitary and combined sewer systems.
- Surface ponding in the vicinity of basement flooding may contribute to wet weather inflow volume in the local sanitary sewer reducing system capacity.
- The stormwater drainage system does not appear to be the direct cause of flooding in this area.
- Internal flow diversion/overflow points may play a role overloading or providing relief in the flooding area.
- Although the stormwater system does not appear to be the cause of flooding in this area, the location of low points and roadside drainage ditches in the vicinity of reported basement flooding may indicate surface ponding depth may contribute to wet weather inflow volume in the local sanitary sewer reducing system capacity.
- There is no evidence of debris or grease build up that may limit capacity in the area of reported flooding. However, there is evidence of deteriorating sanitary pipe that may reduce pipe performance. A review of pipe slope and minimum velocities during model development may identify possible locations susceptible to debris build up.

Based on the preliminary sewer physical assessment of the LPN study area the following is concluded:

- The primary source of basement flooding is backup from the sanitary system associated with excess inflow and infiltration.

- Surface ponding may contribute to stormwater inflow in the sanitary system in some locations.
- Outlet hydraulic conditions do not appear to play a role in basement flooding given the location of flooding in relation to the system outlets. Outlet conditions will be defined as part of modelling activities.
- The roadside ditch networks in the LPN study area have not been identified as a source of surface flooding.
- In-system diversion/overflow points in the LPN study area may play a role in flow control.
- Data gaps have been filled through a combination of inferring missing data from surrounding information and/or accessing City drawings. In all cases data gaps were addressed.

# TECHNICAL MEMORANDUM NO.2

## 8.0 MONITORING OBJECTIVES

This section describes the flow monitoring program carried-out from June 2013 to November 2013. The objectives of the combined and sanitary sewer flow monitoring program were to collect dry and wet-weather flow in the existing combined and sanitary sewers so as to:

a) Quantify the combined and sanitary flow generation parameters from the tributary areas;
b) Identify infiltration and inflow sources in the sanitary sewers; and
c) Calibrate the hydrologic and hydraulic model to allow for the effective analysis of the causes of Basement Flooding in Lawrence Park Neighbourhood (LPN) Study Area.

## 9.0 FLOW MONITORING STATION LOCATIONS

Flow monitoring locations have been selected at 3 combined sewer sites and 3 sanitary sewer sites. These locations are shown in Figure 1. Site selection criteria includes both technical and safety considerations. High vehicular traffic sites are less preferred if the same technical objective can be achieved in less trafficked areas. In addition, all flow monitoring stations were intrinsically safe area-velocity meters. Table 3-1 summarizes the proposed combined and sanitary monitoring station characteristics. The six keys technical site selection criteria include:

I. Flow monitoring stations must characterize flow generation from known flooding areas (reported flood location clusters). These areas are fully-characterized through the data collection and the enhanced field survey including downspout connection investigation and catchbasin-type-location inventory. These locations provide ideal monitoring sites for future remedial option performance evaluation (measure before and after implementing remedial options).
II. Stations were located to capture the flow from representative tributary areas so that the results can be generated to other non-monitored areas.
III. Stations were located in satisfactory hydraulic sewer conditions to allow for the highest accuracy and reliability.
IV. In the case where primary devices were used (e.g. weirs), these structures were installed within the manhole (not inside the incoming or outgoing pipes) to allow for flow by-pass (overtop) without causing surcharge upstream.
V. Flow monitoring locations were located in readily-accessible locations, preferably away from high-traffic control requirement areas or deep sewers.
VI. Flow monitoring locations were selected to be consistent with previous monitoring sites.

The City RG39-P (Mt. Pleasant) rain gauge station location was selected to provide, precipitation information for the LPN Study Area. The key technical rain gauge location criteria include:

1. Representative rainfall capture locations;
2. Adequate distance from trees and tall buildings which may obstruct rainfall; and
3. Coordinated area coverage with other existing rain gauges.

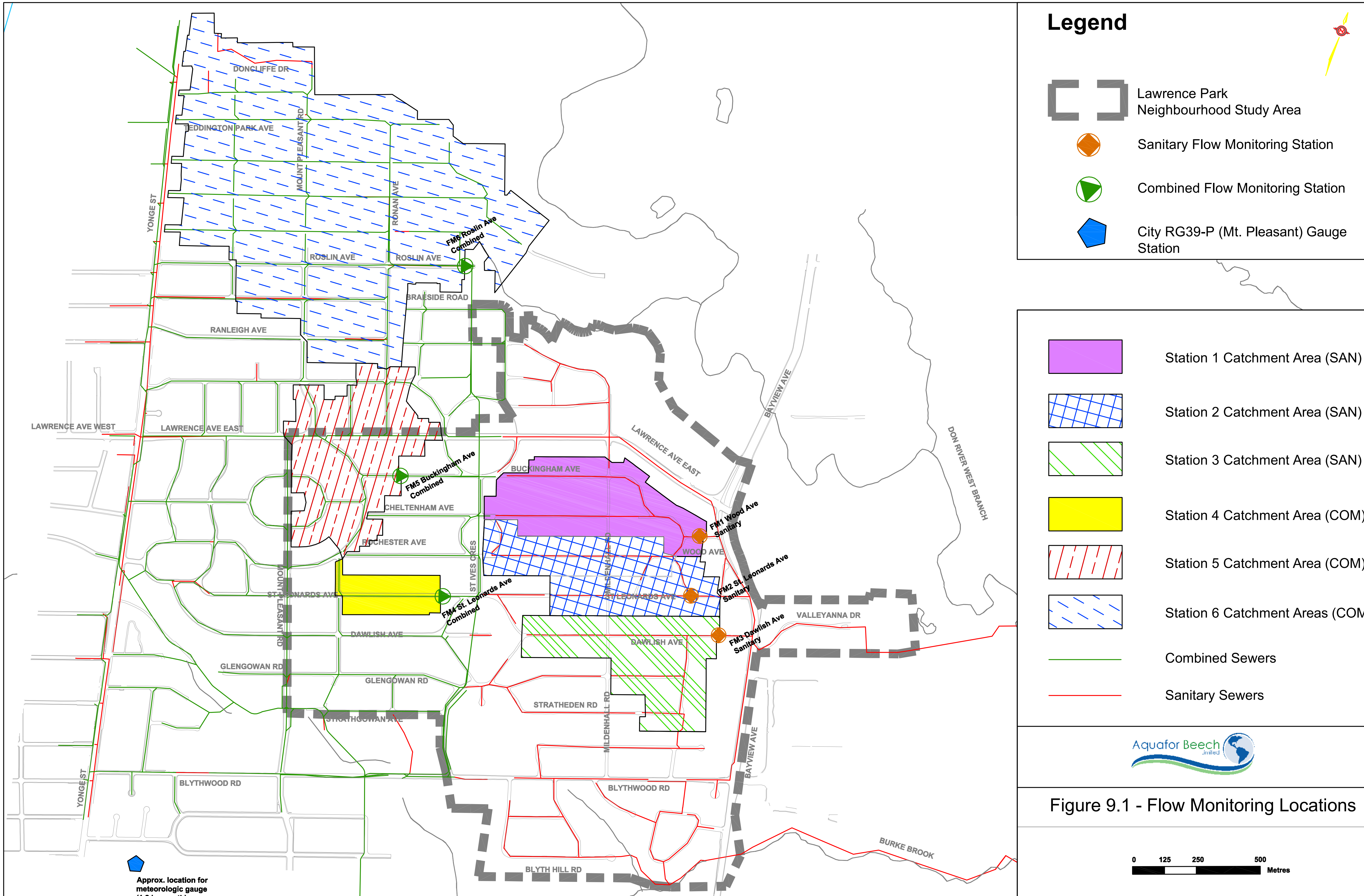



Figure 9.1 - Flow Monitoring Locations

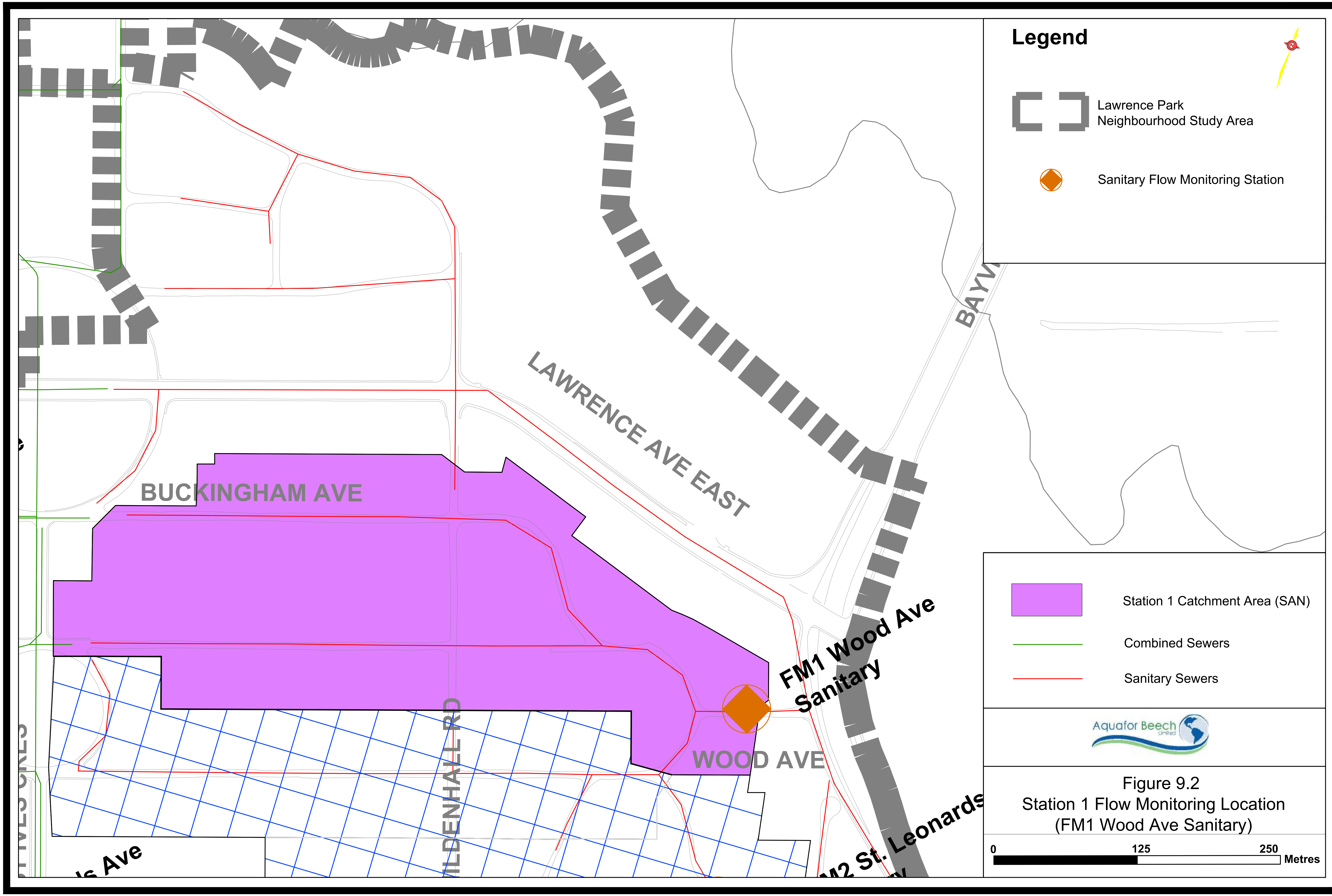



Figure 9.2
Station 1 Flow Monitoring Location
(FM1 Wood Ave Sanitary)

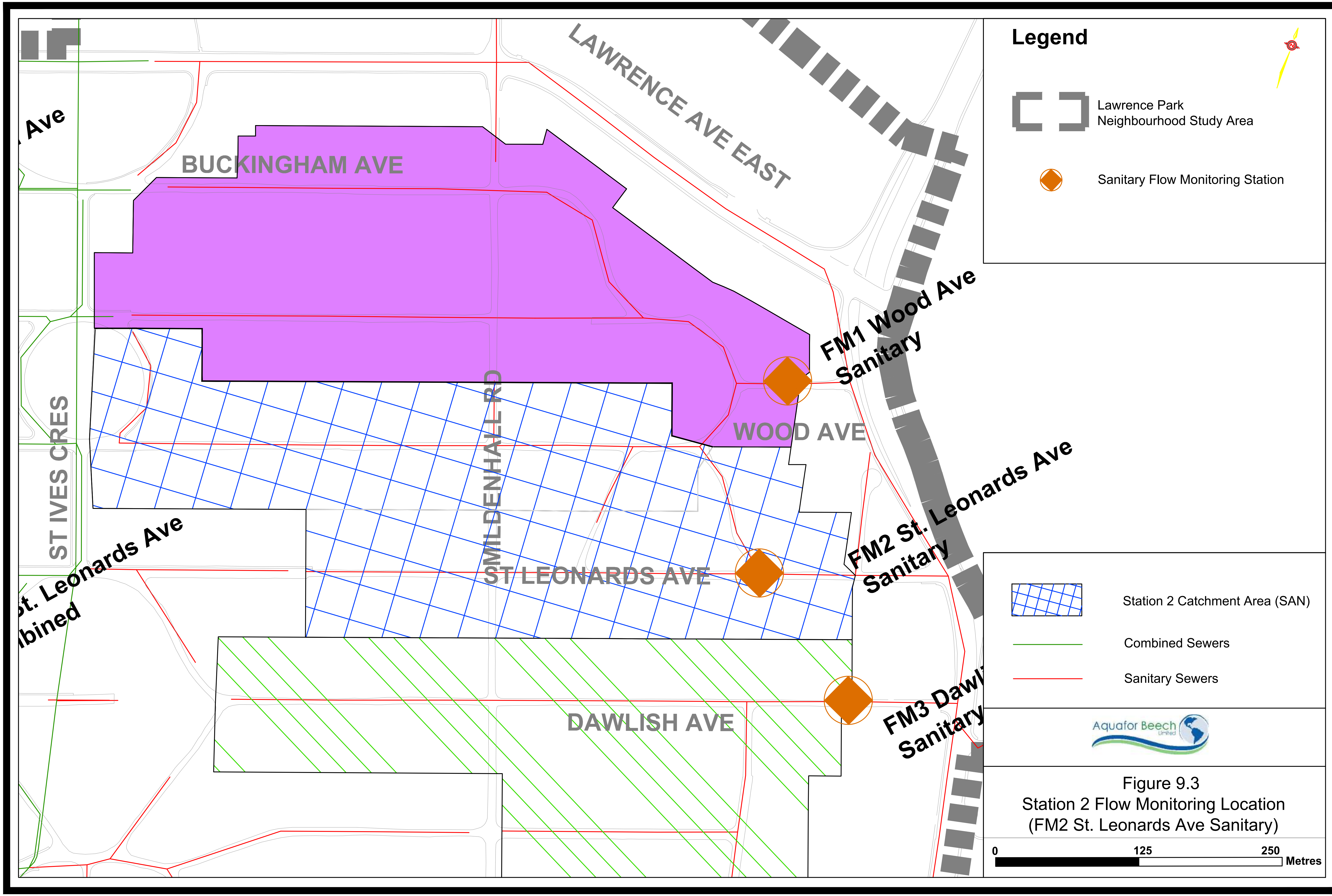



Figure 9.3
Station 2 Flow Monitoring Location
(FM2 St. Leonards Ave Sanitary)

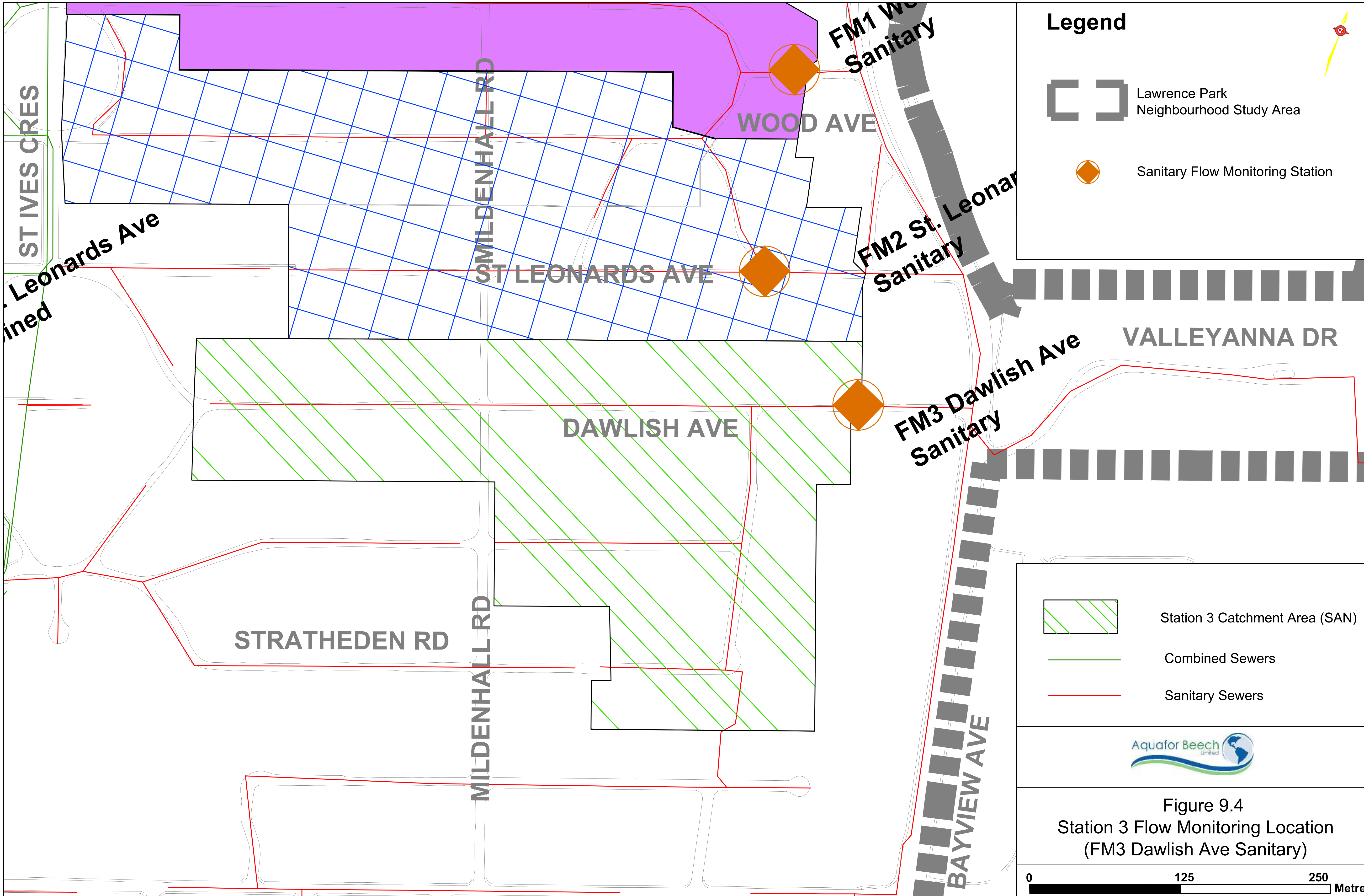


Figure 9.4
Station 3 Flow Monitoring Location
(FM3 Dawlish Ave Sanitary)

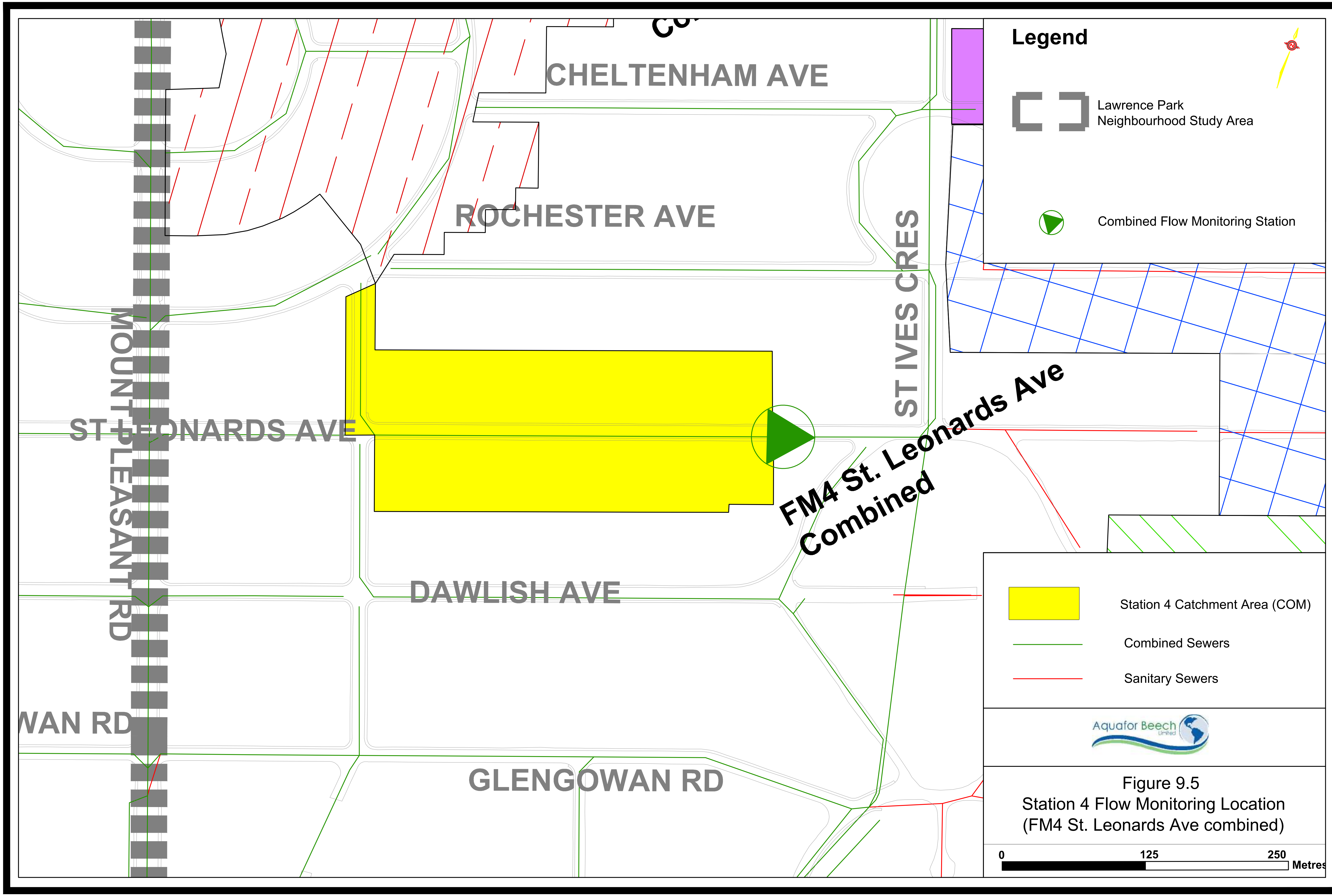


Figure 9.5
Station 4 Flow Monitoring Location
(FM4 St. Leonards Ave combined)

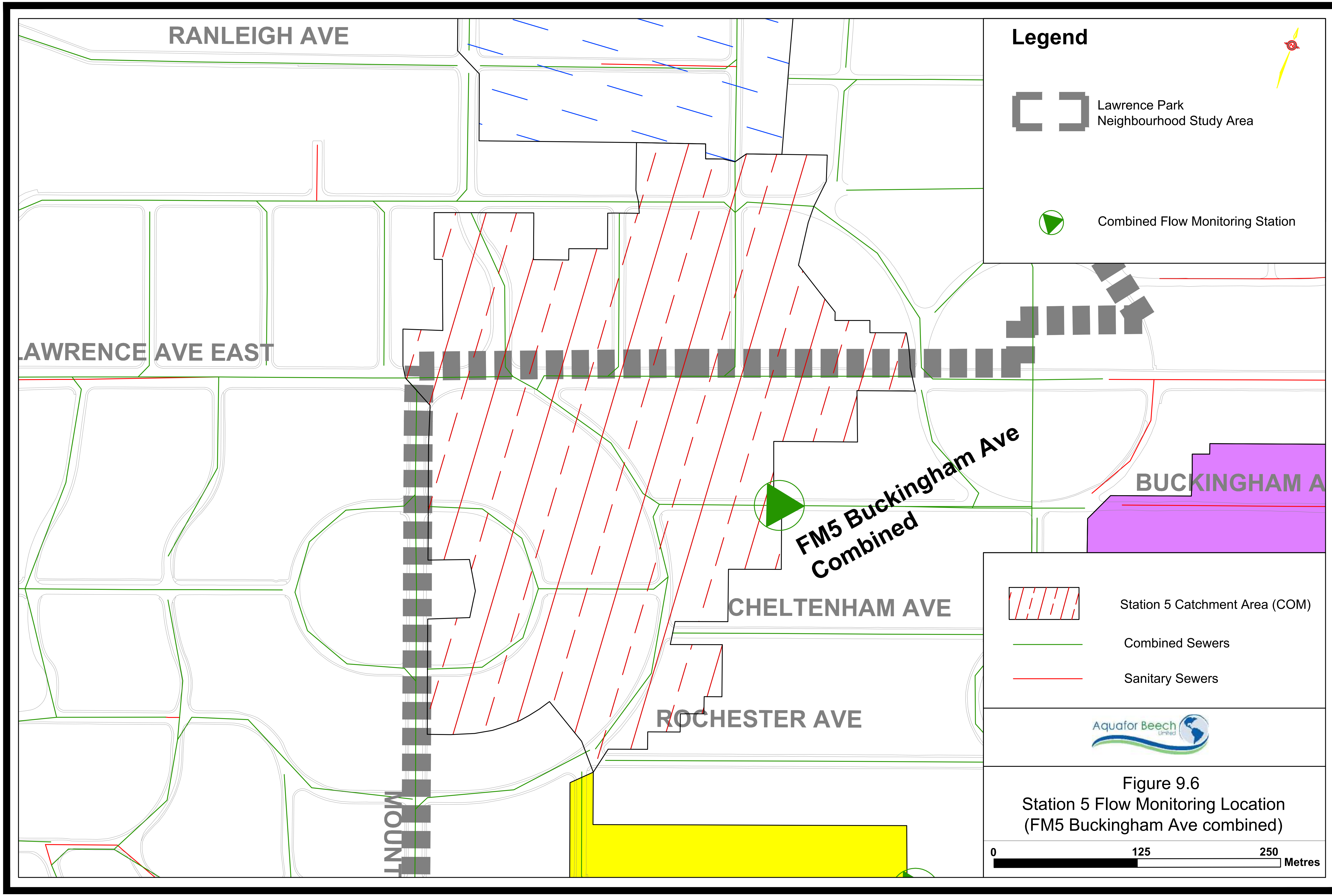



Figure 9.6
Station 5 Flow Monitoring Location
(FM5 Buckingham Ave combined)

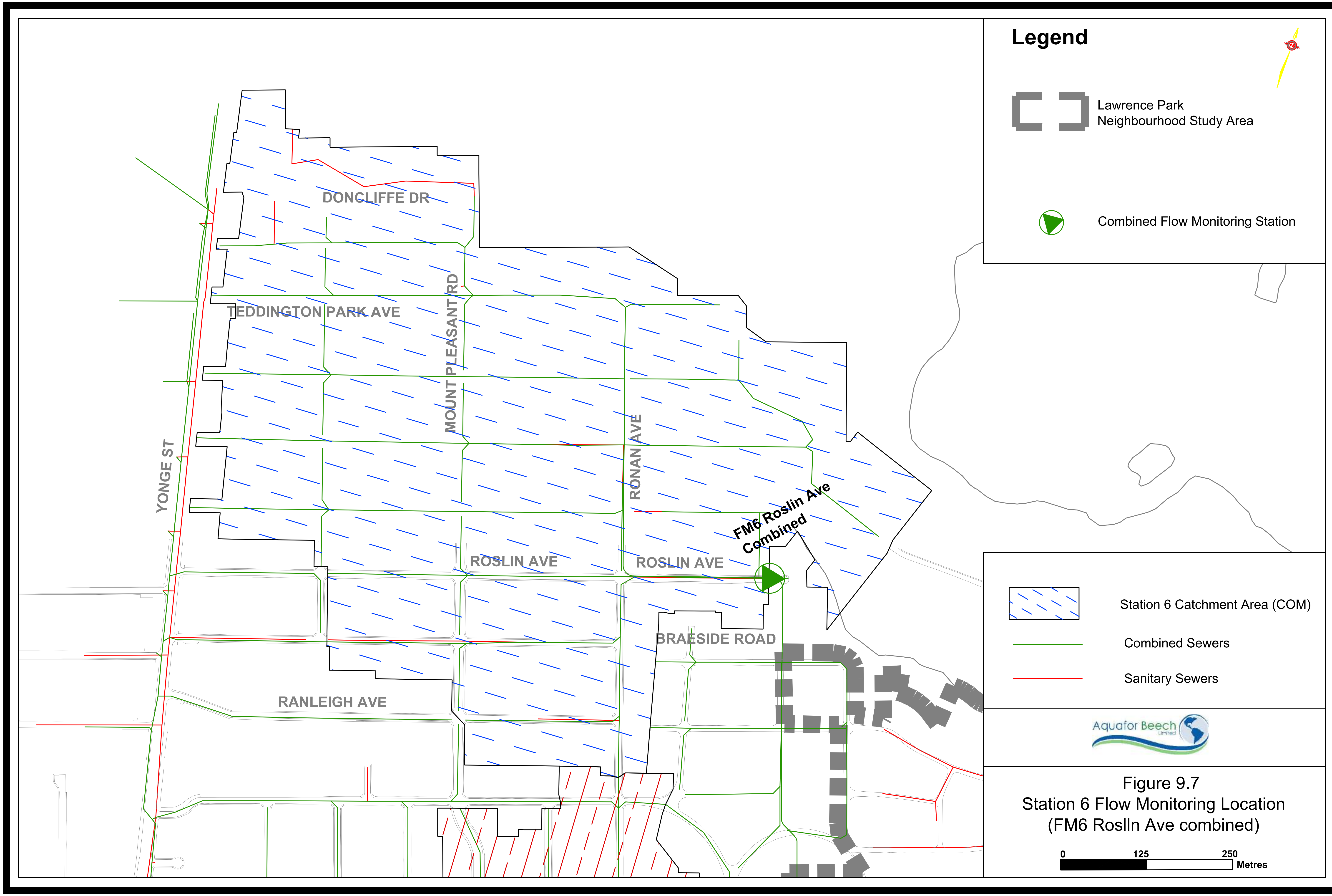



Figure 9.7
Station 6 Flow Monitoring Location
(FM6 Rosln Ave combined)

# 10.0 MONITORING EQUIPMENT AND METHODS

## 10.1 Flow Monitoring Stations

Two types of monitoring equipment were used for flow monitoring – Hatch Sigma 910 & 920 Area Velocity Flow Meter and Teledyne Isco 2150 Area Velocity Flow Module & Sensor. Stations 1 and 2 utilized the Hatch Sigma 910 flow meters, stations 3 and 6 utilized the Sigma 920, and stations 4, and 5 utilized the Isco 2150 flow meters. Both the Sigma and Isco monitors have the same configuration of submerged velocity area (AV) sensors which are installed at the pipe invert. The AV sensors use the Doppler Ultrasonic method to calculate velocity and Pressure transducer with stainless steel diaphragms to record level in the pipes. The instrumentation specifications are provided in Appendix D.

The data logger calculates the discharge rate using the continuity equation (Q = AV) based on measured depth and velocity in the pipe and with the user defined shape and dimensions of the pipe. Field verifications of the monitoring stations were carried out on a monthly basis and the field verification reports are provided in Appendix E. This verification included cleaning of the sensors and flume, independent depth and velocity measurements and correction of the measurements if needed based on measured offsets. It is worth noting that the depth readings are more reliable than the velocity readings because they are based on pressure of the water above the sensor where as the velocity readings are more sensitive to environmental conditions such as air bubbles and solids in water columns.

## 10.2 Rain Gauge Station

A City Rain gauge (RG39-P, Mt. Pleasant) is located on the roof of Northern Secondary School located at southeast corner of Mount Pleasant Road and Broadway Avenue. The location of the rain gauge was selected in order to get the local precipitation data for modeling and monitoring purposes.

## 10.3 Duration of Monitoring

The Terms of Reference required that monitoring be carried out for the June to November 2013 period. The summary of flow monitoring stations is provided in Table 10-1.

**Table 10-1: Summary of Flow Monitoring Stations**

| Station | Node ID (City GIS) | Pipe ID (City GIS) | Coordinate X / Y | Sewer Type | Diameter (mm) | Drainage Area (ha) | Monitoring Period from/to | Location Comment |
|---|---|---|---|---|---|---|---|---|
| FM1 (Wood) | 4275314257 | 4273914209.1 | 314257.5 4842753.5 | Sanitary | 250 | 10.8 | June 1, 2013/ November 30, 2013 | Manhole located west of Wood Ave and Bayview Ave |
| FM2 (St. Leonard) | 4258614276 | 4258614276.1 | 314276.5 4842586.5 | Sanitary | 250 | 11.9 | June 1, 2013/ November 30, 2013 | Manhole located at the junction of St. Leonard Ave and Lewes Cres |
| FM3 (Dawlish) | 4250214385 | 4247614296.1 | 314385.0 4842502.4 | Sanitary | 250 | 11.1 | June 1, 2013/ November 30, 2013 | Manhole located west of Dawlish Ave and Bayview Ave |
| FM4 (St. Leonard) | 4238713608 | 4236013518.1 | 313608.3 4842387.1 | Combined | 375 | 3.2 | June 1, 2013/ November 30, 2013 | Manhole located west of St. Leonard Ave and St. Leonard Cres |
| FM5 (Buckingham) | 4267713396 | 4264813297.1 | 313396.9 4842677.3 | Combined | 750 | 14.7 | June 3, 2013/ November 30, 2013 | Manhole located west of Buckingham Ave and north of Dinnick Cres |
| FM6 (Roslin) | 4329413404 | 43381133631.1 | 313404.9 4843294.8 | Combined | 1315 | 59.1 | June 3, 2013/ November 30, 2013 | Manhole located at the east end of Roslin Ave |

Station 3 (Dawlish Ave.) is located in a 250 mm diameter sanitary sewer. A substantial amount of concrete debris was found in the pipe and manhole during a scheduled site investigation visit for the flow monitoring inspection in mid-October, 2013. A request was sent to the City to flush the pipe for flow monitoring program. A recent site visit (November 01, 2013) confirmed that the concrete debris had been removed and flow monitoring data returns to its typical basis. In addition, The model predicts the flow results reasonably well on all the events with the exception of June 28th event. The rainfall on June 28th event did not seem to fall as intensively over the study area.

## 11.0 SANITARY SEWER FLOW TERMINOLOGY

This section defines the terms used to describe the sanitary sewer system flows. In general, the sanitary sewer flows are either ‘wastewater’ or ‘extraneous’. Wastewater is also referred to as ‘population-derived’ flow as it originates from domestic, commercial, and industrial activities. Sanitary sewers are constructed primarily to transport wastewater (population-derived) flow to the treatment facility for treatment.

Depending on the weather, groundwater, and sewer conditions, sanitary sewers also carry various amounts of 'extraneous' flows. Extraneous water is relatively 'clean' water that is captured into the sanitary sewers. Clean water capture is undesirable as it increases the sewer sizes and the treatment plant capacities that are required to convey and treat the wastewater. Although the design for conveyance accounts for some extraneous flow capture, the structural design and construction objective is to minimize the short and long-term capture of extraneous flows. The amount of extraneous flow that does get captured and carried in the sanitary sewers depends not only on the supply of water from rain, snowmelt, or groundwater, but also on the sewer system conditions. Older 'leaky' systems capture more extraneous flows than newer sewers.

Because sanitary sewers are designed to minimize the capture of extraneous flows, the quantification of the actual source is typically not possible without measurements. In some cases such as when there are illegal storm drain connections (or cross-sections), quantification is even more difficult. Measurements must be carefully considered due to variably system conditions.

The sanitary sewer flow can also be evaluated under dry-weather or wet-weather flow conditions.

## 11.1 Dry-Weather Flow

Dry-weather flow occurs during periods without direct contributions from rain or snowmelt and is comprised of the population derived flow (wastewater) plus the groundwater infiltration (extraneous flow) and is represented as follows:

**Equation 1**

DWF = POP_DWF + GWI
where: POP_DWF = Population Derived Flow (residential or employment lands)
GWI = Groundwater Infiltration

## 11.2 Wet-Weather Flow

Wet-weather flow includes dry-weather flow plus direct contribution from rain or snowmelt. It is comprised of the population derived flow (wastewater) plus the groundwater infiltration plus the direct inflow due to rainfall or snowmelt runoff entering the sewer system through manhole covers, cracks, illegal connections. Since the first two components make-up the dry-weather flow, the wet-weather flow (WWF) can be expressed as:

**Equation 2**

WWF = DWF + II
where: II = Rain/Snowmelt-Derived infiltration and inflow

As discussed above, the main reason to build and operate sanitary sewers is to carry the population derived flow (sewage) to the treatment plant. Extraneous flows, either from groundwater or direct runoff inflows (rain or snowmelt), are undesirable because they require additional system capacity for conveyance and treatment. Extraneous flows occur due to poor design or construction, ground movement, material and structural deterioration with aging, or illegal connections such as connections from the roofs, yards, or foundation drains. These flows should be excluded as much as possible from the wastewater stream.

### 11.3 Dry-Weather and Wet-Weather Flow Hydrographs

A hydrograph is a representation of the changes in flow over time at one location. Conceptual sanitary DWF and WWF hydrographs are illustrated in Figure 8 and 9. As shown, the DWF hydrograph can be described in parts or using the following terms:

a) DWF (Total):

| | |
|---|---|
| Peak DWF | = Peak Dry-Weather Flow |
| Avg DWF | = Average Dry-Weather Flow |
| Min DWF | = Minimum Dry-Weather Flow |
| GWI | = Non-Rainfall Derived Groundwater Infiltration |

b) Population DWF:

| | |
|---|---|
| Peak Pop DWF | = Peak Population (Wastewater) Dry-Weather Flow |
| Avg Pop DWF | = Average Population (Wastewater) Dry-Weather Flow |
| Min Pop DWF | = Minimum Population (Wastewater) Dry-Weather Flow |

Quantification of wet weather flow hydrograph in a sanitary sewer requires 'separation' of the measured dry-weather hydrograph from the total measured hydrograph.

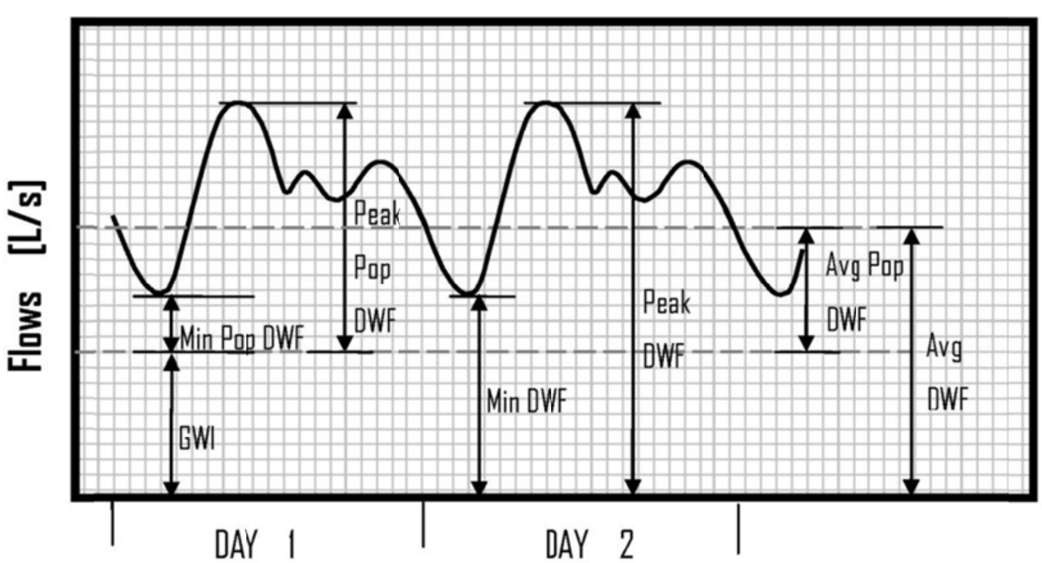



Figure 11.1 Components of Dry Weather Flow Hydrograph

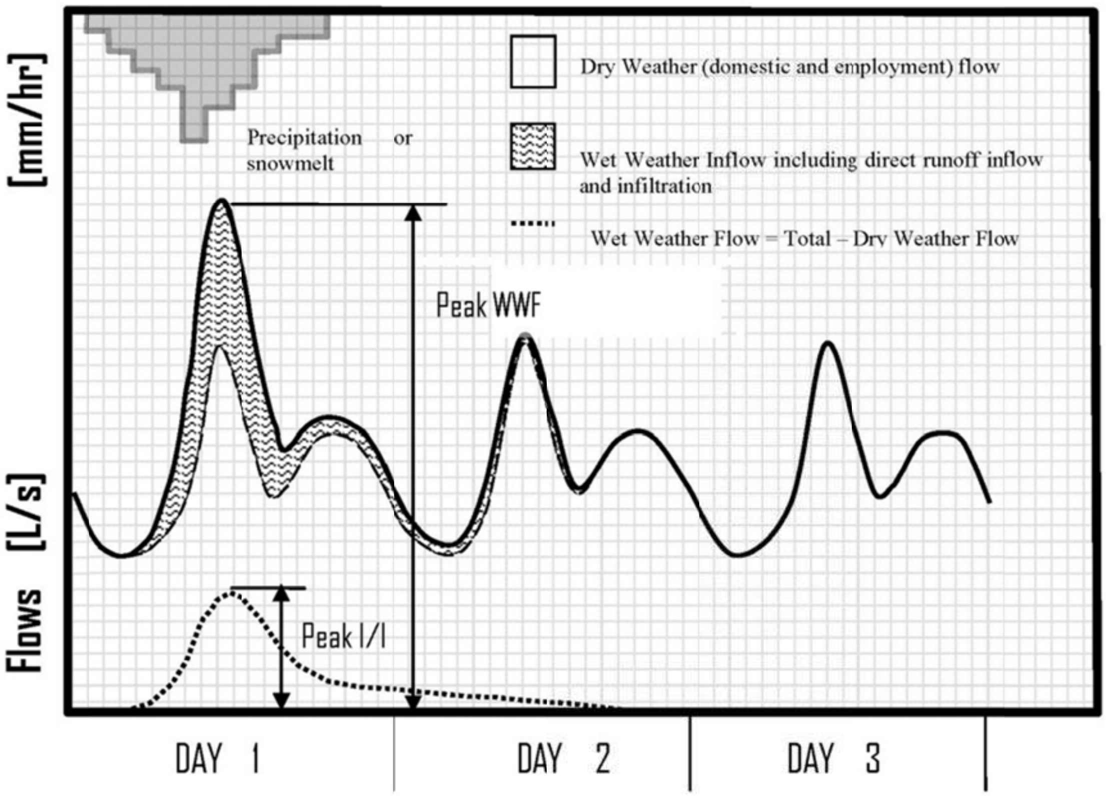



Figure 11.2 Wet and Dry-Weather Flow Hydrograph

# 12.0 SANITARY AND COMBINED FLOW MONITORING RESULTS

Monitoring results are included in Appendix E. Monitoring continuity is displayed in Appendix F.

## 12.1 Dry-Weather Flows

Table 12-1 summarizes the dry-weather flow parameters monitored for the lumped areas upstream the sanitary monitoring stations up to and including October 2013 (refer to Figure 1 for sanitary sewer locations). Dry-weather flow was classified as flow that occurs during periods without direct contributions from rain or snowmelt. As defined in Section 5.1, dry weather flow is comprised of the population derived flow (wastewater) plus the groundwater infiltration (extraneous flow).

Where GWI = Ground Water Infiltration; PDWF = Population-derived Dry-Weather-Flow; DWF = Average population-derived Dry-Weather-Flow. The groundwater infiltration (GWI) parameter is estimated as 80% of the minimum daily DWF. This relationship has been used in other nearby jurisdictions.

It is useful to compare the sanitary sewer monitoring results with typical sewer design parameters. For example, an average per capita sanitary flow of 240 L/cap/day is identified for all the residential areas and 250 L/cap/day is identified for all the industrial/Commercial/Institutional areas. These values are identified from a study entitled "Don, Humber & Highland Creek Sanitary Trunk Sewer Capacity Analysis, Phase 1 - Existing (2001) Trunk Sewer Spare Capacity, June 2004".

The monitoring data is summarized in the following tables:

Table 12-1 summarizes the sanitary and combined dry weather flows. Dry weather days are defined as dry if no rainfall had occurred within the previous 72 hours. The summary table shows the average and minimum dry weather flows for the sanitary sewers and combined sewers in the study area. The higher Average DWF (L/Cap/day) values are most likely reflect the age and condition of the sewer system in the area.

**Table 12-1: Summary of Monitored Sanitary/Combined Dry weather flow**

| Station | Gross Area (ha) | Popu.[a] | Popu./ha | Average DWF | | Min. DWF | Max. DWF | General Land Use |
|---|---|---|---|---|---|---|---|---|
| | | | | L/sec | L/Cap/day[b] | L/sec | L/sec | |
| 1 (SAN) | 10.8 | 384 | 35.6 | 2.1 | 472.5 | 0.6 | 4.1 | Residential |
| 2 (SAN) | 11.9 | 441 | 37.1 | 2.2 | 431.0 | 1.5 | 6.1 | Residential |
| 3 (SAN) | 11.1 | 415 | 37.4 | 3.1 | 645.2 | 2.1 | 8.3 | Residential |
| 4 (COM) | 3.2 | 263 | 82.2 | 2.1 | 589.9 | 0.4 | 1.0 | Residential |
| 5 (COM) | 14.7 | 706 | 48.0 | 6.7 | 819.9 | 1.0 | 4.0 | Residential |
| 6 (COM) | 59.1 | 3250 | 54.9 | 12.3 | 327.1 | 4.4 | 12.4 | Residential |

a - Based on City GIS database
b - Calculated from average DWF divided by Population

### 12.2 Wet-Weather Flows

One significant rainfall event was observed with the rainfall amount greater than 40 mm. The one event occurred on July 8, 2013.

The quality of the data is satisfactory for the monitoring period. However, as noted in other Technical Memos the results for stations 1, 2 and 3 (sanitary sewers within a separated sewer area) show clear evidence of infiltration/inflow during rainfall events.
For stations 1, 2, and 3, discussions with City staff, after completion of the field investigation would suggest that the storm and sanitary sewer systems have various levels of inter-connections.

Detailed line charts of all the rainfall and flow events (rainfall intensity, depth versus velocity, depth versus flow) are provided in Appendix E of this document. Scatter plots of flow versus depth are also provided in Appendix F.

The scatter plots show that 5 out of 6 flow monitoring locations provided acceptable results. However, the scatter plots show that at monitoring location #2, there is a significant amount of scatter in the observed flow and depth data. For example at station 2, a small scatter in observed data is observed probably due to the inherent difficulty of monitoring in a small pipe size and due to the malfunctioning of the sensor during the events. This issue occurred for a few weeks. A resident approached Aquafor staff during their field investigation and mentioned that station 3 was surcharged and water was flowing out of the manhole on July 8, and 9, 2013.

Stations 1, 2, 3, and 4 exhibit surcharged conditions during the July 8 event due to the various levels of inter-connections between the storm and sanitary sewer systems, and downspout connections to the sanitary (stations 1, 2, and 3) or combined sewers (station 4).

Table 12-2 provides details about the recorded rainfall data obtained from City's RG39-P (Mt. Pleasant) rain gauge station. A total of 78.3 mm rainfall was recorded at the station on July 8th 2013 with 120.1 mm/hr peak rainfall intensity. The rainfall intensity plots are provided in Appendix E. This rainfall event is considered as a 25-year storm event for the LPN study area.

**Table 12-2: Summary of Monitored Rainfall**

| | **July 07, 2013** | **July 08, 2013** | **July 27, 2013** |
|---|---|---|---|
| | **Rainfall Depth (mm)** | **Rainfall Depth (mm)** | **Rainfall Depth (mm)** |
| Rain gauge station | 34.0 | 78.3 | 12.3 |
| | **Peak (5 minute) Intensity (mm/hr)** | **Peak (5 minute) Intensity (mm/hr)** | **Peak (5 minute) Intensity (mm/hr)** |
| Rain gauge station | 57.0 | 120.1 | 44.9 |

Table 12-3 shows the peak inflow and infiltration (I/I) flows for the rainfall event of July 08. The peak I/I flow is obtained by subtracting the dry weather flow (diurnal DWF patterns) from the observed peak flow for each event. The observed peak I/I flows for separated system range from 0.1 to 6.39 L/s/ha where as, for combined system, the observed peak I/I flows range from 0.3 to 59.69 L/s/ha.

**Table 12-3: Summary of Monitored Sanitary/Combined Peak I/I Flow (L/sec/ha)**

| | | **July 07, 2013** | **July 08, 2013** | **July 27, 2013** |
|---|---|---|---|---|
| **Total Daily Rainfall (mm)** | | 34.0 | 78.3 | 12.3 |
| **Station** | **Area (ha)** | **Observed Peak I/I Flow (L/sec/ha)** | **Observed Peak I/I Flow (L/sec/ha)** | **Observed Peak I/I Flow (L/sec/ha)** |
| 1 (SAN) | 10.8 | 5.4 | 6.5 | 0.4 |
| 2 (SAN) | 11.9 | 0.9 | 5.5 | 0.1 |
| 3 (SAN) | 11.1 | 0.7 | 4.4 | 0.1 |
| 4 (COM) | 3.2 | 21.9 | 59.7 | 8.8 |
| 5 (COM) | 14.7 | 2.4 | 8.0 | 0.1 |
| 6 (COM) | 59.1 | 8.6 | 17.3 | 2.8 |

Table 12-4 provides a summary of estimated I/I volumes and associated peak unit flow rates for the July 7, July 8 and July 27 runoff event. The values show that the percentage of rainfall contributing to the flow in the respective sewers. For station 4 infiltration/inflow values are high as this sewer collects roadway runoff in addition to domestic flows and flows from roof downspouts.

**Table 12-4: Summary of Monitored Sanitary/ Combined I/I Volume**

| | | **July 07, 2013** | **July 08, 2013** | **July 27, 2013** |
|---|---|---|---|---|
| **Total Daily Rainfall (mm)** | | 34.0 | 78.3 | 12.3 |
| **Station** | **Area (ha)** | **Observed I&I Volume ($m^3$)** | **Observed I&I Volume ($m^3$)** | **Observed I&I Volume ($m^3$)** |
| 1 (SAN) | 10.8 | 400 | 1324.0 | 21 |
| 2 (SAN) | 11.9 | 663 | 1366.7 | 34 |
| 3 (SAN) | 11.1 | 684 | 1009.2 | 70 |
| 4 (COM) | 3.2 | 185 | 729.0 | 30 |
| 5 (COM) | 14.7 | 666 | 1107.1 | 52 |
| 6 (COM) | 59.1 | 4079 | 9746.0 | 346 |
| | | **Observed I&I Volume (% of rain)** | **Observed I&I Volume (% of rain)** | **Observed I&I Volume (% of rain)** |
| 1 (SAN) | 10.8 | 10.9% | 15.7% | 1.6% |
| 2 (SAN) | 11.9 | 16.4% | 14.7% | 2.3% |
| 3 (SAN) | 11.1 | 18.1% | 11.6% | 5.1% |
| 4 (COM) | 3.2 | 17.0% | 29.1% | 7.6% |
| 5 (COM) | 14.7 | 13.3% | 9.6% | 2.9% |
| 6 (COM) | 59.1 | 20.3% | 21.1% | 4.8% |
| | | **Peak Event Discharge (L/sec)** | **Peak Event Discharge (L/sec)** | **Peak Event Discharge (L/sec)** |
| 1 (SAN) | 10.8 | 58 | 70 | 4 |
| 2 (SAN) | 11.9 | 11 | 65.5 | 1 |
| 3 (SAN) | 11.1 | 8 | 49 | 1 |
| 4 (COM) | 3.2 | 70 | 191 | 28 |
| 5 (COM) | 14.7 | 36 | 117 | 2 |
| 6 (COM) | 59.1 | 509 | 1024 | 168 |

# 13.0 DIURNAL FLOW PATTERNS

From sanitary and combined sewers flow monitoring data, the hourly diurnal dry weather flow (DWF) patterns were extracted for weekdays and weekends. The following steps summarize the procedure used to determine the flow patterns:

Step 1 Dry weather days are defined as dry if no rainfall had occurred within the previous 72 hours

Step 2 Separate weekdays and weekends.

Steps 3-5 Carry out for the weekdays and the weekends separately;

Step 3 Series of diurnal flows were drawn for each station and from series of diurnal flows, approximately 5 typical days were selected; Selection criteria was based on visually examining and excluding flow patterns with outliners;

Step 4 The typical day flows selected were then normalized to determine a pattern for each day;

Step 5 The normalized patterns were averaged to get a typical hourly diurnal DWF pattern;

A weighted average of weekday and weekend patterns ({5 weekdays + 2 weekends}/7) can also be developed but for this study the flow patterns developed using the above five steps was used to calibrate the model.

The resulting hourly diurnal DWF pattern is illustrated in Figure 13.1**.** The hourly diurnal DWF patterns for the other stations are included in Appendix H.

The flow monitoring data collected was not specific enough for the determination of separate diurnal flow patterns to apply to Industrial/Commercial/Institutional (ICI) areas. These areas are combined with medium and high density residential areas.

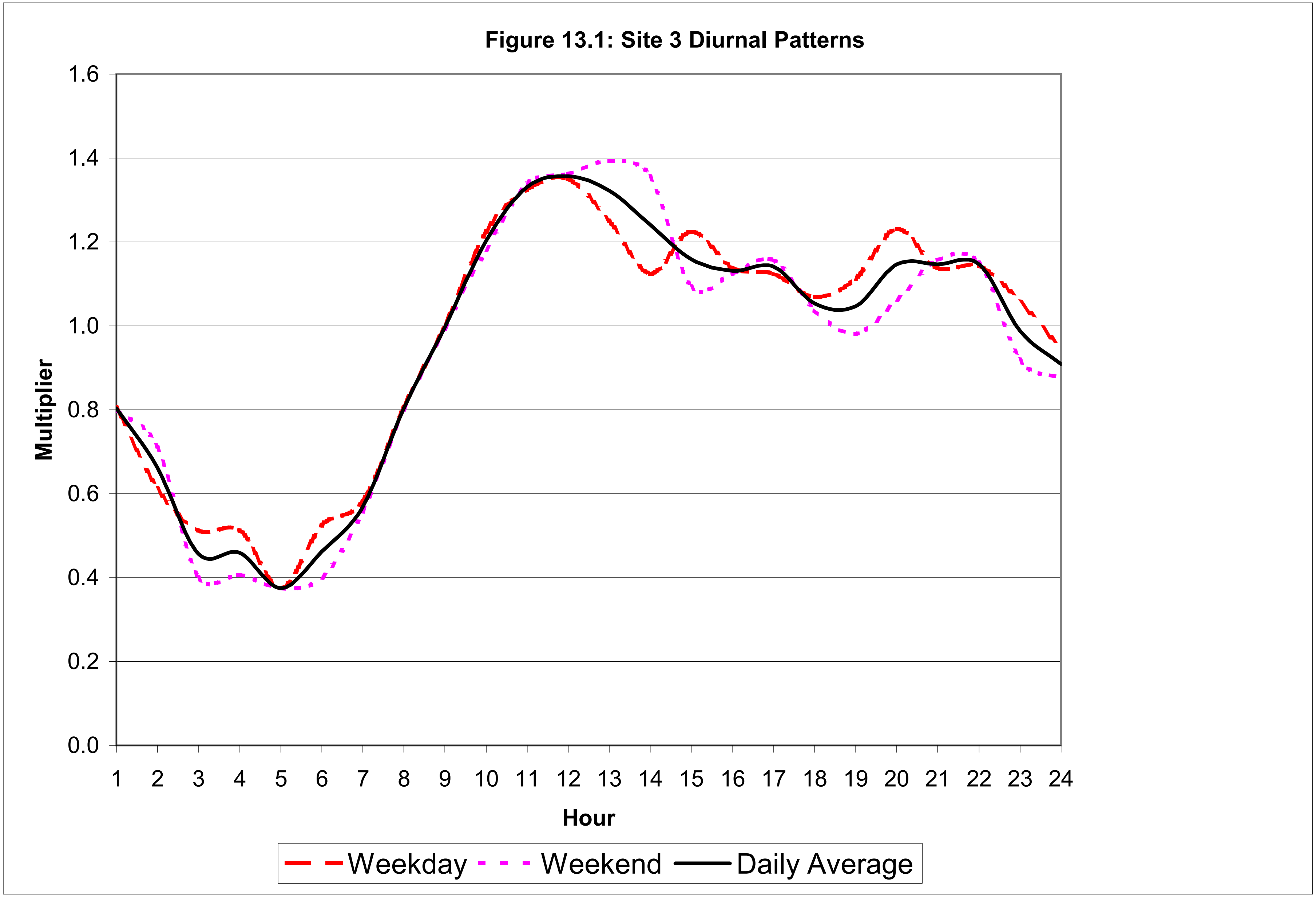


Figure 13.1: Site 3 Diurnal Patterns
Multiplier
Hour
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Weekday
Weekend
Daily Average

# 14.0 CONCLUSIONS

A total of six (6) flow monitoring stations were installed next to or in the LPN study area to observe the flows. One (1) rain gauge from the City was adopted close to the LPN study area to observe the precipitation. Three flow monitors (station 1, 2, and 3) were installed within the sanitary sewer system, and three flow monitors (station 3, 4, and 5) were installed within combined sewer system.

During the period of June 01, 2013 to November 01, 2013, one rainfall event (July 8, 2013) with total precipitation of 78.3 mm was recorded at the rain gauge station.

The quality of the flow monitoring data was reasonable for a majority of the stations. However, for three flow monitoring locations (station 1, 2 and 3) which are serviced by separated sewers, the results for the sanitary sewers show significant infiltration/inflow during rainfall events. This would suggest that there are inter-connections between the storm and sanitary sewer systems.

Stations 1, 2, 3, and 4 exhibit surcharged conditions during the July 8, 2013 event due to the various levels of inter-connections between the storm and sanitary sewer systems, and downspout connections to the sanitary (stations 1, 2, and 3) or combined sewers (station 4).

Limited information was provided with respect to the cause and/or type of potential interconnections. Information provided by the City would suggest that there are interconnections upstream of station 1, 2 and 3 potentially on private property.

# TECHNICAL MEMORANDUM NO.3

## 15.0 INTRODUCTION

### 15.1 General

Periodically, the City has experienced both surface and basement flooding in response to relatively infrequent rainfall events. One of the more recent events was the storm of August 19, 2005, an event in excess of 100 year return frequency that resulted in over 3,600 reported basement flooding occurrences across the City. In April 2006, City Council approved a work plan designed to focus on prevention, to the highest economical degree possible of surface flooding and reducing the amount of stormwater entering all sewer systems. The work plan identified 34 basement flooding areas throughout the City.

Basement Flooding Area 20, within the Lawrence Park neighbourhood is one of 34 areas in Toronto included in the “Basement Flooding Work Plan’, approved by City Council to address basement flooding across the City.

Traffic and pedestrian safety issues exist and road drainage systems are also unable to convey stormwater effectively

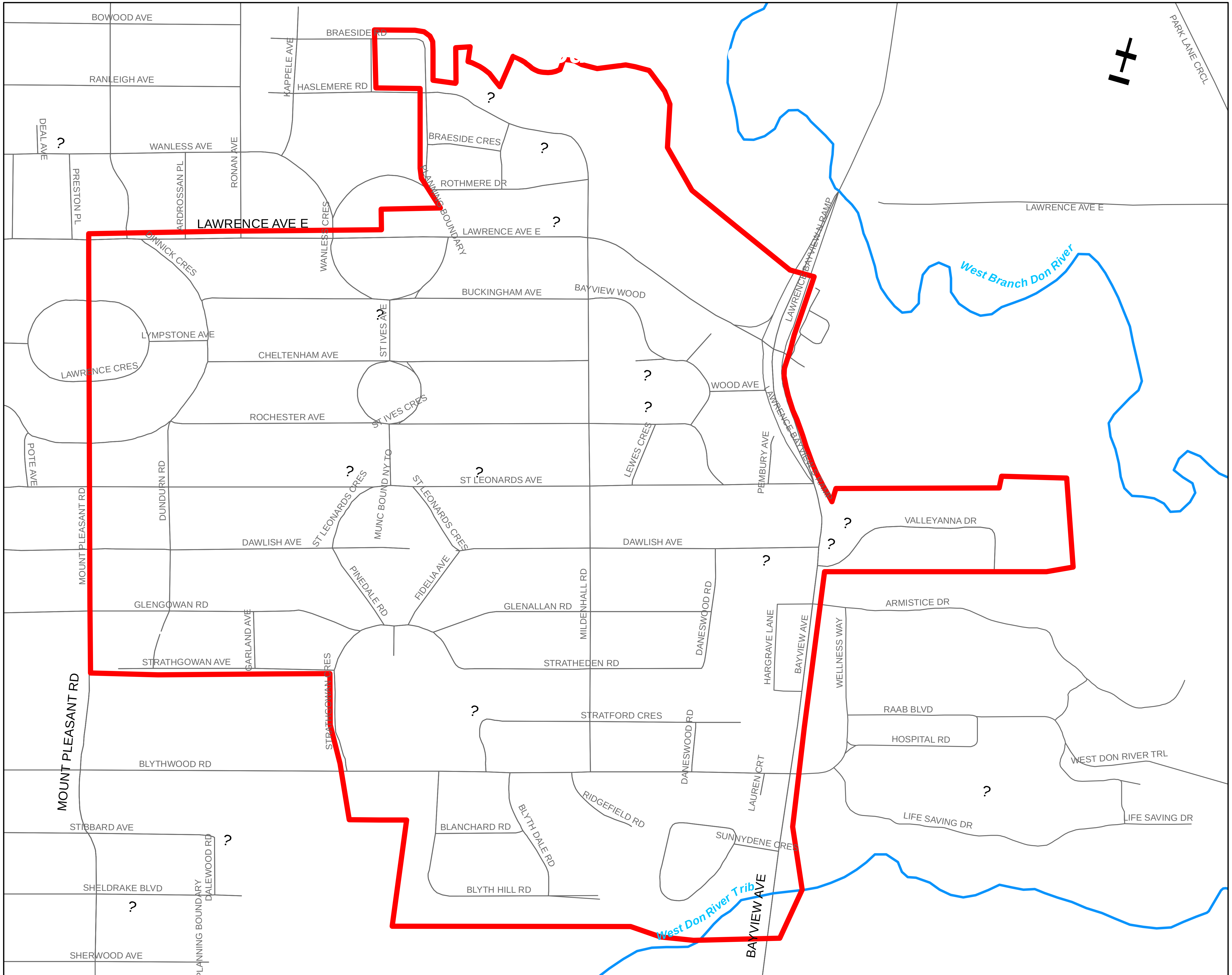
The City of Toronto has initiated a Municipal Class Environmental Assessment (EA) study to address issues relating to deteriorating road conditions, traffic, pedestrian safety, drainage problems and basement in the Lawrence Park neighbourhood.

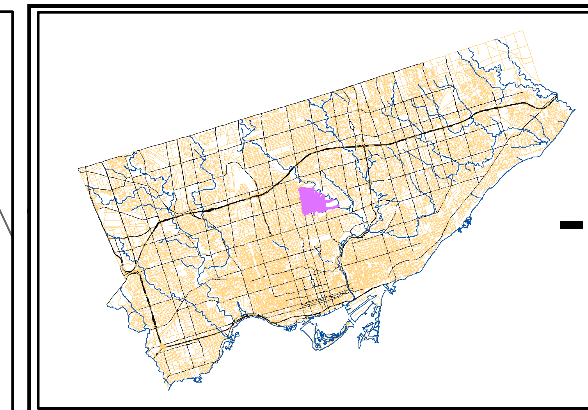
Figure 15.1 shows the Lawrence Park Neighbourhood (LPN) study area which is generally located in the central part of the City within Ward 25 – Don Valley West. The study area is roughly bounded by Blythwood Road, Ridgefield Road and Sunnydene Crescent to the south, Don River West Branch to the north, Mount Pleasant Road to the west, and Bayview Avenue in the east.

The study area is serviced by a mix of combined, sanitary and road storm sewers as well as roadside ditches. The Lawrence Park Neighbourhood Sewershed has four (4) stormwater outfalls discharging into the tributary of West Branch of the Don River.

The distribution of land use within the study area is approximately 70% single and multiple residential, approximately 10% institutional, commercial and industrial, and 23% park area and roadway. A majority of the commercial developments are located adjacent to Bayview Avenue.

A majority of the homes in area to the west of St. Ives Avenue (former City of Toronto) were initially serviced with combined sewers, which carry both wastewater and stormwater runoff. Throughout the 1960s until the mid 1980s, the City undertook sewer separation programs whereby stormwater runoff from public property was directed to a storm sewer. Subdivisions to the east of St. Ives Avenue (former City of North York) within the study area that were constructed from the 1960's onward are serviced by road ditches as well as a separate storm and sanitary system. Also provided in figure 15.1 are the former municipal boundaries for Cities of Toronto and North York.





LEGEND:

LPN Study Area

**HistoricalFlooding**

? Aug 19, 2005 & May 12, 2000

Watercourses

Roads

NOTES:

Base Mapping was provided by the City of Toronto

400 200 0 Meters

**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Lawrence Park Neighbourhood Study Area**

**FIGURE No. 15.1**

**DATE: SEPTEMBER 2013**

As of 2013, approximately 10% of the area is serviced by combined sewers, 20.5% with partially separated sewers (storm/combined) and 69.5% with separated sewers (storm/sanitary).

The intent of Technical Memorandum #3 is to summarize the model development process, present the analysis of the storm, combined and sanitary systems under a range of conditions as well as to define the primary source(s) and/or causes of basement flooding in the LPN study area.

### 15.2 Target Level of Service

The City of Toronto has defined the following level of service criteria for sanitary, storm and combined sewer systems.

These criteria are defined below:

- **Sanitary Sewer System:**

The maximum hydraulic grade line (HGL) of the sanitary system shall be maintained at an elevation at least 1.8m below the ground elevation under a storm event equivalent to the May 12, 2000 storm as gauged at the City’s Oriole Yard, located at Sheppard Avenue and Leslie Street;

- **Storm Drainage System:**

A 100 year level of protection is being targeted for the storm system. During this event, the major system flows are to be maintained within the road allowance and no deeper than outlined in the Wet Weather Flow Management Guidelines, November 2006 and the maximum HGL of the storm sewer system shall be maintained at no surcharge level, where feasible, for the local street sewers, during the City 100-year design storm.

- **Combined Sewer System**

The maximum HGL of the combined sewer system shall be maintained at an elevation at least 1.8m below the ground elevation under a storm event equivalent to the City 100-year design storm. During the 100-year design event, if the depth of the major system flow is less than 300 mm within the right-of-way, then the target level of service is considered satisfied.

These criteria were used as a basis for defining level of service and subsequent remedial works. The criteria were further refined to address the conditions within the study area as follows:

**Sanitary Sewer System**

The maximum hydraulic grade line (HGL) of the sanitary system shall be maintained at an elevation at least 1.8m below the ground elevation under a storm event equivalent to the May 12, 2000 storm as gauged at the City's Oriole Yard, located at Sheppard Avenue and Leslie Street;

**Storm Drainage System**

A 100 year level of protection is being targeted for the storm system. During this event, the major system flows are to be maintained within the road allowance and no deeper than outlined in the Wet Weather Flow Management Guidelines, November 2006 and the maximum HGL of the storm sewer system shall be maintained at no surcharge level, where feasible, for the local street sewers, during the City 100-year design storm.

- **Partially separated area (combined/storm)** – in areas where a majority of the storm sewers are shallow and constructed after combined sewer were installed – only surface flooding criteria is applied as the foundation drain is connected to the combined sewer; and

- **Separated area (sanitary/storm)** – in areas where sanitary and storm sewers were installed – surface flooding criteria is applied;

**Combined Sewer System**

The maximum HGL of the combined sewer system shall be maintained at an elevation at least 1.8m below the ground elevation under a storm event equivalent to the City 100-year design storm. During the 100-year design event, if the depth of the major system flow is less than 300 mm within the right-of-way, then the target level of service is considered satisfied.

- **Partially separated area (combined/storm)** – in areas where combined sewer were originally installed – only sewer HGL criteria (the maximum HGL shall be maintained at least 1.8m below the ground under a 100-year design storm event) is applied; and

- **Fully combined area (combined sewer only)** – in areas where only combined sewer were installed – both surface flooding criteria and sewer HGL criteria (the maximum HGL shall be maintained at least 1.8m below the ground under a 100-year design storm event) are applied.

### 15.3 Technical Memorandum #3 Organization

Technical Memorandum #3 is organized into the following sections:

1. Introduction

- Provides the background underlying the preparation of the Technical Memorandum.

2. Model Overview

- Overview of the InfoWorks modelling tool and data sources.

3. Storm System Model Development

- Detailed description of storm model development and calibration.
- Application of storm system model for historical events and 100-year design storm.

4. Sanitary System Model Development

- Detailed description of sanitary model development and calibration.
- Application of sanitary system model for historical events including May 12th, 2000 assessment event.

5. Combined System Model Development

- Detailed description of combined model development and calibration.
- Application of combined system model for historical events and 100-year design storm.

6. Conclusions and Recommendations

- Brief conclusions and recommendations of the calibration / validation are presented.

# 16.0 OVERVIEW OF MODEL DEVELOPMENT

Historically, the City has used two separate models to assess system performance. One model, the Quantity-Quality Simulation Model (QQS), was used to assess effectiveness of potential control measures on an annual basis, while the Hydrograph-Volume-Method (HVM) was used to assess system performance on a single-event basis. For this Class EA study, a more detailed and site-specific model has been developed that integrates sanitary, combined and storm system modelling taking into account overland flow as part of the drainage network.

This section is intended to provide details on the development of the hydrologic and hydraulic modelling tools used to assess surface and basement flooding in the LPN study area. InfoWorks CS software by Innovyze was selected by the City for this assignment and is used for the sanitary, combined and storm models. The version of InfoWorks used for this assignment is InfoWorks CS 11.5. The model of the sanitary, storm and combined sewer systems in the LPN Study Area will be a single integrated model network, including a minor drainage system comprising the sanitary, storm and combined sewers; all connected to a major drainage system including overland flow routes for surface runoff and excess flows spilled from surcharged sewers. The sanitary and storm (and combined) sewer systems will be effectively integrated and interconnected by the major drainage system.

## 16.1 Modelling Objectives

A detailed hydrologic/hydraulic model assessment of the sanitary, combined and storm networks using InfoWorks was undertaken with the following objectives:

- To define the primary cause(s) of basement flooding;
- To define the magnitude and extent of surcharging in the collection system as well as estimate surface flooding depths;
- To aid in the development and evaluation of alternatives based on the City's target level of service/performance; and,
- To integrate the sanitary, combined and storm system modelling where potential interaction is identified.

The sanitary, combined and storm system models are tools used to illustrate how the collection systems work and interact for a range of wet weather conditions. The model is a tool limited by the available calibration data and assumptions made based on best professional judgment. Throughout the development process every effort has been made to document assumptions and to base assumed parameters on available documentation, guidance and experience.

### 16.2 InfoWorks Model

InfoWorks CS by Innovyze was selected by the City as the sewer system modelling software. InfoWorks combines a relational database with geographical analysis to provide a single environment that integrates asset planning with detailed hydrological and hydraulic modelling. The InfoWorks model incorporates full solution modelling of open channel and closed pipe networks simulating complex hydraulic conditions of backwater effects and reverse flow, trunk sewers, complex pipe connections and complex ancillary structures. InfoWorks hydrologic routine generates wastewater flows as well as storm related flows including direct inflow, infiltration and groundwater infiltration.

InfoWorks has various hydrologic models available in the software package. For this project the EPA SWMM RUNOFF routine was adopted for the sanitary, combined and storm sewer systems.

The InfoWorks hydraulic routine is used for the sanitary, combined, and storm sewer systems. A special feature of the InfoWorks model important to model development is the “gully” node definition. The “gully” feature is essential to the development of a dual drainage system connecting overland storm water system (major) with the storm water collection system (minor) representing the entire storm drainage network. By defining a manhole’s flood type as “gully”, flow accumulated on the overland surface is able to enter the minor system, conversely storm water in the collection system can surcharge to the overland network. In actuality, the gully represents catchbasins where surface runoff enters the collection system. A specified number of catchbasins within a subcatchment along with a flow rating curve allows the gullies to limit the rate at which flow can enter or exit the sewer system.

InfoWorks CS is a comprehensive hydrologic/hydraulic modelling tool suitable for modelling all of the complexity of sanitary, combined and storm water drainage systems found in LPN study area.

### 16.3 Data Sources and Compilation

To meet the modelling objectives of this study, it is necessary for the sewer system model to reasonably represent the current physical systems. This section presents a summary of data sources used to define the necessary physical data as well as other supporting information used during model development.

The primary source of information is the City’s Geographical Information System (GIS) database. The City maintains physical network information in a GIS format detailing sewer and manhole data for sanitary, storm and combined systems. The GIS datasets provided physical information related to pipe diameter, invert elevation, pipe length, and manhole ground elevation. The available GIS database information was imported into the

InfoWorks collection system model for the respective systems (sanitary, combined and storm).

Considerable effort was made to identify erroneous data and to identify data gaps to establish a reasonable representation of the storm and sanitary collection systems. Data was corrected and data gaps were filled by reviewing as-built drawings as well as inferring data from surrounding information using best professional judgment where needed to develop the necessary physical information.

As part of the data vetting process InfoWorks completes a data validation process after data is imported. The validation identified possible discrepancies in the data that need to be addressed before proceeding in the sanitary, combined and storm systems. Discrepancies included but were not limited to sanitary or combined sewer manholes identified as storm manholes and vice versa, incorrect ground elevations of manholes, missing diameters, and missing invert elevations. As part of the data vetting process the InfoWorks model validation process was used to identify possible data anomalies not apparent in data import process. Technical Memorandum #1, Preliminary Sewer System Physical Assessment, October 2013 highlights the data gaps and anomalies and how they were addressed.

Additional GIS data and AutoCAD drawings provided included information themes related to land use, population, topography,  historical basement flooding, water consumption and natural drainage. This information was used in the definition of storm, combined and sanitary model catchments, dry weather flow characterization and the development of initial model hydrologic parameters.

Another important source of data was the flow monitoring program conducted in 2013 between June and November. In total, six (6) monitoring stations were installed consisting of three (3) combined, and three (3) sanitary stations. Technical Memorandum #2 provides a description of the flow monitoring program and data analysis. The flow and rainfall information collected as part of this program was used to calibrate the combined and sanitary system models.

Other sources of information used in the development of the sanitary, combined and storm system models included background reports and previous studies conducted in the study area. This background information provided insight on system performance under a range of conditions.

As well, Technical and District staff with the City provided background information on the area and compiled the CCTV results, flooding records, foundation drain connection records and historical reports. Staff insight and information was used in reviewing results as a way to check the modelling results.

An un-calibrated InfoWorks CS model which included part of combined sewer system in the LPN study area was provided by the City in late June 2013 for reference beyond the initiation setup of the LPN model. The un-calibrated model provided a template for the

LPN model construction as it included various useful hydrologic and hydraulic parameters.

# 17.0 STORM SYSTEM MODEL DEVELOPMENT AND PERFORMANCE

The following section outlines the development and calibration of the storm system model for LPN study area. Figures in this section are located at the end of the section.

## 17.1 Description of Storm Drainage System

Figure 17.1 shows the storm sewer system and locations of storm outfalls. The overall storm study area is approximately 160 ha. The 160 ha LPN study area consists of approximately 1300 properties. The LPN study area is primarily single-family detached residential landuse developed in the 1920’s to 1940’s. A significant percentage of the houses have been renovated or torn down and rebuilt. The storm drainage system for the study area drains to the West Don River.

The Digital Elevation Model (DEM) with break lines was used to delineate the overland drainage system features such as surface drainage flow path and direction, surface ponding areas, and drainage area boundaries. Topography of the LPN study area is such that the overland flow drains from northwest to the southeast and east ends to the West branch of the Don River at the designated outfalls as shown in Figure 1.1. The high point in study area is located at northwest side where as the low point is located at the southeast boundary of the study area. Not all streets provide positive drainage as a result some low lying areas exist where there is no defined overland flow route or outlet. Overland storm flows accumulate in these areas and surface flooding may occur under heavy storm events. Low lying areas identified as part of the field survey include the Buckingham Avenue, Blyth Hill Road, Strathgowan Crescent, Sunnydene Crescent and Stratheden Road locations which correspond to reported basement flooding and/or responses basement flooding from PIC 1 questionnaire in the area.

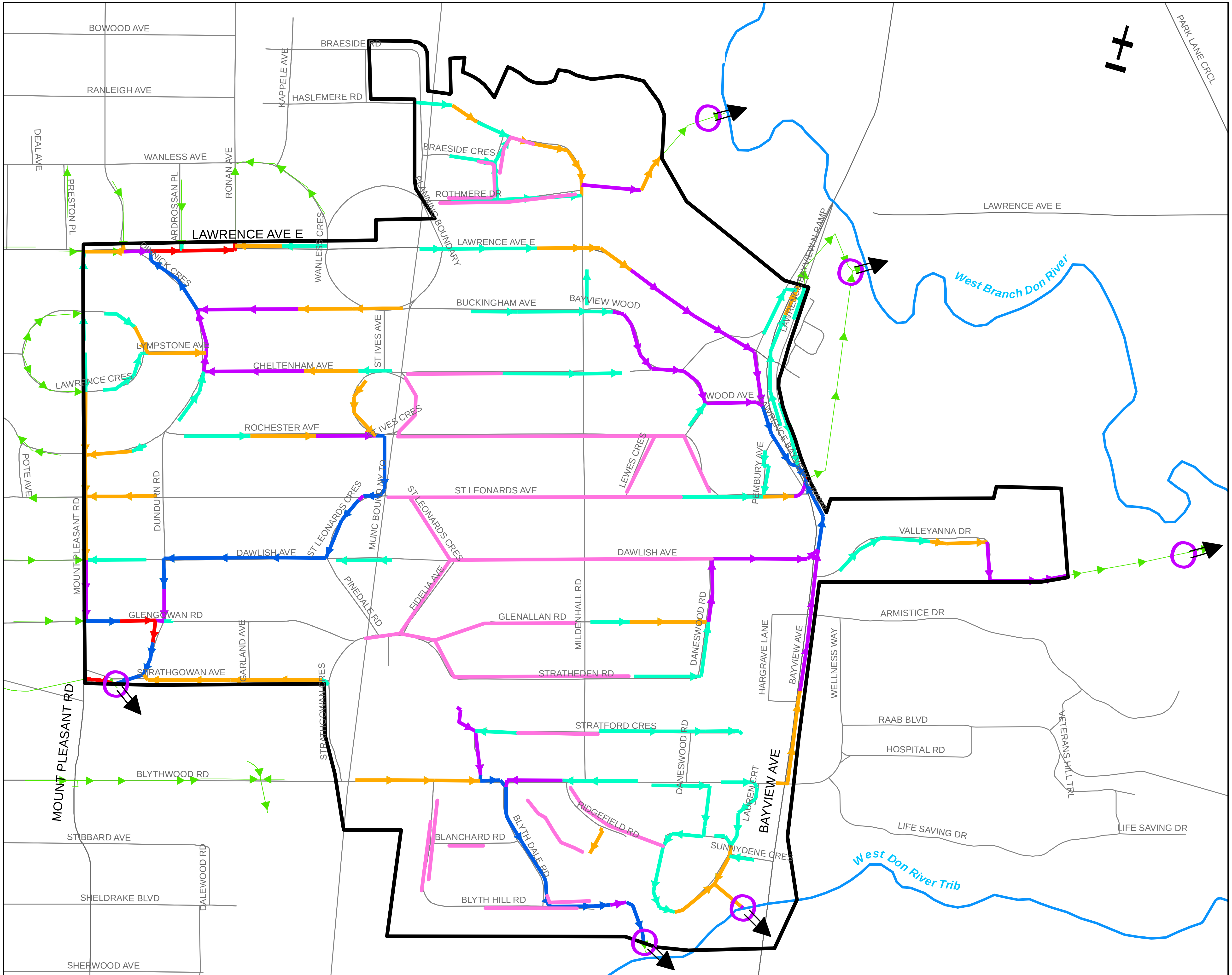
Figure 17.2 shows the overland flow path and surface ponding areas. Field checks were completed to verify the DEM with respect to surface ponding locations, overland flow routes and the storm catchment boundary.

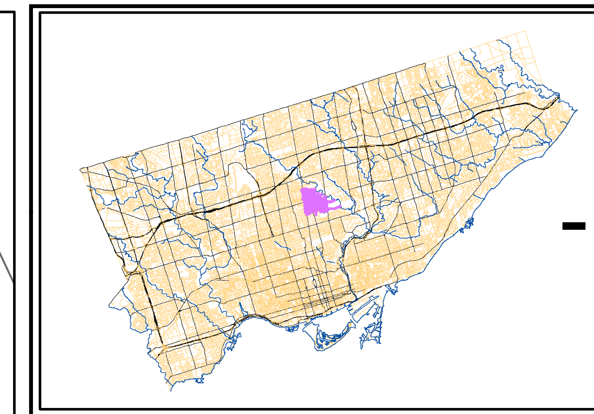
## 17.2 Model Development

The following section describes the InfoWorks hydrologic/hydraulic model developed to simulate the performance of the existing storm drainage system. The model was developed to assess existing sewer and overland drainage capacity under varying rainfall events, and is the basis for developing and evaluating remedial measures.

## 17.3 Network Data

The storm dual drainage water collection system consists of two components; the major and minor systems. The major system represents overland flow paths such as roadways and ditches, while the minor system is predominately defined as the underground pipe network. The major system is connected to the minor system through catchbasins, which are defined as a “gully” in the InfoWorks model.



LEGEND:

- LPN Study Area
- Storm Sewer
- Watercourses
- Roads
- Outlet

**Storm Pipe Diameter (mm)**

- 200 - 300
- 300 - 450
- 450 - 750
- 750 - 1200
- 1200 - 2100
- Ditches

400 200 0 Meters

NOTES:

Base Mapping was provided by the City of Toronto

TORONTO

Aquafor Beech Limited

**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Storm Sewer System**

**FIGURE No. 17.1**

**DATE: APRIL 2014**

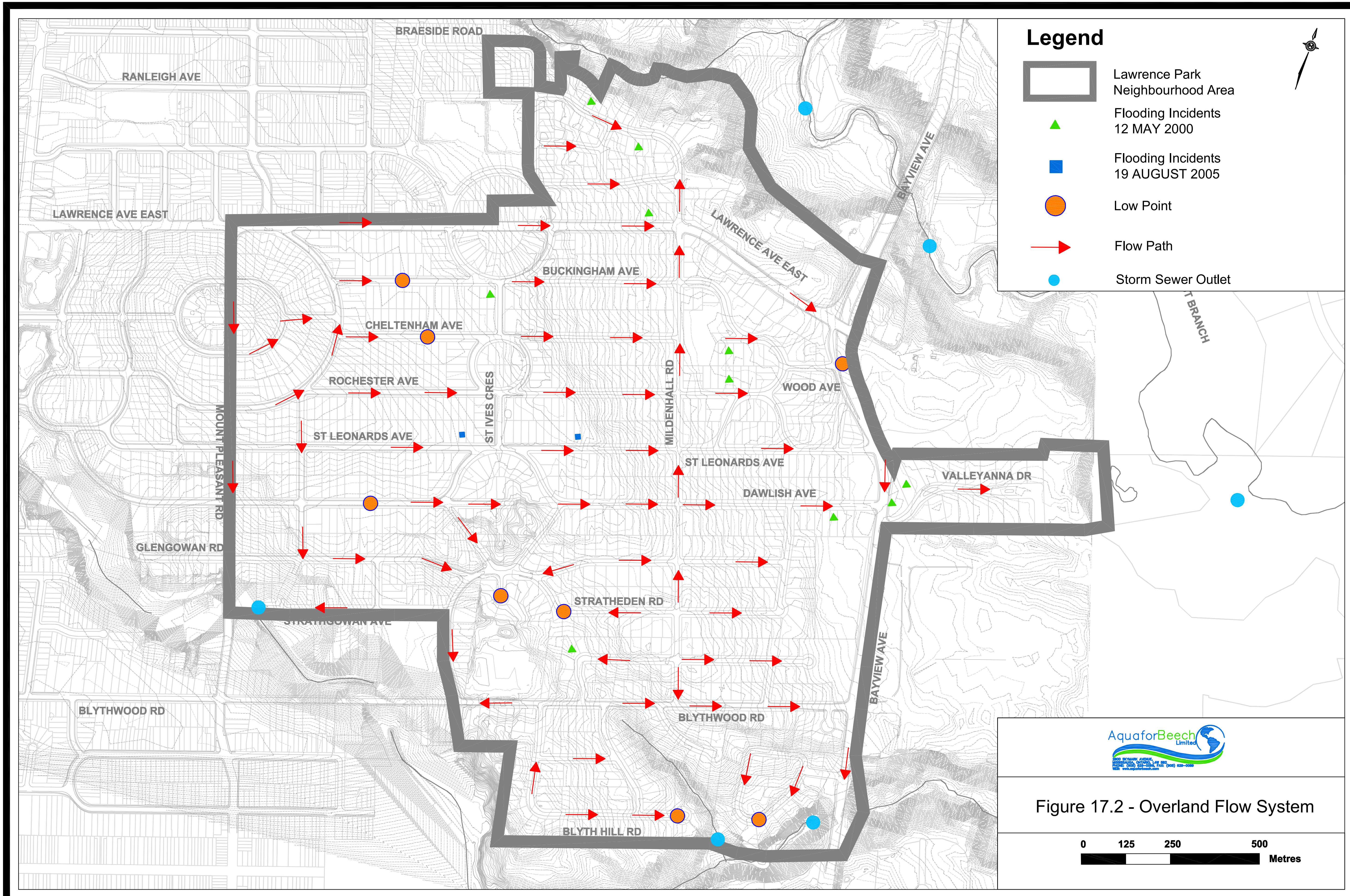


Figure 17.2 - Overland Flow System

The following highlights the development of the minor and major systems.

### 17.4 Minor System

The City provided a series of databases associated with the storm collection system. Databases associated with pipes, manholes and catchbasins provided geometry information such as length, diameters and elevations. As well, other physical information regarding material and date of construction provided the relevant information used to develop the storm system model.

In reviewing the data provided and through the importing process of the InfoWorks model, data gaps were identified. Data gaps tended to fall into the following categories:

- Isolated Manholes – not connected to the sewer network.
- Isolated Storm Sewers – not connected to the network.
- Missing Pipe Information – such as invert elevations or diameter.
- Special Features – such as control structures were not contained as part of the infrastructure databases.

An initial validation was conducted to identify where anomalies occurred in the physical pipe network. It was discovered that after validating, errors and warnings were found within the system, many of which were repetitive due to the nature of the error/warning. As well at times, terminology used in the GIS format was not compatible with terminology used in InfoWorks when importing. An example of this would be shape of pipe; while in GIS a circular pipe would have the notation “RND” (round), InfoWorks does not recognize this notation and views rounded pipes as “CIRC” (circular), hence generating repetitive error messages.

An initial “walk-through” of the storm system identified obvious information that did not import from the GIS database into InfoWorks. Correction of the obvious information greatly shortened the list of errors and warnings. Most of the remaining errors or warnings were associated with missing physical data. Where missing information was limited, the calculated or assumed value was flagged in the model. In most cases, missing data was associated with pipe diameter or pipe/manhole inverts.

Most of the gaps were filled using the digital sewer plan and profile drawings available from the City’s ImageSite. When no information was available in the ImageSite, the missing information was inferred using the InfoWorks model inference tool and best engineering judgment. The following assumptions were also considered to complete the sewer network model:

- Missing pipe inverts that could not be inferred by the InfoWorks inference tool was assigned inverts based on the average slope of pipe up and downstream of the missing inverts; and

- Physical sewer connections that did not have a manhole at the connection point (i.e. private property sewers or laterals connected to collectors) were connected in the model using a dummy manhole.

The data gap analysis associated with link information such as missing pipe inverts for the storm system, as well as the data flags used is summarized in Appendix A of Technical Memorandum #1. Information pertaining to manhole ground surface elevations was complete for LPN study area.

All manholes were represented as nodes in the model. Additional fictitious nodes were created for modeling purposes (e.g. major changes in major system grade not located near a manhole, nodes to simulate flow control functions of roof drains, etc.). Prefixes were applied to the node ID's of fictitious nodes created in the model to indicate their purposes. Some fictitious nodes examples are listed below:

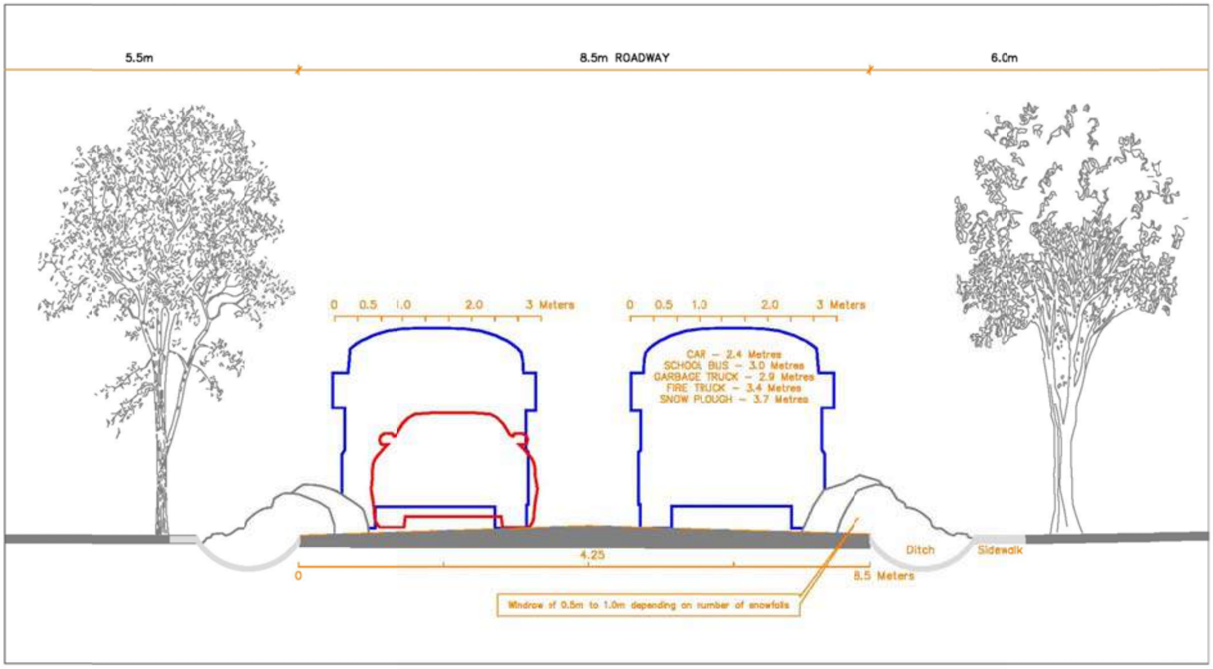
OVL#01 – represent overland flow node;
RRF#01 – represents residential roof node; and
ICIRF#01- represents Industrial/Commercial/Institutional roof mode.

The storm sewer model was assembled using the database provided by the City and considering every manhole as a node. There are approximately 240 storm pipes within the storm service boundary of the LPN study area. All the pipes are either circular or rectangular and range in diameter from 200 mm to 2100 mm. A majority of the streets in the study area are serviced by a storm sewer system. These storm sewers discharge to the receiving watercourses via storm sewer outfalls.

### 17.5 Major System – Overland Flow

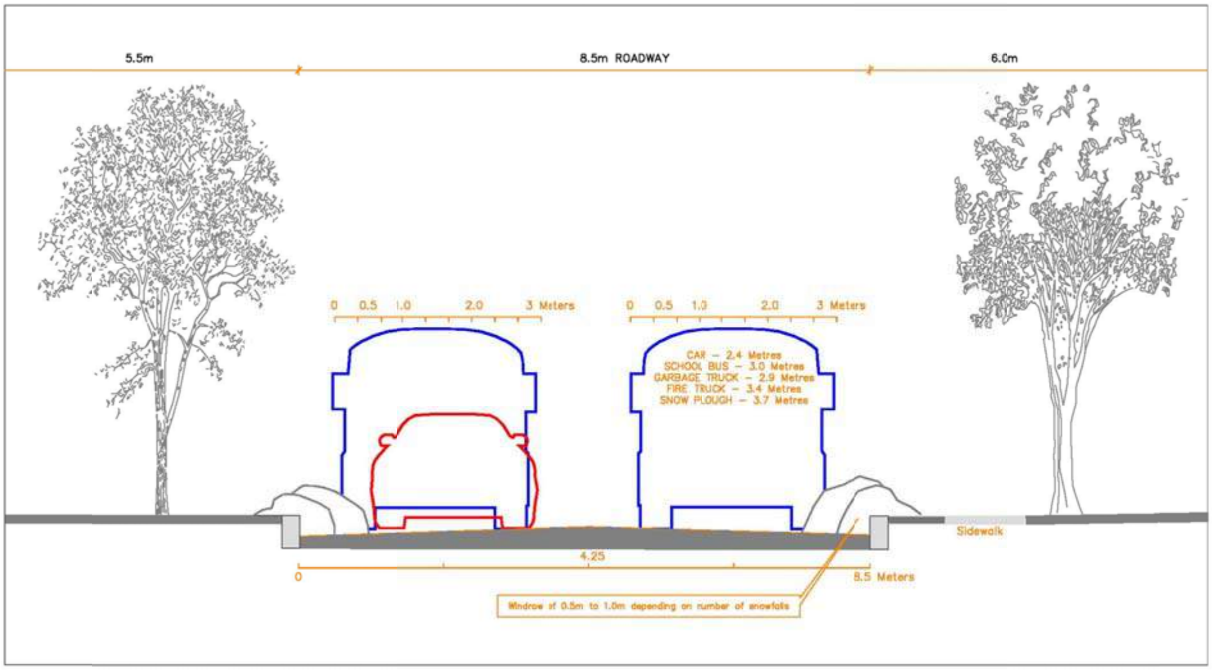
Surface area characteristics were considered for every subcatchment which was described on a manhole to manhole basis. The overland runoff system was then added as an additional link between nodes as represented by the street cross sections.

The overland flow system typically consisted of streets with flows constrained by the curb along both sides of the street. LPN study area does have approximately 5.0 km of ditch drainage as part of the overland flow network. The accompanying graphic below illustrates a typical rural roadway cross section.




The streets were modelled as wide shallow open channels to reflect the appropriate geometry, cross section and channel roughness. The overland channel invert levels were set at the manhole cover levels such that flows in the overland channels can occur when there is flooding out of the manholes from the minor drainage system or when the flow is restricted into the minor system at the catchbasin based on the catchbasin inlet capture capacity.

The typical roadway channels defined to represent local and collector roads consisted of user defined cross sections. Two typical cross sections were used in the study area including a road right-of-way (ROW) width of 20.1 metres with a height of 0.30 metres for local roads, and a ROW width of 26.1 metres and a height of 0.30 metres for collector roads. Adjustments were made to the network as necessary, such as additional nodes, overland segments, invert adjustments, etc., to replicate the overland flow paths predominately associated with roadways. The accompanying graphic below illustrates a typical urban roadway cross section.




A portion of the LPN study area has ditch drainage along the road right-of-way instead of standard curb and gutter which is typically found in urban residential neighbourhoods. For this portion of the LPN study area, the roadway cross sections were used including survey data undertaken in the winter of 2013 to define existing road conditions. While the surface flow depth greater than 300 mm above surface, it could indicate potential surface flooding of private properties, and hence potential basement flooding from surface runoff in these areas.

The major system is connected to the minor system through inlets, or catchbasins. The number of catchbasins was adjusted in the database and the type of catchbasin cover was considered using the information obtained from the field survey. Catchbasin capacity was considered in the model as a head discharge relationship and limited to 55 L/s which was provided based on the road drainage study entitled “Road and Bridge Deck Drainage Systems, J. Marsalek, 1982”. The inlet characteristics and number of catchbasins associated with a subcatchment and overland flow segment are defined at model nodes defined as “gully” nodes.

With the completion of the major system network, tests were undertaken to ensure network continuity between the overland network (major) and pipe network (minor) behaved as expected. The end result was a dual drainage model of the storm drainage network.

### 17.6 Catchment Delineation

The storm system catchment delineation process used GIS generated layers and manual interpretation of urban features and topography. Overland flow routes and low-points were generated from the DEM provided by the City and verified in the field defined major drainage areas which were subsequently broken down to individual subcatchments based on the major/minor system network. Land parcel boundaries, buildings, contours, and aerial photography were used in conjunction with storm system elements (pipes, manholes and catchbasins) to delineate subcatchments boundaries in GIS. Each delineated subcatchment was associated with a node (manhole) as the load point to the major and minor system storm model. Some subcatchments were associated with links (overland flow - roadway within the right-of-way) in the model to mimic the runoff from the roof to the roadway.

The composition of pervious and impervious areas in each subcatchment was calculated from GIS and aerial information. The parcel data layer provided the boundaries of properties and road allowances. The aerial photos were used to categorize all roadways in LPN study area and determine the total paved area based on width as well as the occurrences of sidewalks and boulevards. The building footprints were used to calculate the roof area for each parcel and the house-to-house survey results determined whether the roof area was attributed to either the directly connected or to the overland system.

Paved areas such as driveways, patios, and parking lots that are not defined in a GIS layer were determined by using land use classifications and aerial photos. Distinct parcels of land that differed from the normal land use classification impervious area were examined directly from aerial photos in the GIS and appropriate impervious areas were assigned to these subcatchments.

For each subcatchment, the total contributing area was split to represent the portion that contributes directly to the sewer (minor) system, and the portion that contributes to the overland (major) system. The connected portion would include roof and driveway drains that are connected through a storm lateral to the storm sewer.

The balance of the catchment area was connected to an overland flow segment and consists of pervious and impervious areas associated with grassed areas, driveways, roadways, and disconnected downspouts. The overland flow would only enter the minor system through a model node defined as a “gully”.

The subcatchment takeoffs quantified roof area, impervious surfaces (roads, driveways, sidewalks) and pervious surfaces (grass, open space). The area survey information, in combination with the connection history, was used to identify roof tops connected to the storm sewer or discharging to the surface. This information is used to prepare the InfoWorks catchment dataset and storm system hydrology. The subcatchment is structured using four “runoff area”.

Table 17.1 provided in City’s Draft InfoWorks CS Modeling Guidelines which summarizes the possible sewer types of a catchment and its subcatchment ‘runoff area’ connections to sewers.

**Table 17-1: Subcatchment ‘runoff area’ Connections to Sewers**

| Sewer system type in a catchment | Sub-catchment #1 (wastewater & baseflow - DWF) | Sub-catchment #2 (connected roof) | Sub-catchment #3 (foundation drain) | Sub-catchment #4 (disconnected roof and surface runoff, via CBs - WWF) |
|---|---|---|---|---|
| Combined sewer (s) only | to combined sewer | | | |
| Combined sewer and storm sewer (partially separated) | to combined sewer | | to combined or storm sewer | to storm sewer |
| Sanitary sewer and storm sewer (separated) | to sanitary sewer | to sanitary sewer | to sanitary sewer | to storm sewer |

Four types of sub-catchments were setup based on the recommendations from the draft InfoWorks CS Modelling Guidelines provided by the City. They are listed in the following:

Subcatchment #1 - Dry Weather Flow (DWF) represents wastewater from residential and Industrial, Commercial, and Institutional (ICI) areas plus baseflow (i.e. Groundwater Infiltration or GWI) drain directly to corresponding sewer;

Subcatchment #2 - Connected Roof (CR) represents area from connected roof drains directly to the corresponding sewer;

Subcatchment #3 - Foundation Drain (FD) represents area from foundation wall drains directly to the corresponding sewer. It is our assumption that a FD area equivalent to 10% of the building area, which has been input in the model for initial model setup; and

Subcatchment #4 - Surface Runoff (WWF) represents disconnected roof areas, as well as tributary paved and non-paved (i.e. pervious) areas over private and public properties drain to the major system or catchbasin.

The hydrologic model used in InfoWorks is the EPA SWMM RUNOFF routine. The primary hydrological parameters include the subcatchment area, percent imperviousness, width, and ground slope. The initial values for these parameters were determined by using land use and topography information contained in the City's GIS database.

For the larger storm event, it is assumed that the downspout capacity of a roof drainage system would be exceeded (roof downspout capacity - 3 L/s each as suggested by the City's Draft InfoWorks CS Modelling Guidelines) such that a portion of roof runoff would overflow to the surrounding pervious surface and contribute to the overland flow.

Surface infiltration was simulated using the Horton equation, which is a widely accepted method. Three input parameters are required: the maximum infiltration rate, minimum rate, and a decay rate parameter which determines how quickly infiltration rate declines during a storm event. For LPN study area, maximum and minimum rates of 260.0 and 26.0 mm/hr were applied respectively, and a decay rate parameter of 2 mm/hour. These values were selected based on consideration of local surficial soil conditions and recommended literature values.

### 17.7 Rainfall and Flow Monitoring Data

Technical Memorandum #2 provides details regarding the extent of the rainfall and flow monitoring program. Rainfall and flow monitoring data was collected for calibrating the sanitary, combined and storm system hydrologic and hydraulic model.

The rainfall and flow monitoring program was carried out from June 2013 to November 2013. Flow monitoring locations have been selected at three (3) combined sewer sites and three (3) sanitary sewer sites. A City rain gauge (39-P, Mt. Pleasant) is located on the roof of Northern Secondary School located at southeast corner of Mount Pleasant Road and Broadway Avenue. The location of the rain gauge was selected in order to get the local precipitation data for modeling and monitoring purposes.

Figure 17.3 showed the locations of flow monitoring and rain gauges.

Five rainfall events (total precipitation amount > 10mm) were recorded in the summer and fall monitoring periods suitable for model calibration/verification. The recorded rainfall events are shown in Table 17.2.

**Table 17-2: Summary of Rainfall Events**

| Rainfall Event Date | Total Precipitation (mm) | Peak Precipitation intensity in 1 Hour (mm) | Duration (hr) | Peak Precipitation Intensity (mm/hr) |
|---|---|---|---|---|
| June 10th, 2013 | 21.5 | 11.0 | 4.1 | 5.3 |
| June 28th, 2013 | 33.5 | 30.3 | 2.2 | 15.5 |
| July 7th, 2013 | 34.0 | 21.0 | 4.6 | 7.4 |
| July 8th, 2013 | 78.3 | 51.0 | 6.8 | 11.5 |
| July 27th, 2013 | 12.3 | 12.3 | 1.0 | 12.3 |

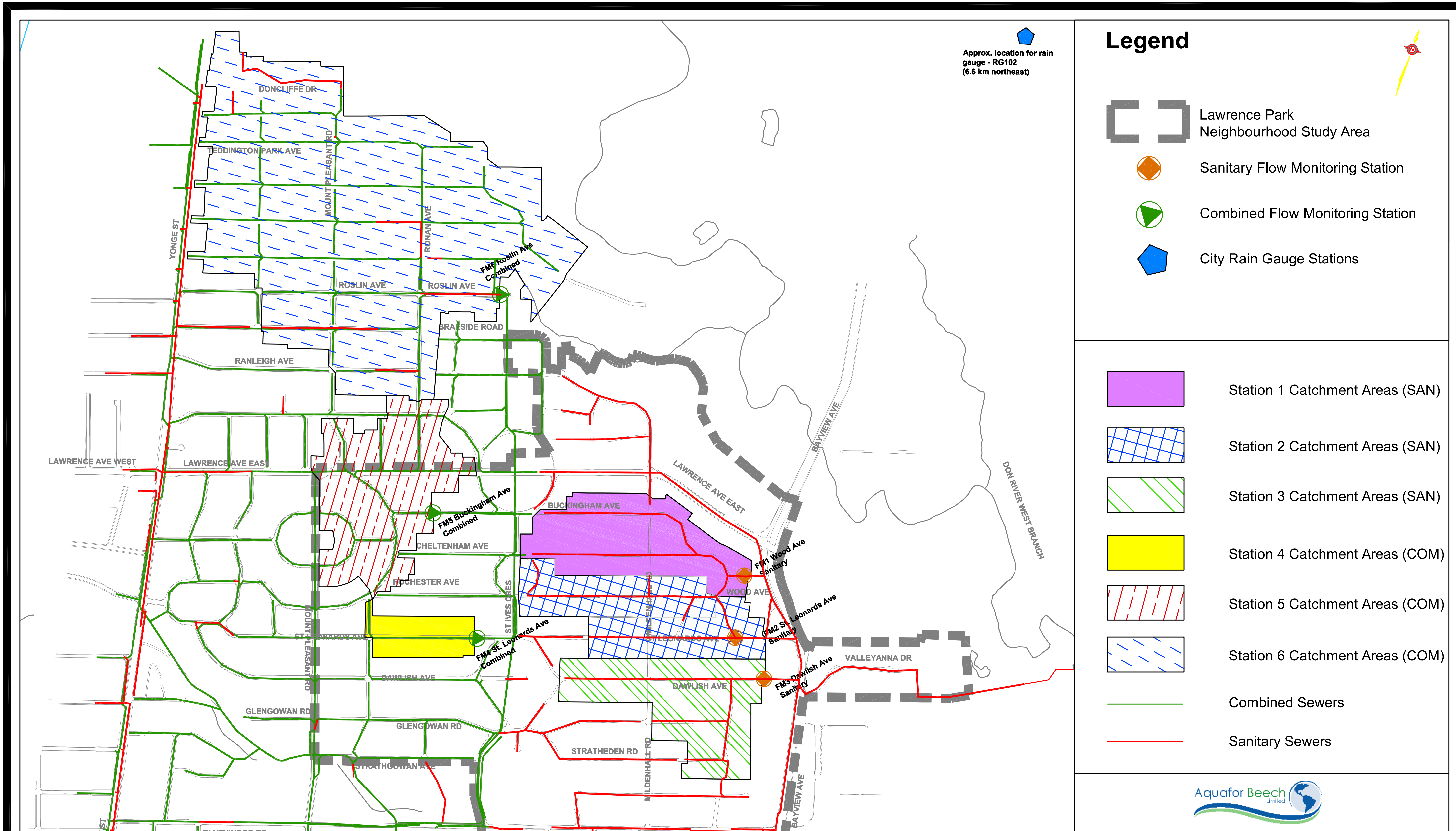



Figure 17.3 - Flow Monitoring and Rain Gauge Locations

## 17.8 Historic Storm Events

Several historical rainfall events have been known to cause flooding in various areas across the City. Two of the more significant events which were used to simulate by the calibrated/verified in this study are:

- **May 12, 2000** (94.2mm over 24hrs with a peak intensity of 160mm/hr at Station 102) - This event is considered to have a 25-year to 50-year return period with a longer duration than the August 19, 2005 event. For the purposes of this study, the May 12, 2000 event is considered to be the critical storm on the sanitary system; and,

- **August 19, 2005** (105.8mm over 13hrs with a peak intensity of 141.6mm/hr at Station 102) – This event is considered to be greater than the 100-year event.

## 17.9 Model Calibration and Verification

The calibration procedure was undertaken once the physical attributes such as diameter, invert, etc. in the model were validated without any errors. The following section discusses calibration and verification using the monitored events as well as model validation for historical events (May 12th, 2000 and August 19th, 2005).

## 17.10 Wet Weather Calibration/Verification

Model calibration is achieved by changing model parameters to produce results matching the measurements within reasonable accuracy. Model verification involves testing the calibrated model performance using measurements different than the calibration period to ensure the repeatability of the model results.

After reviewing the results of the monitoring program, five storm events were selected for calibration and verification of the model. The storms were selected based on their relative intensity, accuracy of recording and reliability. The five selected storms are those shown in Table 17-2 and occurred on June 10th, 2013, June 28th, 2013, July 07th, 2013, July 08th, 2013 and July 27th, 2013.

The July 08th, 2013 event was the **primary** calibration event having the greatest volume (78 mm) with a moderate intensity (11.5 mm/hr.). The June 10th, 2013, June 28th, 2013, July 07th, 2013 and July 27th, 2013 events were used for model verification. The summary of modelled versus measured event volumes and peak flows for the storm verification events is presented in Sections 18.8 and 19.9. In comparing model results with measurements, flows in the sewer were considered. Appendix I contains the calibration curves showing measured and modelled flow for the July 8$^{th}$ event.

The InfoWorks model was calibrated using the flow and rainfall data as described above. Once the process of calibration is achieved, key parameters in the model are to remain the same and the model would be simulated to compare the measured and modeled data with different sites. This process is to validate and verify the results reasonably due to the adjustment of the parameters in calibration.

The calibration process focused on the July 08th event initially to achieve calibration as the largest event, then verifying the calibration with the other events.

In general there is reasonable agreement between modelled and observed flows for all events at all station. The following observations were made in reviewing the calibration curves in Appendix I:

- Generally very little adjustment to parameters was found necessary from the initial model parameters; and,
- The July 8th event showed very good agreement for flow and volume.

Table 17.3 presents a summary of modelled versus measured event volumes and peak flows for the storm calibration and verification events. It should be emphasized that the calibration/validation focused on key locations in the sanitary and combined sewer systems as surcharging in these two systems will result in basement flooding. Conversely, storm sewers in the LPN area are primarily intended to convey surface flows from private property and public right of ways.

**Table 17-3: Flow Monitoring Station Peak Flow & Volume Summary – July 08, 2013**

| Flow Monitoring Station ID and Location | Volume Model (m3) | Volume Observed (m3) | Peak Flow Model (m3/s) | Peak Flow Observed (m3/s) |
|---|---|---|---|---|
| | | | | |
| SAN 1 – Wood Ave | 1068 | 1015 | 0.077 | 0.069 |
| SAN 2 – St Leonards Ave | 825 | 1264 | 0.066 | 0.066 |
| SAN 3 – Dawlish Ave | 625 | 697 | 0.045 | 0.049 |
| COM 4 – St Leonards Ave | 745 | 670 | 0.194 | 0.191 |
| COM 5 – Buckingham Ave | 1012 | 1139 | 0.158 | 0.117 |
| COM 6 – Roslin Ave | 8466 | 9837 | 1.00 | 1.02 |

Overall the July 08th event calibration is considered reasonable at all sites.

### 17.11 Calibration/Verification Using Historic Storm Events

The results of overland flow depth and storm pipe flow depth were compared to actual flooding records for the May 12th, 2000 and August 19th, 2005 event to further verify that the model is representative of stormwater conditions in the area.

The May 12th, 2000 simulation was completed using rainfall data from the Oriole Yard City gauge while the August 19th, 2005 simulation was completed using rainfall data from the City gauge no. 102 north of LPN study area. The rainfall data for the August 19th, 2005 is not available from the local Mount Pleasant/Broadway City gauge. Hence, the rainfall data was adopted from the City gauge no. 102 north of LPN study area. Appendix K contains the relevant historical and assessment events used in the model. The May 12th, 2000 event was reviewed initially as this event resulted in more widespread flooding in LPN study area while the August 19th, 2005 event did not.

Results of the analysis in terms of water level in the sewer system and in the overland flow system were compared to the historic basement flooding reports for each storm. The potential of basement flooding occurring was considered if this condition was reached:

- Surface water level is above an elevation (gutter elevation) of greater than 300 mm.

Figure 17.4 presents the surface water levels in the overland flow system for the May 12th, 2000 event for LPN study area. Figure 17.5 shows the surface water level in the overland flow system for the August 19th, 2005 event. Four different surface flow depth categories that are outlined in these figures for these two storms include:

1. From surface to 150 mm above surface. This indicates that the flow is contained within the street pavement.
2. From 150 mm to 300 mm above surface. This indicates the water is above the pavement but contained within the street right-of-way.
3. More than 300 mm above surface. This indicates potential surface flooding of private properties, and hence potential basement flooding from surface runoff.
4. A portion of the LPN study area has ditch drainage along the road right-of-way instead of standard curb and gutter which is typically found in urban residential neighbourhoods. For this portion of the LPN study area, the existing road conditions are deteriorated and in poor condition. While the surface flow depth is less than 300 mm above surface, it could indicate potential surface flooding of private properties, and hence potential basement flooding from surface runoff.

Figures 17.6 and 17.7 show the surcharge state in the storm sewer system for the May 12th, 2000 event and August 19th, 2005 event respectively for LPN study area. The surcharge state in the sewer system is defined in three categories as follows:

1. Pipe is not surcharged (i.e. water level is below the crown of pipe)

2. Pipe is surcharged at the upstream and/or downstream end of the pipe. Hydraulic gradient line (HGL) is less than or equal to pipe gradient.

3. Pipe is surcharged at the upstream and/or downstream end of the pipe. Hydraulic gradient line (HGL) is greater than pipe gradient.

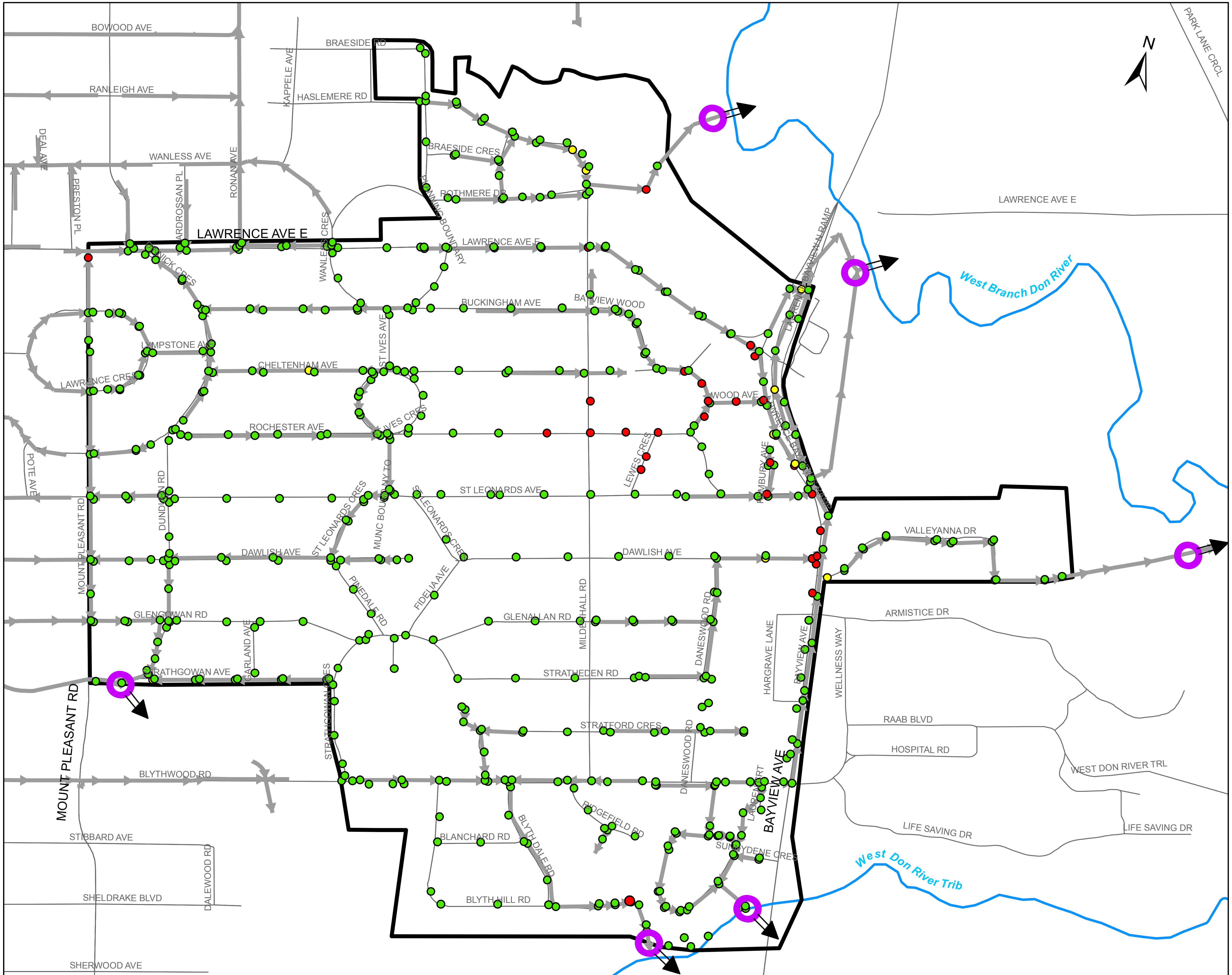
Reviewing Figures 17.4 through 17.7 in conjunction with the flooding records and historical reports the modelling results provide insight to the possible causes of flooding as it relates to the storm drainage system.

The results of the calibrated model for the May 12th, 2000 and August 19th, 2005 events show several locations (Dawlish Avenue at Bayview Avenue, Rochester Avenue at Mildenhall Road, and Wood Avenue at St. Aubyns Crescent) where the overland depth is greater than 300 mm.

The elevated storm flows and overland flow shown for the May 12th, 2000 event may contribute to inflow to the sanitary system at low points in the overland flow system and therefore contribute to basement flooding. Overall the storm system model results are consistent with reported flooding in LPN study area.

Reviewing Figures 17.4 through 17.7 reveals the following about the May 12th, 2000 and August 19th, 2005 events:

- For the May 12th, 2000 event there is widespread surcharging in the system that overlaps with historical flooding. Surface flow is generally greater than 300 mm for several locations;
- The August 19th, 2005 event results in widespread surcharging in the system; this is consistent with locations where surface or basement flooding has been reported. The general locations where surface or basement flooding has been reported are provided in Figure 15.1; and,
- Based on the historical events simulation the storm system model is considered representative of the storm systems in LPN study area verifying the model for subsequent analysis.




LEGEND:

- LPN Study Area
- Watercourses
- Roads
- Outlet

**Depth of Water Level (mm)**

- 0 - 150
- 150 - 300
- > 300

**FLOW_TYPE**

- Storm Sewer & Flow Direction

TORONTO

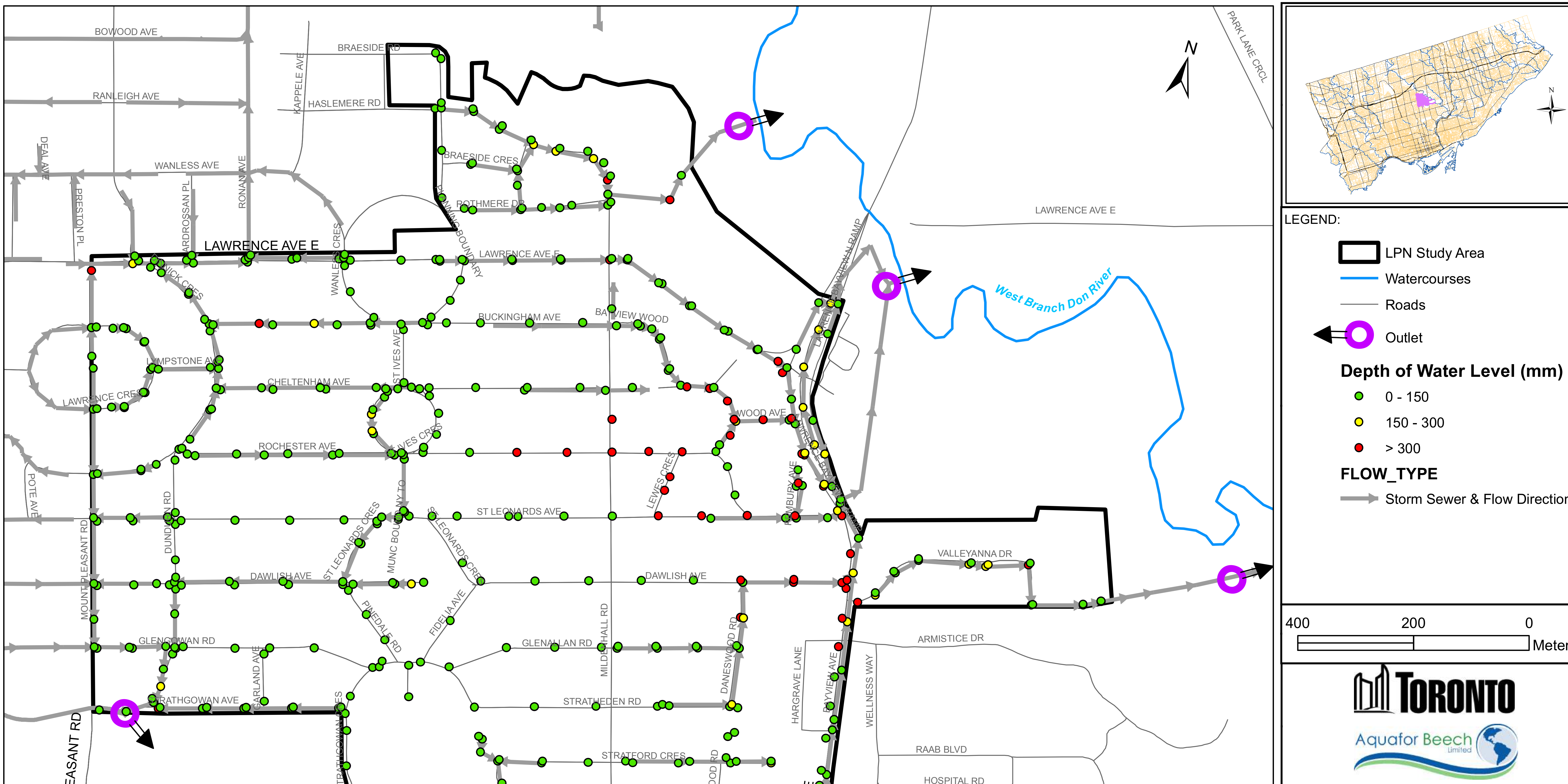
Aquafor Beech Limited

**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Storm Sewer May 12, 2000 Event Overland Flow Depth**

**FIGURE No.** 17.4

**DATE: APRIL 2014**

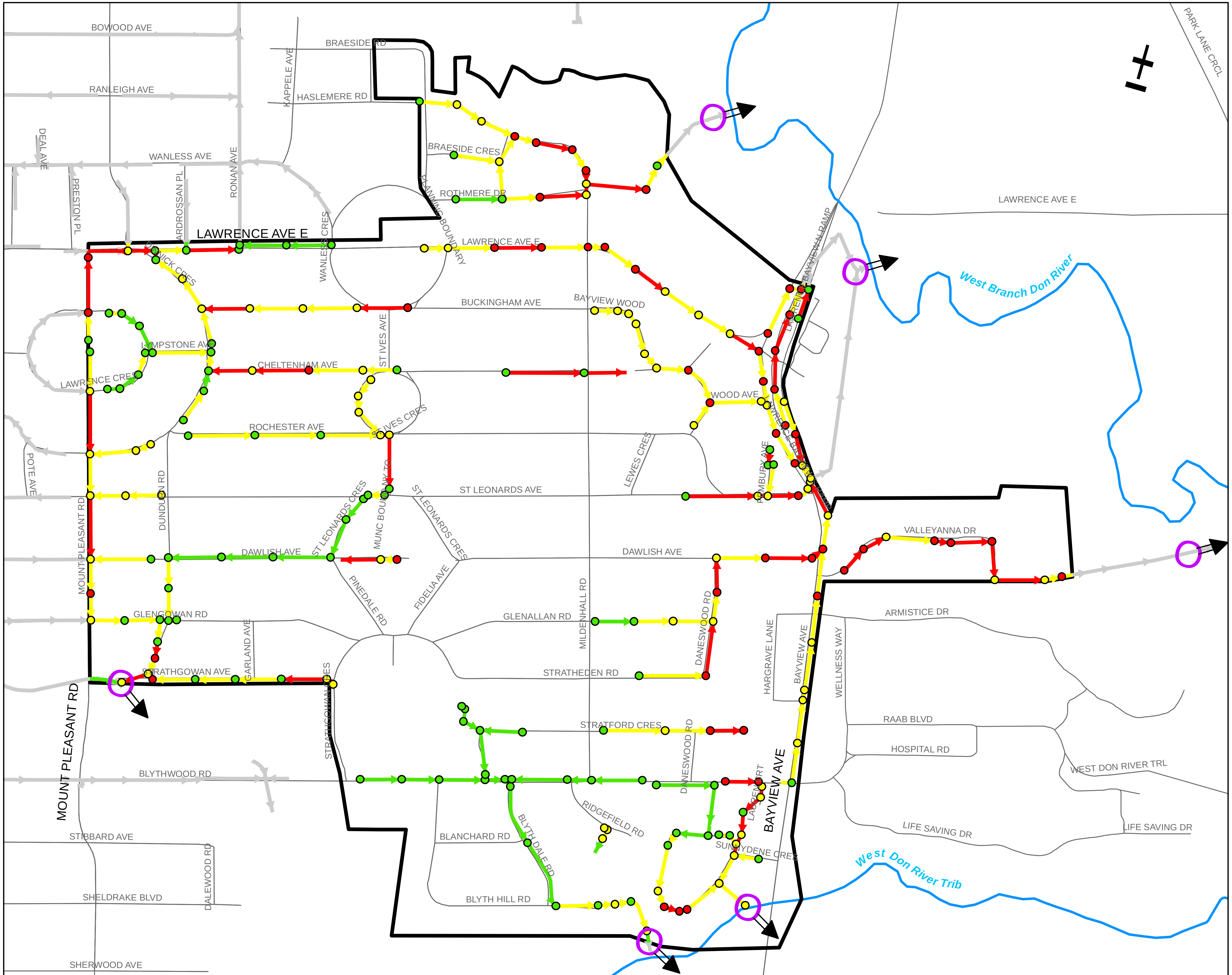


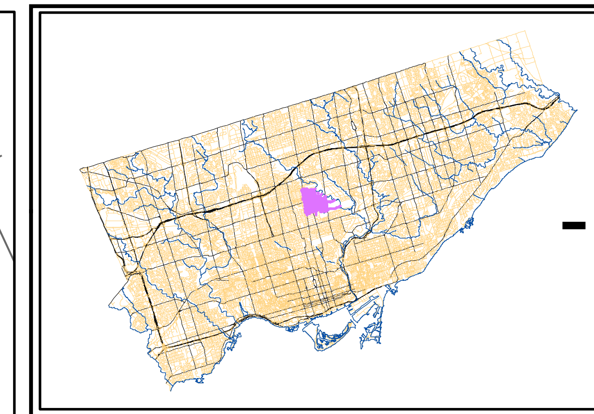

**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Storm Sewer**
**August 19, 2005 Event**
**Overland Flow Depth**

**FIGURE No.** 17.5

**DATE: APRIL 2014**



LEGEND:

- LPN Study Area
- Watercourses
- Roads
- Outlet

**Pipe Surcharge State**

- No Surcharge
- Slope of HGL < Pipe Slope
- Slope of HGL > Pipe Slope

**Depth of Water Level**

- > 1.8m
- 0 - 1.8m
- Flooding

400 200 0 Meters

TORONTO

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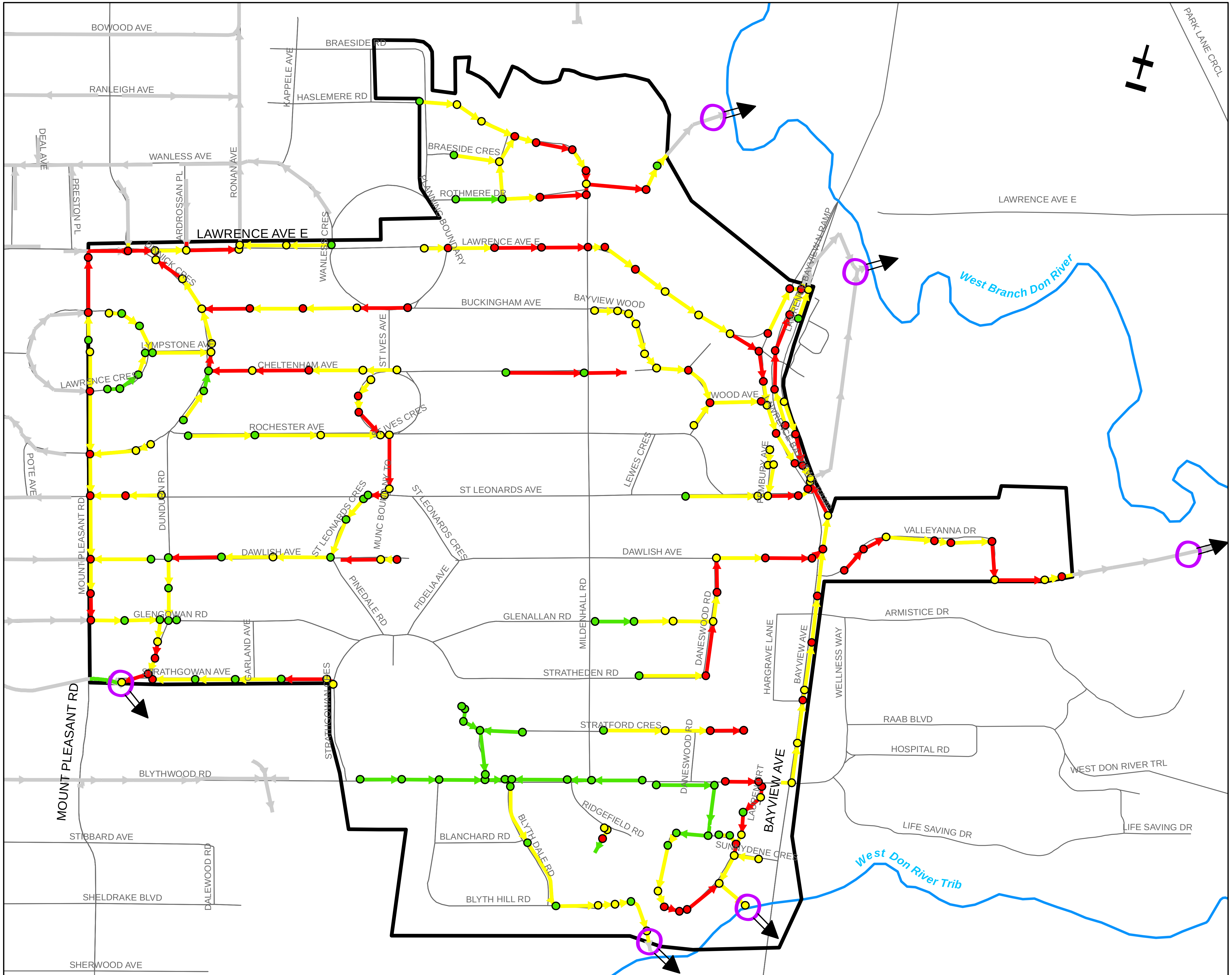
**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

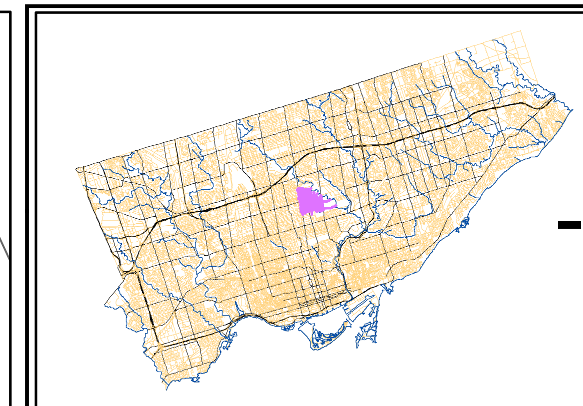
**Storm Sewer**
**May 12, 2000 Event**
**Depth of Water and Surcharge State**

**FIGURE No. 17.6**

**DATE: APRIL 2014**







LEGEND:

- LPN Study Area
- Watercourses
- Roads
- Outlet

**Pipe Surcharge State**

- No Surcharge
- Slope of HGL < Pipe Slope
- Slope of HGL > Pipe Slope

**Depth of Water Level**

- > 1.8m
- 0 - 1.8m
- Flooding

400 200 0 Meters

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**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Storm Sewer**
**August 19, 2005 Event**
**Depth of Water and Surcharge State**

**FIGURE No. 17.7**

**DATE: APRIL 2014**

### 17.12 Assessment of Storm System Hydraulic Performance

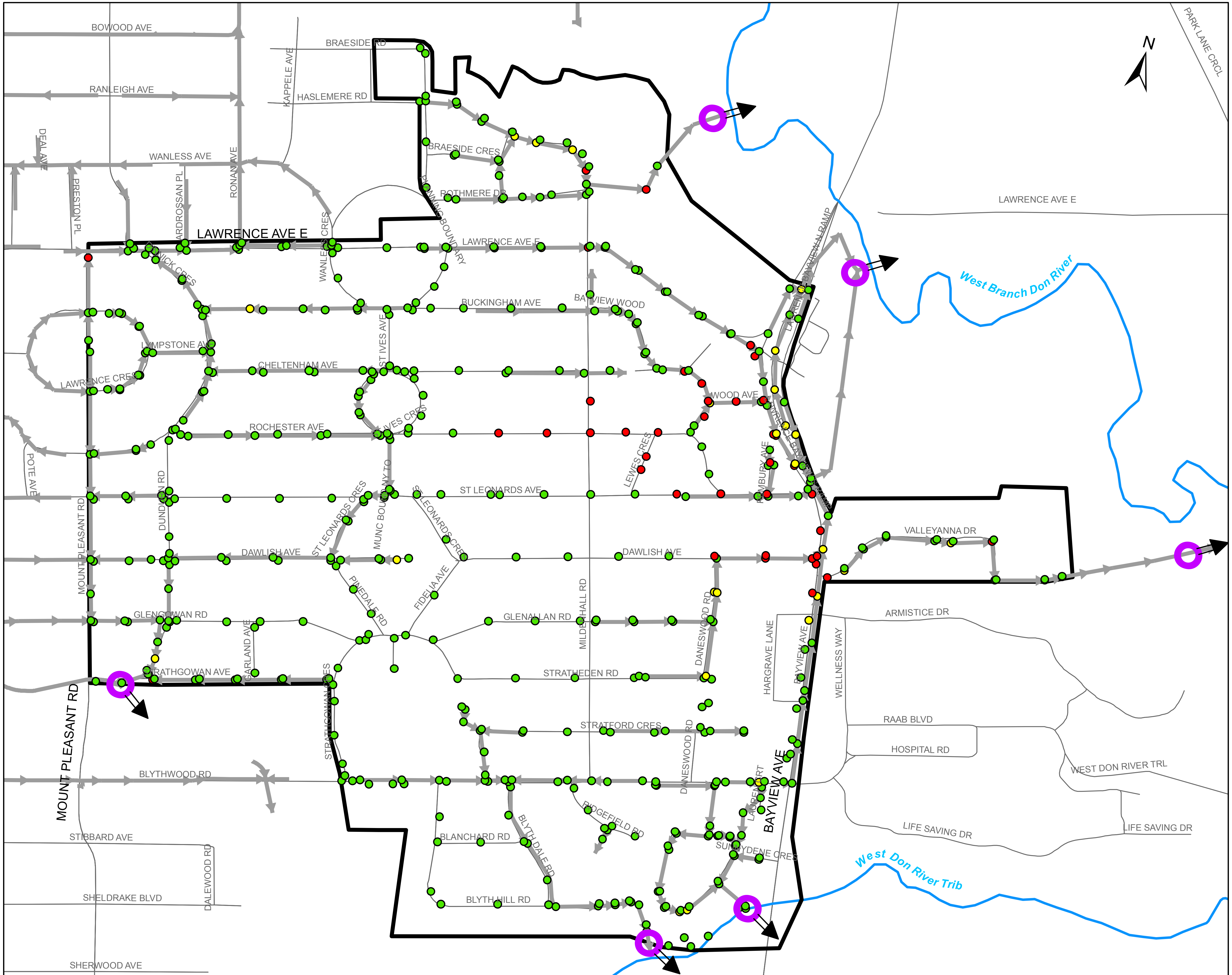
The 100-year assessment event is presented as the storm system assessment event as part of the problem definition.

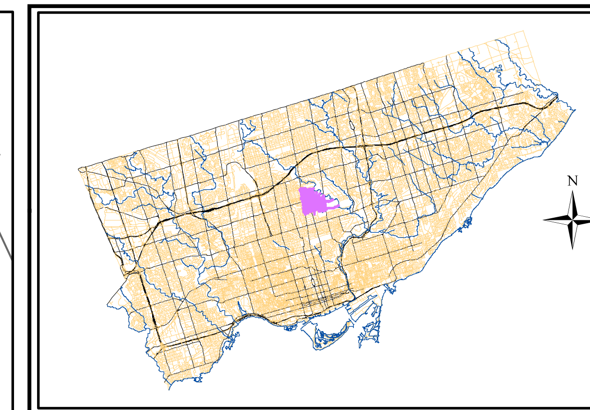
### 17.13 100-Year Storm Assessment Event

The City assessment event for the storm system is the 100-year design storm. The results of the model simulation are presented in Figure 17.8 and 17.9, respectively showing overland flow depth and minor system surcharge.

Figure 17.8 shows the overland flow depth is exceeded throughout most of ditch drainage system east of Mildenhall Road. Figure 17.9 also shows the storm pipe network is surcharged throughout most of the system with the water surface elevation within 1.8 m of the ground surface.

The 100-year assessment event model results are used to develop and evaluate alternative remedial measures and size the preferred solutions for LPN study area.



LEGEND:

- LPN Study Area
- Watercourses
- Roads
- Outlet

**Depth of Water Level (mm)**

- 0 -150
- 150 - 300
- > 300

**FLOW_TYPE**

- Storm Sewer & Flow Direction

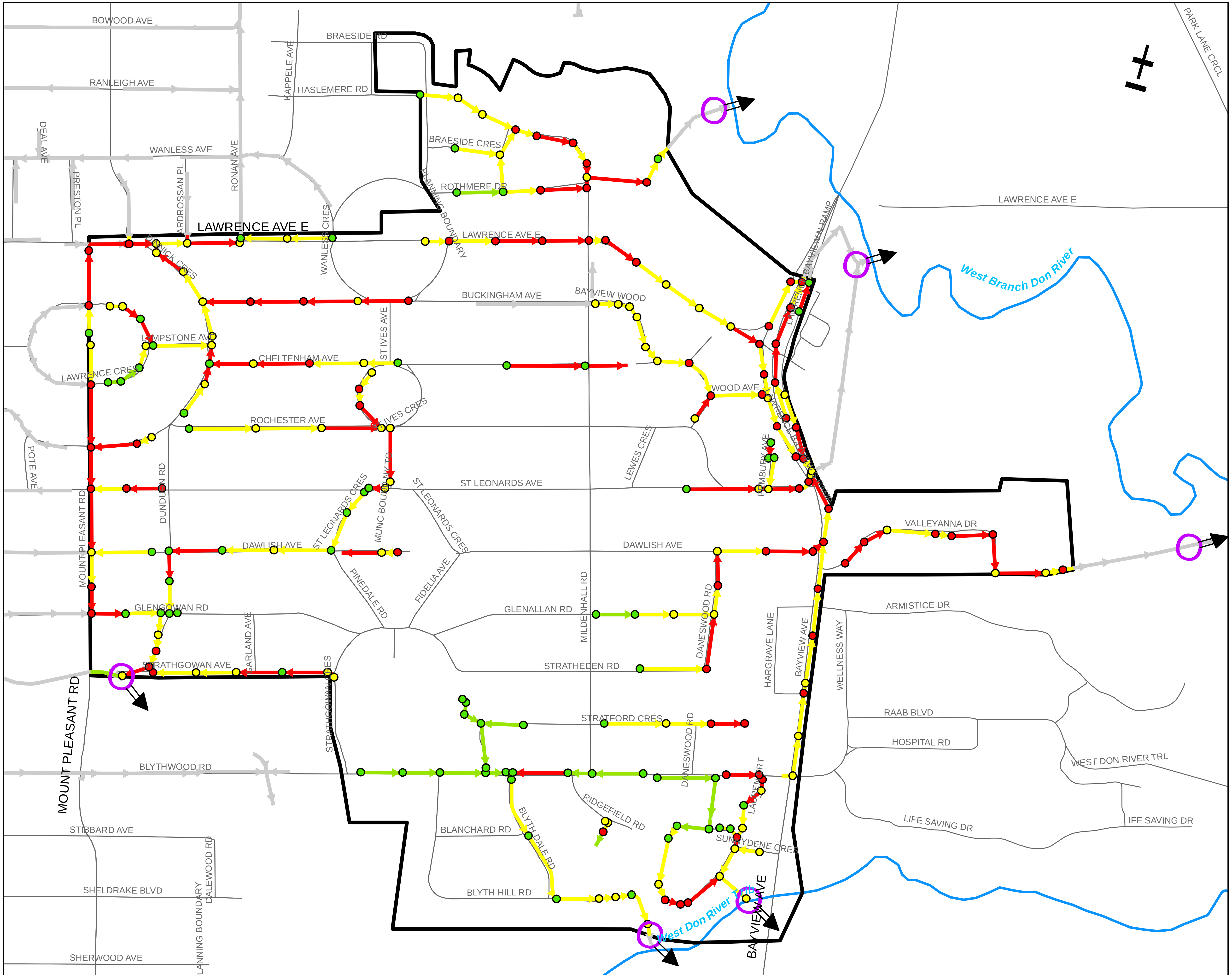
400 200 0 Meters

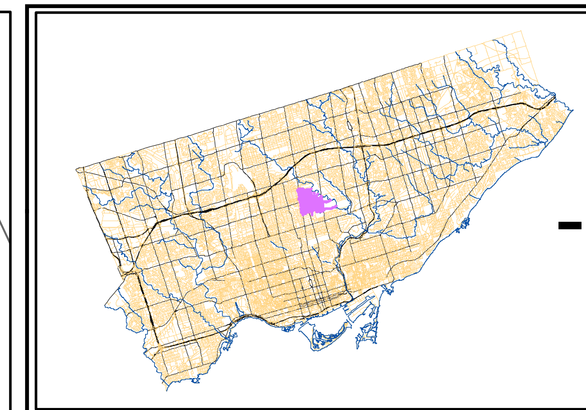
**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Storm Sewer 100-Year Design Storm Assessment Event - Overland Flow Depth**

FIGURE No. 17.8

DATE: APRIL 2014



LEGEND:

- LPN Study Area
- Watercourses
- Roads
- Outlet

**Pipe Surcharge State**

- No Surcharge
- Slope of HGL < Pipe Slope
- Slope of HGL > Pipe Slope

**Depth of Water Level**

- > 1.8m
- 0 - 1.8m
- Flooding

400 200 0 Meters

TORONTO

Aquafor Beech Limited

**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Storm Sewer - 100 Year Design Storm Assessment Event Depth of Water and Surcharge State**

**FIGURE No. 17.9**

**DATE: APRIL 2014**

# 18.0 SANITARY SYSTEM MODEL DEVELOPMENT AND PERFORMANCE

The following section outlines the development and calibration of the sanitary system model for the LPN study area. Figures in the section are located at the end of the section.

## 18.1 Description of Sanitary Sewer System

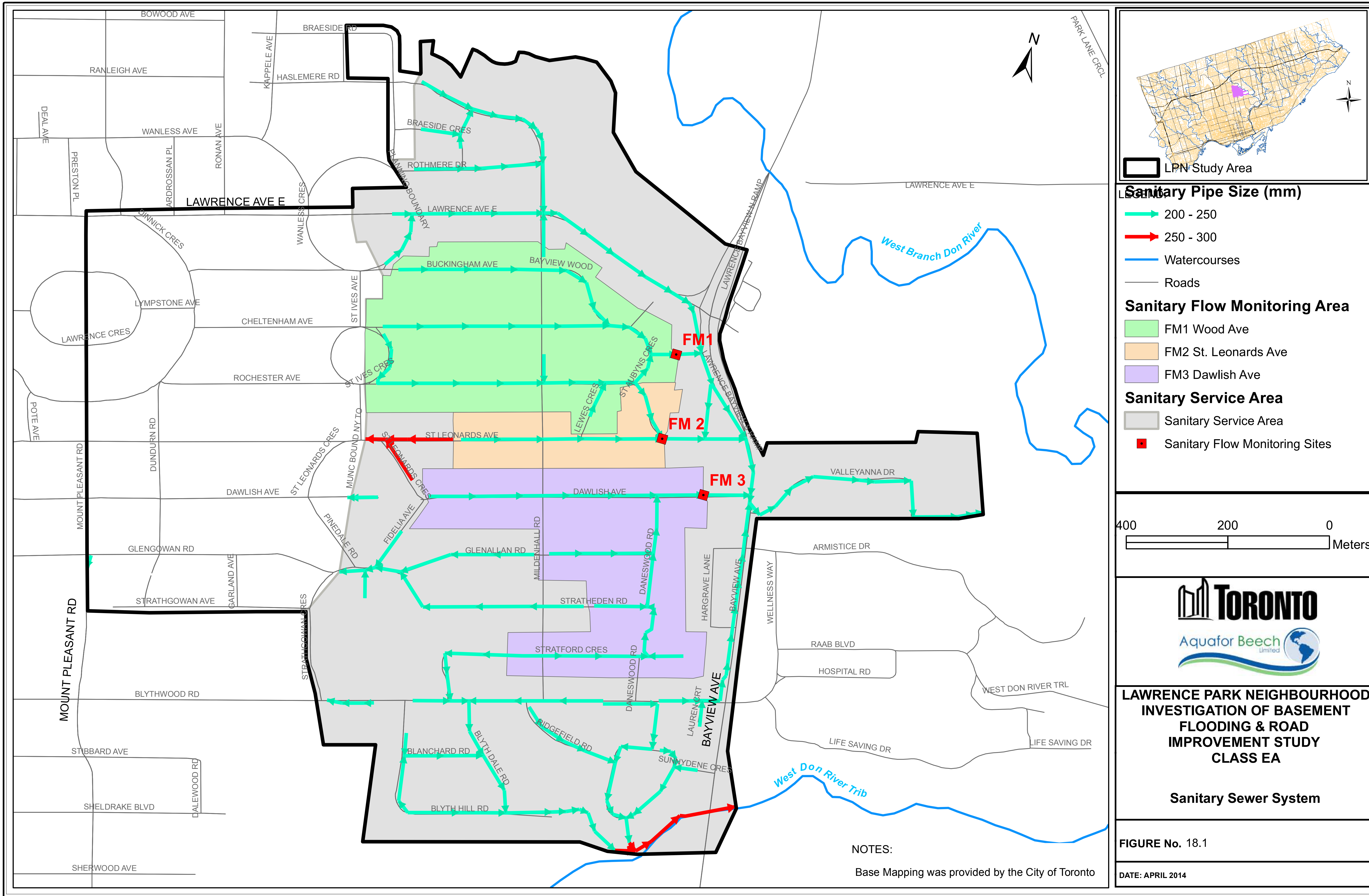
Figure 18.1 shows the sanitary sewer system. The figure also shows the range of pipe sizes identified in the LPN study area. The 75 ha sanitary service area consists of 610 properties according to the population database. The area is primarily single-family detached residential landuse which was initially developed in the 1920's to 1940's. The sanitary sewer system drains to the West Don Sanitary Trunk Sewer. The trunk sewer flows easterly and combines with the Wilket Creek Sanitary Trunk Sewer that ultimately discharges to the Ashbridges Bay Wastewater Treatment Plant.

A memorandum dated September 12, 1991 from the former city of North York indicated that the connection policy for house foundation drains was to connect them to the sanitary sewer prior to 1991. The memo also stated that "Effective September 1, 1991 the Ontario Plumbing Code (O. Reg. 401/91) requires that all foundation drains be connected to the storm sewer system, if this is available. If a storm sewer is not available on the street, the foundation drains are to be pumped above ground, on private property." The runoff from the foundation drain was assigned to corresponding sewer system in the model based on the statement from this memo.

## 18.2 Downspout Connectivity Testing

As part of the field program undertaken for this study Aquafor staff identified approximately 90 homes within the former City of North York within the LPN study area where downspout discharged to the ground (see figure 18.2).

A downspout connectivity testing program in Basement Flooding Area 20 was then conducted by the City in the fall/winter of 2013. The objective of the survey was to perform dye testing at selected houses to determine where roof downspouts discharge (sanitary sewer or otherwise). The dye test results are shown in Figure 4.0. A total of 22 houses were tested, nine (9) of the houses showed that the downspouts are discharged to a sanitary sewer and thirteen (13) showed that the downspouts are connected elsewhere. Based on the dye test results, approximately 41 percent of the house downspouts discharge to the sanitary sewer. The remaining 59 percent of the downspouts would discharge to the combined or storm sewers.




NOTES:

Base Mapping was provided by the City of Toronto

**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Sanitary Sewer System**

**FIGURE No.** 18.1

**DATE: APRIL 2014**

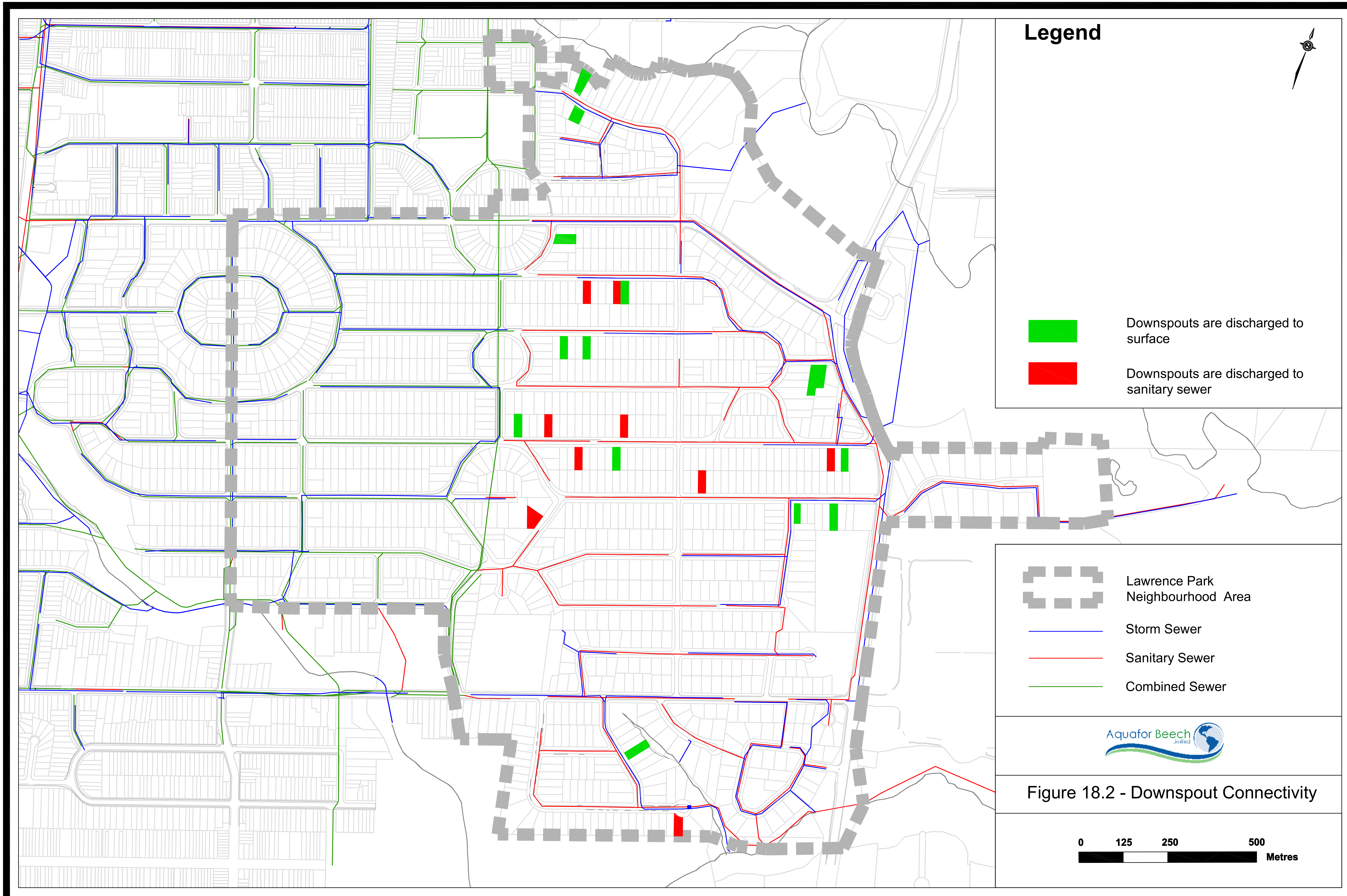



Figure 18.2 - Downspout Connectivity

### 18.3 Model Development

The following sections describe the InfoWorks CS hydrologic/hydraulic model created to simulate the performance of the existing sanitary sewer system. The model was developed to assess the existing sanitary sewer capacity under a range of rainfall events and is the basis for developing and evaluating basement flooding mitigation measures.

### 18.4 Network Data

The City provided a series of databases associated with the sanitary collection system. The databases included information from the former City of North York. Databases associated with pipes and manholes provided geometry information such as length, diameters and elevations. As well, other physical information regarding material and date of construction provided the relevant information which was used to develop the sanitary system model.

In reviewing the data provided and through the importing process to the InfoWorks model, data gaps were identified. Data gaps tended to fall into the following categories:

- Isolated Manholes – not connected to the sewer network.
- Isolated Sanitary Sewers – not connected to the network.
- Missing Pipe Information – such as invert elevations or diameter.
- Special Features – such as control structures were not contained as part of the infrastructure databases.

An initial validation was conducted to identify where anomalies occurred in the physical pipe network. It was discovered that after validating, errors and warnings were found within the system, many of which were repetitive due to the nature of the error/warning. As well at times, terminology used in the GIS format was not compatible with terminology used in InfoWorks when importing. An example of this would be shape of pipe; while in GIS a circular pipe would have the notation “RND” (round), InfoWorks does not recognize this notation and views rounded pipes as “CIRC” (circular), hence generating an error messages.

An initial “walk-through” of the sanitary system identified obvious information that did not import from the GIS database into InfoWorks. Correction of the obvious information greatly shortened the list of errors and warnings. Most of the remaining errors or warnings were associated with missing physical data. Where missing information was limited, the calculated or assumed value was flagged in the model. In most cases, missing data was associated with pipe diameter or pipe/manhole inverts.

Most of the gaps were filled using the digital sewer plan and profile drawings available from the City’s ImageSite. When no information was available in the ImageSite, the missing information was inferred using the InfoWorks model inference tool and best engineering judgment. The following assumptions were also considered to complete the sewer network model:

- Missing pipe inverts that could not be inferred by the InfoWorks inference tool was assigned inverts based on the average slope of pipe up and downstream of the missing inverts; and
- Physical sewer connections that did not have a manhole at the connection point were connected in the model using a dummy manhole.

The data gap analysis associated with link information such as missing pipe inverts for the sanitary system, as well as the data flags used is summarized in Appendix B of Technical Memorandum #1.

Questionable or uncertain data were identified during the model construction and preliminary simulation phases using the Engineering Validation Tool in InfoWorks. Shallow/steep pipes, reverse pipe direction, reduction in downstream diameter, connectivity and other physical parameters outside traditional design standards were identified and flagged for review.

Data gaps and checks were filled through review of the City's plan and profile drawings, and through a series of inference assumptions based on surrounding infrastructure and engineering judgment. Where sufficient uncertainty remained, confirmation with City staff or a field investigation was undertaken.

The final check on the sanitary sewer continuity was the review of sewer profiles through the InfoWorks interface.

## 18.5 Flow Monitoring Data

Technical Memorandum #2 provides details regarding the extent of the rainfall and flow monitoring program. Rainfall and flow monitoring data was collected for calibrating the sanitary and combined system hydrologic and hydraulic model.

The rainfall and flow monitoring program was carried out from June 2013 to November 2013. Flow monitoring locations have been selected at 3 combined sewer sites and 3 sanitary sewer sites. The sanitary sewer system is shown in Figure 18.2, and Table 18-1 presents the dry weather flow results.

**Table 18-1: Summary of Monitored Sanitary Dry Weather Flows**

| Station | Gross Area (ha) | Population.[a] | Population./ha | Average DWF | | Min. DWF |
|---|---|---|---|---|---|---|
| | | | | L/sec | L/Cap/day[b] | L/sec |
| 1 (SAN) | 10.8 | 384 | 35.6 | 2.1 | 472.5 | 0.6 |
| 2 (SAN) | 11.9 | 441 | 37.1 | 2.2 | 431.0 | 1.5 |
| 3 (SAN) | 11.1 | 415 | 37.4 | 3.1 | 645.2 | 2.1 |

a - Based on City GIS database
b - Calculated from average DWF divided by Population

Sanitary flow monitoring data at three sites is considered reasonable and suitable for model calibration. The average dry weather flow rate observed at the sanitary monitoring location is within a typical range for the service area size, the age of system and based on similar monitoring results in the City.

Five rainfall events (total precipitation amount > 10mm) were recorded and were considered suitable to characterize wet weather response in the system. The wet weather inflow/infiltration (I/I) results from the flow monitoring during these events are shown in Table 18-2. The peak I/I flow is obtained by subtracting the dry weather flow from the observed peak flow for each event.

**Table 18-2: Summary of Monitored Sanitary Peak I/I Flow (L/sec/ha)**

| | | June 10, 2013 | June 28, 2013 | July 07, 2013 | July 08, 2013 | July 27, 2013 |
|---|---|---|---|---|---|---|
| Total Daily Rainfall (mm) | | 21.5 | 33.5 | 34.0 | 78.3 | 12.3 |
| Station | Area (ha) | Observed Peak I/I Flow (L/sec/ha) | | | | |
| 1 (SAN) | 10.8 | 1.3 | 5.6 | 5.4 | 6.5 | 0.4 |
| 2 (SAN) | 11.9 | 0.3 | 1.3 | 0.9 | 5.5 | 0.1 |
| 3 (SAN) | 11.1 | 0.1 | 0.9 | 0.7 | 4.4 | 0.1 |

With respect to wet-weather flow, results of the monitoring data analysis identified peak I/I rates to greatly exceed 0.26 L/s/ha for all events. The July 8, 2013 event had a peak I/I rate of 6.48 L/s/ha, the highest of the 2013 events.

The three flow monitoring locations (station 1, 2 and 3) are serviced by separated sewers, the results for the sanitary sewers show significant infiltration/inflow during rainfall events. This would suggest that there may be cross-connections between the storm and sanitary sewer systems.

### 18.6 Catchment Delineation

Subcatchment areas were discretized on a manhole-to-manhole basis. ArcGIS and AutoCAD were used with the parcel (land use) layer and the sewer flow paths to refine the subcatchment shape. The subcatchments were checked as they were being created to ensure that they picked up the appropriate population points. The detailed delineation allows modelled flows to be distributed avoiding significant flow load points that can create instability issues in the hydraulic modelling. It would suggest that there may be cross-connections between the storm and sanitary sewer systems and home foundation drains constructed prior to 1991 are connected to the sanitary sewer. Therefore, foundation drains (FD) are included in the model. It is our assumption that a FD area equivalent to 10% of the building area, which has been input in the model for initial model setup.

### 18.7 Wastewater Flow Generation

To generate the wastewater flow from the area, data provided by the City such as land use and population were defined for each Dry Weather Flow (DWF) subcatchment. Land use information in the form of a shapefile was provided by the City for all development blocks within the study area. In the LPN study area land use was classified into four categories: Residential Single Family, Multilevel Residential, Commercial / Industrial / Institutional and Open Space. The predominate land use is single family residential. In addition to shapefiles, aerial photos were used for defining the unknown land use types.

The flow generated for each DWF subcatchment was based on the distribution of land use within each area as generated in ArcGIS. Days are defined as dry if no rainfall had occurred within the previous 72 hours. Collected flow monitor data is used to define average dry weather flow and wastewater waste profiles.

Wastewater flow for dry weather conditions is generated in InfoWorks using an average per capita flow (Lpcd) multiplied by the population of each DWF subcatchment. The population of each DWF subcatchment was determined by using the GIS theme containing population data and intersecting it with the sanitary subcatchment boundaries. The individual sanitary wastewater flow hydrographs from each subcatchment contributing to a monitoring location sum up to the flow observed at the flow meter as a basis of comparison for calibrating the dry weather flow component. The per capita flow rate used in the model includes groundwater infiltration contribution associated with each of the monitoring stations.

The dry weather flow results for LPN service area indicate that the per capita generation rate of approximately 430 L/c/d for the area. This value seemed to be high compared with the typical design values. The per capita generation rate of 330 L/c/d was used in the model. The area is predominately residential where typical design values range from 265 to 350 L/c/d.

### 18.8 Dry Weather Flow Calibration

The average dry weather flow pattern over the six month 2013 monitoring period was used to calibrate the model. To calibrate the model the DWF generation rate calculated for the LPN study area shown in Table 4.3 was used and the diurnal pattern applied. The dry weather flow generation was compared to the observed flows at the sanitary monitoring locations.

Table 18.3 presents a summary of modelled versus measured volume and peak flow for the DWF calibration of the sanitary system. The sanitary area model compares well with dry weather flow measured in the system.

**Table 18-3: Dry Weather Flow Calibration Summary**

| Site ID (SAN) | Event Date | Event Volume (m3) | | | Peak Flow (m3/s) | | |
|---|---|---|---|---|---|---|---|
| | | Observed | Modelled | % Difference | Observed | Modelled | % Difference |
| 2 | DWF | 402 | 390 | <3% | 0.008 | 0.008 | 0% |

### 18.9 Wet Weather Calibration/Validation

The wet weather and dry weather flow data were combined in order to produce a complete time series of sanitary sewer flow that represents observed data occurring before, during and after a rainfall event. The data was used for model calibration and validation. Observed wet and dry weather flow time series are included in Appendices A and B with the calibration and validation results. Modelled dry weather flow was used for wastewater flow prior to a wet weather event.

The model was calibrated by matching as best as possible, the modelled flows to the monitored values at 3 stations, where reasonable flow monitoring data existed. The primary storm event that was used for calibration was the July 08th, 2013 which had a total rainfall depth of 78 mm over 24 hours.

This event was used for calibration as it was the largest storm event recorded according to volume, as well as the most intense over the course of the entire flow monitoring period. The June 10th, 2013, June 28th, 2013, July 07th, 2013 and July 27th, 2013 events were used for model verification.

A summary of modelled versus measured event volumes and peak flows for the sanitary calibration and validation events are found in Table 18-4 for the July 08th, 2013 event. The results of the calibration and validation curves are found in Appendix J.

In general for the calibration, subcatchment parameters were adjusted so that the peak flow and total volume for the simulated values were within 15% of the monitored data. There is generally good agreement for the July 08th, 2013 event on volume, peak flow and depth with the exception on volume for site 2. It might be caused by a malfunction of measuring equipment at that time.

**Table 18-4: Flow Monitoring Station Peak Flow & Volume Summary – July 08, 2013**

| Flow Monitoring Station ID and Location | Volume Model (m3) | Volume Observed (m3) | % Difference | Peak Flow Model (m3/s) | Peak Flow Observed (m3/s) | % Difference |
|---|---|---|---|---|---|---|
| | | | | | | |
| SAN 1 –Wood Ave | 1068 | 1015 | 5.2% | 0.077 | 0.069 | 11.6% |
| SAN 2 – St Leonards Ave | 825 | 1264 | 34.7% | 0.066 | 0.066 | 0.0% |
| SAN 3 – Dawlish Ave | 625 | 697 | 10.3% | 0.045 | 0.049 | 8.2% |

A summary of modelled versus measured event volumes and peak flows for the sanitary validation events are found in Table 18-5 for the June 10, June 28, July 7 and July 27 events. The calibration and validation curves are found in Appendix E.

**Table 18-5: Flow Monitoring Station Peak Flow & Volume Summary**

| Flow Monitoring Station ID and Location | Volume Model (m3) | Volume Observed (m3) | Peak Flow Model (m3/s) | Peak Flow Observed (m3/s) |
|---|---|---|---|---|
| **June 10, 2013** | | | | |
| SAN 1 – Wood Ave | 134 | 93 | 0.022 | 0.013 |
| SAN 2 – St Leonards Ave | 98 | 157 | 0.010 | 0.025 |
| SAN 3 – Dawlish Ave | 96 | 141 | 0.009 | 0.018 |
| **June 28, 2013** | | | | |
| SAN 1 – Wood Ave | 275 | 21 | 0.069 | 0.005 |
| SAN 2 – St Leonards Ave | 118 | 27 | 0.025 | 0.005 |
| SAN 3 – Dawlish Ave | 97 | 51 | 0.017 | 0.010 |
| **July 07, 2013** | | | | |
| SAN 1 – Wood Ave | 488 | 400 | 0.066 | 0.019 |
| SAN 2 – St Leonards Ave | 570 | 663 | 0.018 | 0.040 |
| SAN 3 – Dawlish Ave | 637 | 684 | 0.015 | 0.027 |
| **July 27, 2013** | | | | |
| SAN 1 – Wood Ave | 51 | 21 | 0.012 | 0.008 |
| SAN 2 – St Leonards Ave | 52 | 34 | 0.007 | 0.008 |
| SAN 3 – Dawlish Ave | 57 | 70 | 0.007 | 0.024 |

Overall the July 08th event calibration is considered reasonable at all sites. There is reasonable agreement also between observed and modelled flows for the other events. The model predicts the flow results reasonably well on all the events with the exception of June 28th event. The rainfall on June 28th event did not seem to fall as intensively over the study area.

For the purposes of this flood study dealing with extreme storm events, a second validation of model parameters was undertaken using historical events as described in the following section.

### 18.10 Calibration/Verification Using Historic Storm Events

The rainfall on July 8th event recorded during the monitoring period was equivalent to a 25-year storm event. The calibration /validation of the model to this storm were reasonable. A secondary verification was undertaken to assess the impact of larger storms such as the May 12th, 2000 event with the intention of replicating the flooding that occurred in LPN study area for confirmation purposes.

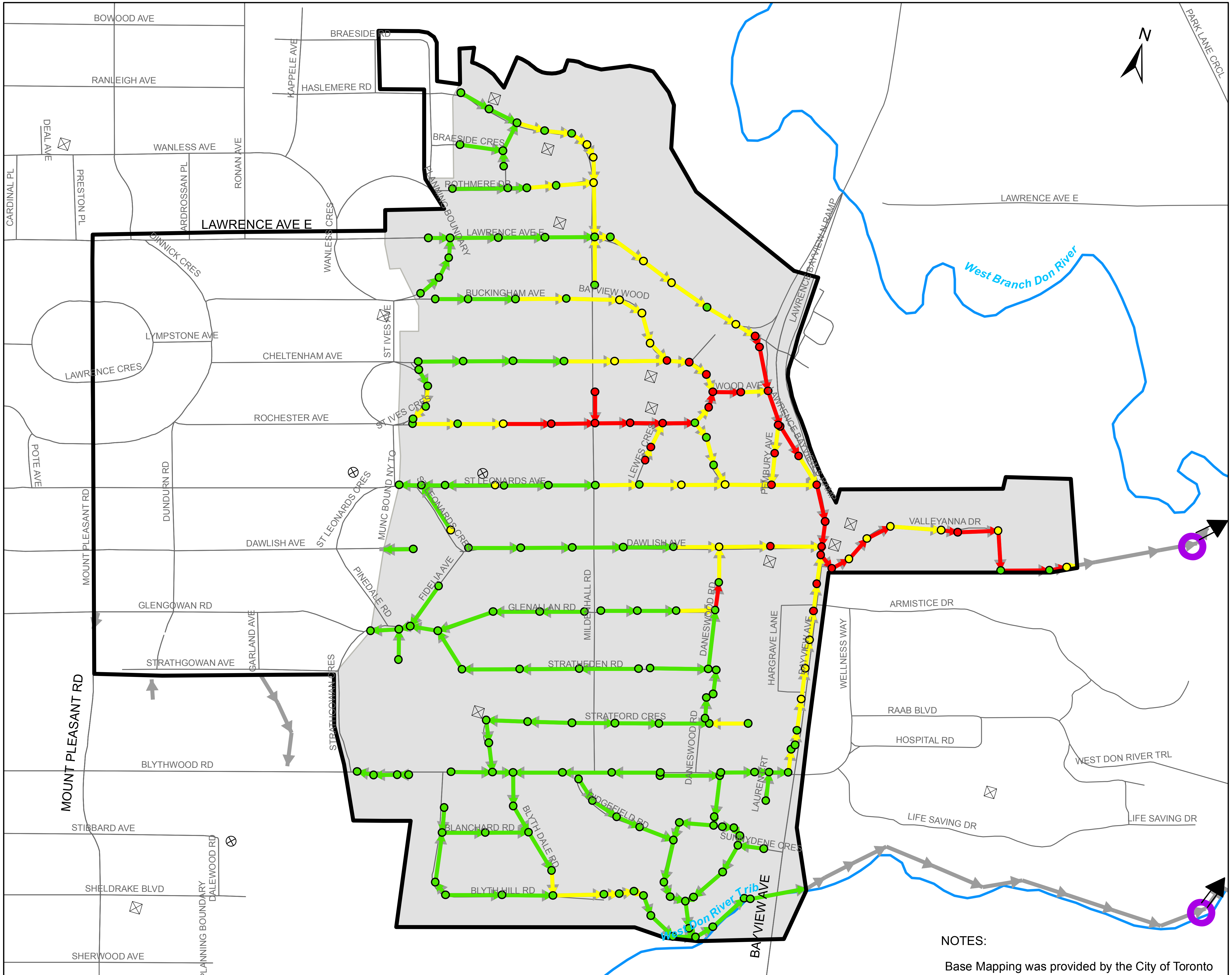
Figure 18.3 shows the May 12, 2000 historical event sanitary system results using local Mount Pleasant/Broadway City rain gauge data. The May 12, 2000 simulation results show surcharging in the area of Rochester Avenue and Mildenhall Road, Valleyanna Drive and Bayview Avenue where the water surface elevation is within 1.8 m of the ground surface where historical basement flooding has been reported.

The model was also validated with the August 19, 2005 event using rainfall data from the City gauge no. 102. Figure 18.3 shows the location of the City's rain gauge. During this event there were two incidences of flooding which were reported to the City. Figure 18.4 shows the August 19, 2005 historical event model simulation results. Figure 18.4 shows hydraulic issues in the system for this event and a high risk of basement flooding, which is consistent with locations where basement flooding has been reported. The records are provided by the City or collected from a questionnaire at the initial stage of this study..

For the purpose of evaluating the sanitary system for the May 12, 2000 event the sanitary system model is considered valid and suitable. As such, the model calibration parameters were considered valid to represent the wet weather response in the system to replicate the flooding that occurred in LPN study area for this event.

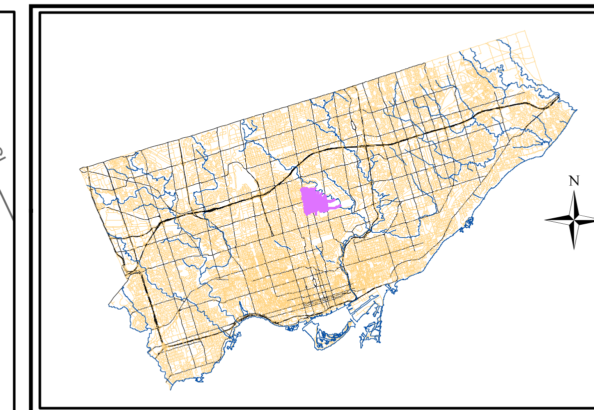
### 18.11 Assessment of Sanitary System Hydraulic Performance

The May 12th, 2000 assessment event as recorded at the Oriole Gauge is used for the sanitary system baseline assessment. For these simulations the per capita average dry weather flow is based on existing dry weather flow conditions.




NOTES:

Base Mapping was provided by the City of Toronto



LEGEND:

**Depth of Water Level**
- > 1.8m
- 0 - 1.8m
- Flooding

Outlet

LPN Study Area

**Pipe Surcharge State**
- No Surcharge
- Slope of HGL < Pipe Slope
- Slope of HGL > Pipe Slope

**HistoricalFlooding Layer**
- Aug 19, 2005
- May 12, 2000

Watercourses

Roads

Sanitary Service Area

400 200 0 Meters

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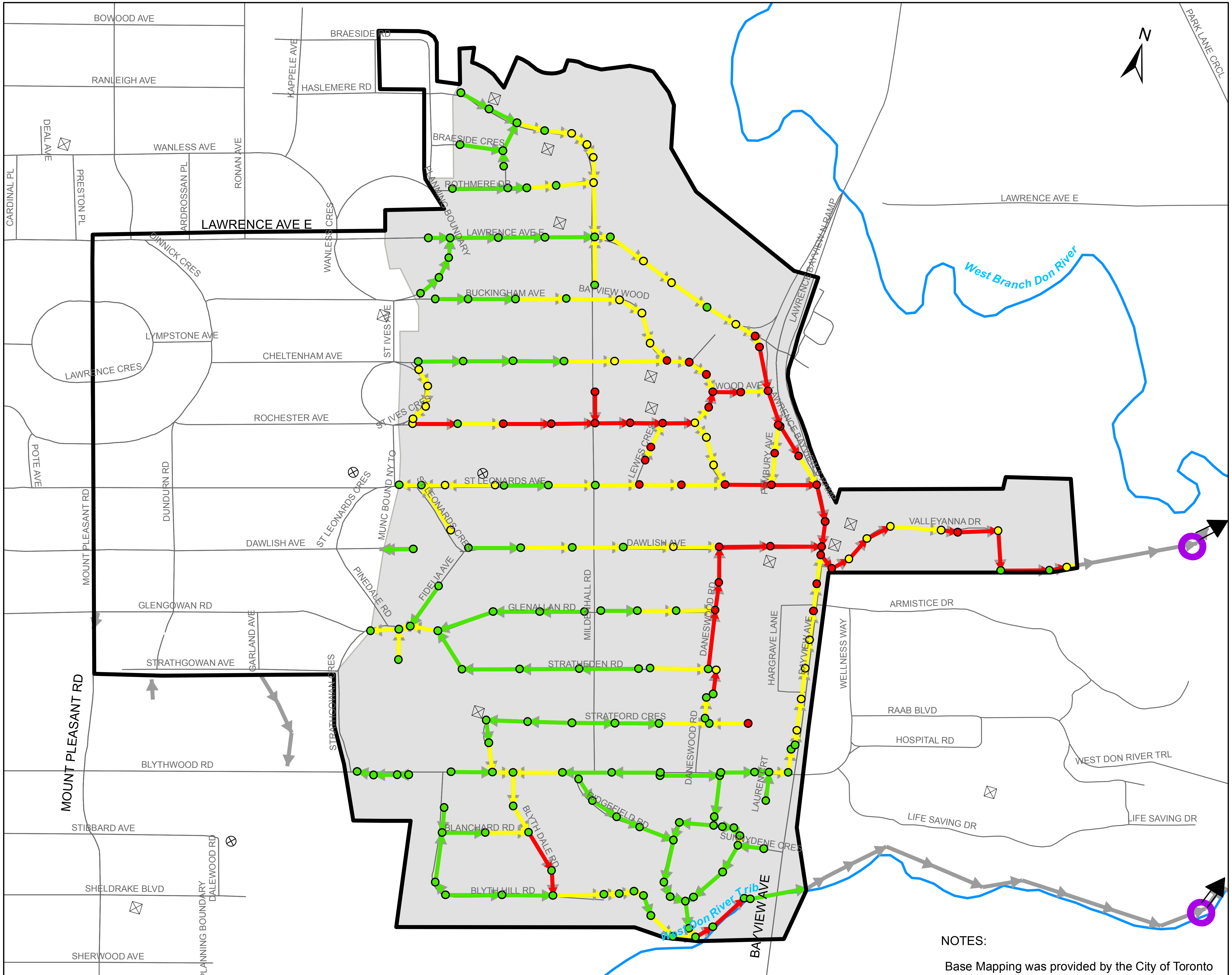
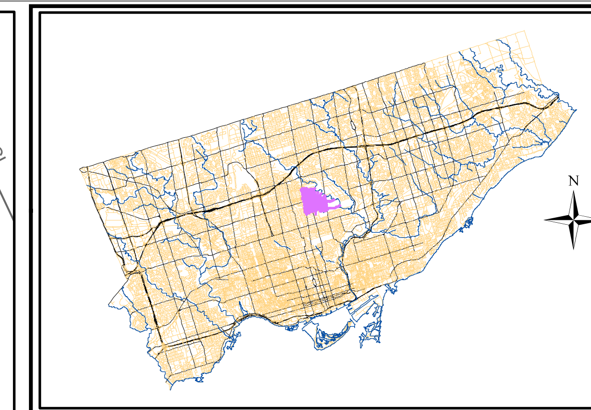
**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Sanitary Sewer**
**May 12, 2000 Event (Local Gauge)**
**Depth of Water and Surcharge State**

**FIGURE No.** 18.3

**DATE: APRIL 2014**



LEGEND:

- LPN Study Area
- Watercourses
- Roads
- Outlet

**Pipe Surcharge State**

- No Surcharge
- Slope of HGL < Pipe Slope
- Slope of HGL > Pipe Slope

**Depth of Water Level**

- > 1.8m
- 0 - 1.8m
- Flooding

**HistoricalFlooding Layer**

- Aug 19, 2005
- May 12, 2000
- Sanitary Service Area

400 200 0 Meters

TORONTO

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**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Sanitary Sewer August 19, 2005 Event Depth of Water and Surcharge State**

**FIGURE No.** 18.4

**DATE: APRIL 2014**

NOTES:

Base Mapping was provided by the City of Toronto

### 18.12 May 12th, 2000 Assessment Event

The model was used to simulate the May 12, 2000 event as measured at the Oriole Yard Station. The event is considered the design or assessment event for the sanitary sewer system for the basement flooding level of protection criteria. For the assessment event the per capita average dry weather flow is based on existing dry weather flow conditions.

Figure 18.5 shows the simulation results showing surcharging in the sanitary system and water surface elevations less than 1.8 m below the ground. The model water surface elevation is elevated because there is insufficient conveyance capacity in the system during peak wet weather flow periods as a result of I/I. The model shows the HGL is within 1.8 m of the ground surface in the area including in the vicinity of Valleyanna Drive and Bayview Avenue where the water surface reaches ground level.

The assessment event model results display more widespread surcharging risks than expected based on the historical basement flooding reports from the City. The sanitary system can be described as not providing adequate capacity to convey additional I/I flows associated with the assessment event of May 12, 2000 as measured at Oriole Yard Station.

### 18.13 Factors Contributing to Flooding

The causes of flooding for the separate sewer system in LPN study area could be generally attributed to the following:

- Surcharging in the sanitary sewer system;
- Excessive I/I flows in the sanitary system with the primary sources of I/I being downspouts connected to the sanitary sewer, private property I/I and storm flows entering sanitary manhole covers; and
- Poor overland flow routes resulting in surface ponding.

By analyzing the above information, it was possible to identify the most probable cause of flooding in the flood prone areas. The results are summarized below.

Basement flooding in scattered properties could be attributed to one or more of the following local conditions:

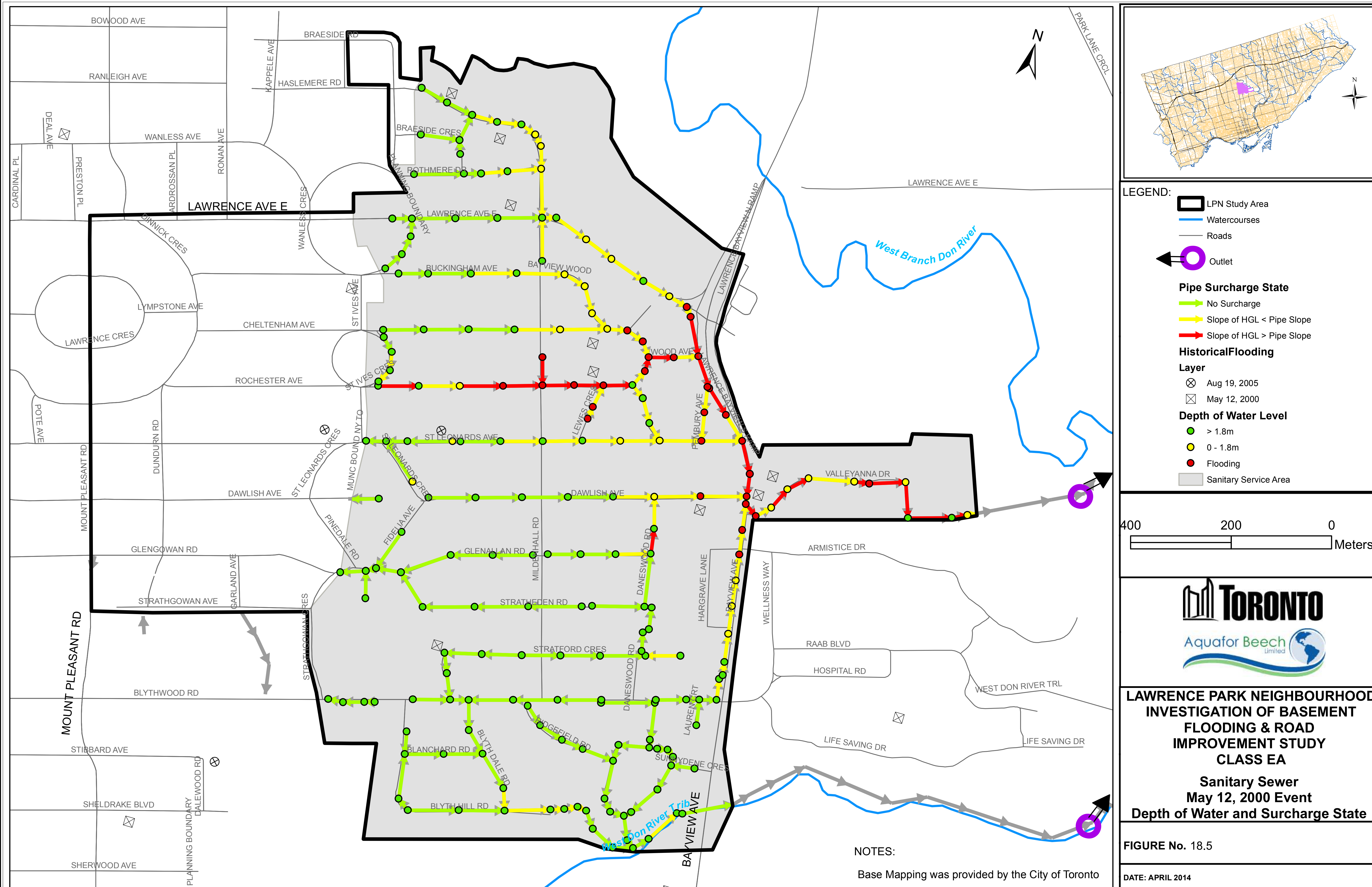
- Poor lot grading adjacent to homes;

- Reverse grade driveways resulting in water entering the homes; and

- Cracks in the basement walls or floor resulting in storm water and/or groundwater leakage;

Specific causes of basement flooding in LPN study area are summarized below:

- Undersized sewers located along Valleyanna Drive and segments along Bayview Avenue; and Surface ponding is likely resulting in excess sanitary system inflow in the area of Rochester Avenue, St. Leonards Avenue, Dawlish Avenue and Valleyanna Drive.




**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Sanitary Sewer**
**May 12, 2000 Event**
**Depth of Water and Surcharge State**

NOTES:

Base Mapping was provided by the City of Toronto

**FIGURE No.** 18.5

**DATE: APRIL 2014**

## 19.0 COMBINED SYSTEM MODEL DEVELOPMENT AND PERFORMANCE

The following section outlines the development and calibration of the combined system model for the LPN study area. Figures in the section are located at the end of the section.

### 19.1 Description of Combined Sewer System

Figure 19.1 presents the drainage area of each of the combined sewer flow monitoring locations . The figure also shows the range of pipe sizes identified in the LPN study area. The 43 ha combined service area consists of 349 properties. The area is primarily single-family detached residential landuse which was initially developed in the 1920’s to 1940’s.

### 19.2 Model Development

The following sections describe the InfoWorks CS hydrologic/hydraulic model created to simulate the performance of the existing combined sewer system. The model was developed to assess the existing combined sewer capacity under a range of rainfall events and is the basis for developing and evaluating basement flooding mitigation measures.

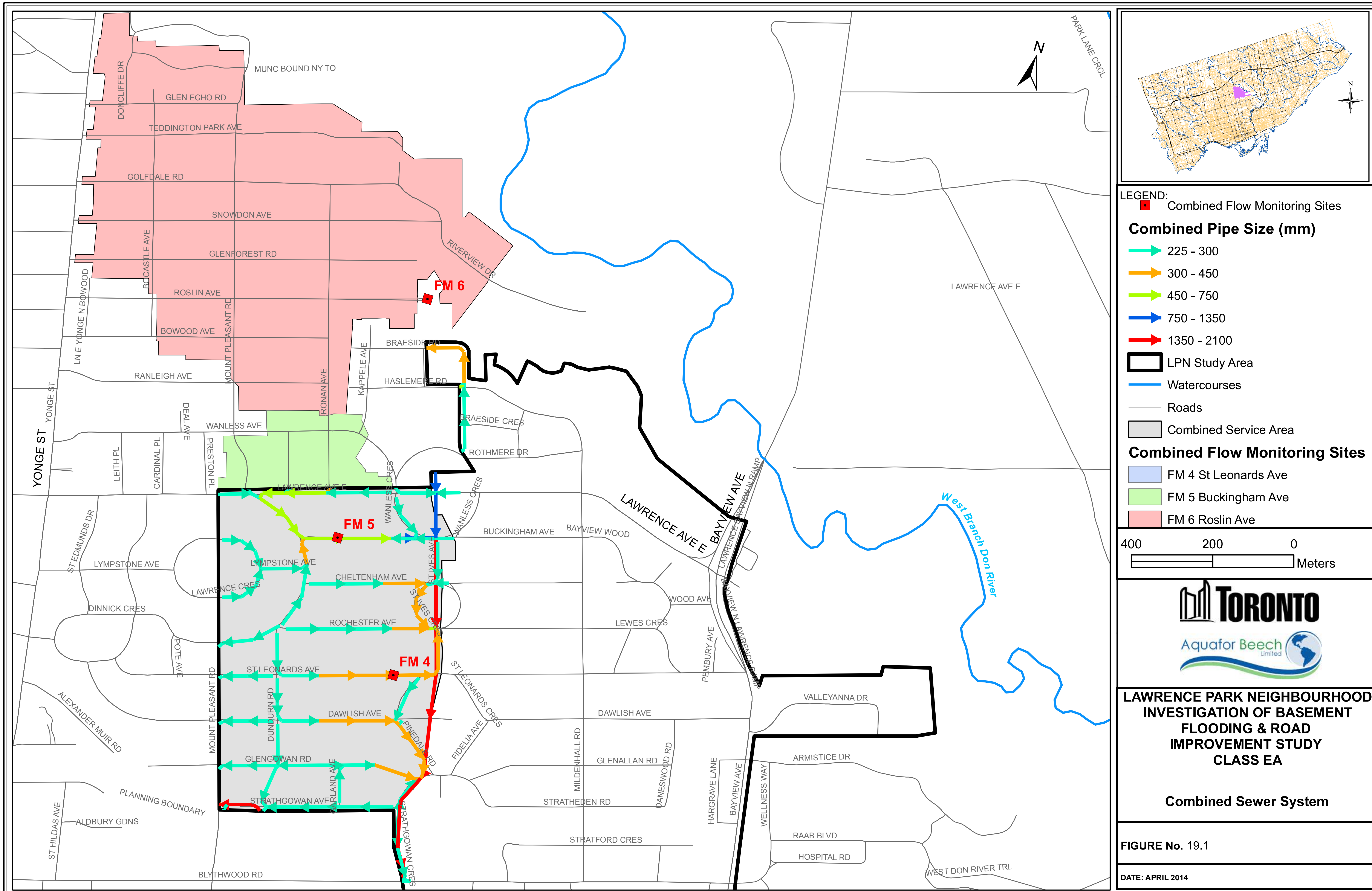
### 19.3 Network Data

The City provided a series of databases associated with the combined collection system. The databases included information from the former City of Toronto. Databases associated with pipes and manholes provided geometry information such as length, diameters and elevations. As well, other physical information regarding material and date of construction provided the relevant information which was used to develop the combined system model.

In reviewing the data provided and through the importing process to the InfoWorks model, data gaps were identified. Data gaps tended to fall into the following categories:

- Isolated Manholes – not connected to the sewer network.
- Isolated Combined Sewers – not connected to the network.
- Missing Pipe Information – such as invert elevations or diameter.
- Special Features – such as control structures were not contained as part of the infrastructure databases.

An initial validation was conducted to identify where anomalies occurred in the physical pipe network. It was discovered that after validating, errors and warnings were found within the system, many of which were repetitive due to the nature of the error/warning. As well at times, terminology used in the GIS format was not compatible with terminology used in InfoWorks when importing. An example of this would be shape of pipe; while in GIS a circular pipe would have the notation “RND” (round), InfoWorks does not recognize this notation and views rounded pipes as “CIRC” (circular), hence generating an error messages.


N
MUNC BOUND NY TO
GLEN ECHO RD
TEDDINGTON PARK AVE
GOLFDALE RD
SNOWDON AVE
GLENFOREST RD
ROSLIN AVE
BOWOOD AVE
RANLEIGH AVE
WANLESS AVE
LAWRENCE AVE E
BUCKINGHAM AVE
LYMPSTONE AVE
CHELTENHAM AVE
ROCHESTER AVE
ST LEONARDS AVE
DAWLISH AVE
GLENGOWAN RD
STRATHGOWAN AVE
BLYTHWOOD RD
YONGE ST
FM 4
FM 5
FM 6
West Branch Don River
LAWRENCE AVE E
BAYVIEW AVE
VALLEYANNA DR
ARMISTICE DR
RAAB BLVD
HOSPITAL RD
WEST DON RIVER TRL
STRATHEDEN RD
STRATFORD CRES
GLENALLAN RD
PLANNING BOUNDARY
ALDBURY GDNS
LEGEND:
Combined Flow Monitoring Sites
Combined Pipe Size (mm)
225 - 300
300 - 450
450 - 750
750 - 1350
1350 - 2100
LPN Study Area
Watercourses
Roads
Combined Service Area
Combined Flow Monitoring Sites
FM 4 St Leonards Ave
FM 5 Buckingham Ave
FM 6 Roslin Ave
400 200 0 Meters
TORONTO
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LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA
Combined Sewer System
FIGURE No. 19.1
DATE: APRIL 2014

An initial “walk-through” of the storm system identified obvious information that did not import from the GIS database into InfoWorks. Correction of the obvious information greatly shortened the list of errors and warnings. Most of the remaining errors or warnings were associated with missing physical data. Where missing information was limited, the calculated or assumed value was flagged in the model. In most cases, missing data was associated with pipe diameter or pipe/manhole inverts.

Most of the gaps were filled using the digital sewer plan and profile drawings available from the City’s ImageSite. When no information was available in the ImageSite, the missing information was inferred using the InfoWorks model inference tool and best engineering judgment. The following assumptions were also considered to complete the sewer network model:

- Missing pipe inverts that could not be inferred by the InfoWorks inference tool was assigned inverts based on the average slope of pipe up and downstream of the missing inverts; and
- Physical sewer connections that did not have a manhole at the connection point were connected in the model using a dummy manhole.

The data gap analysis associated with link information such as missing pipe inverts for the combined system, as well as the data flags used is summarized in Appendix A of Technical Memorandum #1.

Questionable or uncertain data were identified during the model construction and preliminary simulation phases using the Engineering Validation Tool in InfoWorks. Shallow/steep pipes, reverse pipe direction, reduction in downstream diameter, connectivity and other physical parameters outside traditional design standards were identified and flagged for review.

Data gaps and checks were filled through review of the City’s plan and profile drawings, and through a series of inference assumptions based on surrounding infrastructure and engineering judgment. Where sufficient uncertainty remained, confirmation with City staff or a field investigation was undertaken.

The final check on the combined sewer continuity was the review of sewer profiles through the InfoWorks interface.

### 19.4 Flow Monitoring Data

Technical Memorandum #2 provides details regarding the extent of the rainfall and flow monitoring program. Rainfall and flow monitoring data was collected for calibrating the sanitary and combined system hydrologic and hydraulic model.

The rainfall and flow monitoring program was carried out from June 2013 to November

2013. Flow monitoring locations have been selected at 3 combined sewer sites and 3 sanitary sewer sites. The combined sewer system is shown in Figure 19.1, and Table 19-1 presents the dry weather flow results.

**Table 19-1: Summary of Monitored Combined Dry Weather Flows**

| Station | Gross Area (ha) | Population.[a] | Population./ha | Average DWF | | Min. DWF |
|---|---|---|---|---|---|---|
| | | | | L/sec | L/Cap/day[b] | L/sec |
| 4 (COM) | 3.2 | 263 | 82.2 | 2.1 | 589.9 | 0.4 |
| 5 (COM) | 14.7 | 706 | 48.0 | 6.7 | 819.9 | 2.5 |
| 6 (COM) | 59.1 | 3250 | 54.9 | 12.3 | 327.1 | 4.4 |

a - Based on City GIS database
b - Calculated from average DWF divided by Population

Combined flow monitoring data at three sites is considered reasonable and suitable for model calibration. The average dry weather flow rate observed at the combined monitoring location 6 is within a typical range for the service area size, the age of system and based on similar monitoring results in the City.

Five rainfall events (total precipitation amount > 10mm) were recorded and were considered suitable to characterize wet weather response in the system. The wet weather inflow/infiltration (I/I) results from the flow monitoring during these events are shown in Table 19-2. The peak I/I flow is obtained by subtracting the dry weather flow from the observed peak flow for each event.

**Table 19-2: Summary of Monitored Combined Peak I/I Flow (L/sec/ha)**

| | | June 10, 2013 | June 28, 2013 | July 07, 2013 | July 08, 2013 | July 27, 2013 |
|---|---|---|---|---|---|---|
| Total Daily Rainfall (mm) | | 21.5 | 33.5 | 34.0 | 78.3 | 12.3 |
| Station | Area (ha) | Observed Peak I/I Flow (L/sec/ha) | | | | |
| 4 (COM) | | 7.5 | 24.7 | 21.9 | 59.7 | 8.8 |
| 5 (COM) | | 0.7 | 3.5 | 2.4 | 8.0 | 0.1 |
| 6 (COM) | | 3.2 | 9.4 | 8.6 | 17.3 | 2.8 |

### 19.5 Catchment Delineation

Subcatchment areas were discretized on a manhole-to-manhole basis. ArcGIS and AutoCAD were used with the parcel (land use) layer and the sewer flow paths to refine the subcatchment shape. The subcatchments were checked as they were being created to ensure that they picked up the appropriate population points. The detailed delineation allows modelled flows to be distributed avoiding significant flow load points that can create instability issues in the hydraulic modelling.

### 19.6 Wastewater Flow Generation

To generate the wastewater flow from the area, data provided by the City such as land use and population were defined for each Dry Weather Flow (DWF) subcatchment. Land use information in the form of a shapefile was provided by the City for all development blocks within the study area. In the LPN study area land use was classified into four categories: Residential Single Family, Multilevel Residential, Commercial / Industrial / Institutional and Open Space. The predominate land use is single family residential. In addition to shapefiles, aerial photos were used for defining the unknown land use types.

The flow generated for each DWF subcatchment was based on the distribution of land use within each area as generated in ArcGIS. Days are defined as dry if no rainfall had occurred within the previous 72 hours. Collected flow monitor data is used to define average dry weather flow and wastewater waste profiles.

Wastewater flow for dry weather conditions is generated in InfoWorks using an average per capita flow (Lpcd) multiplied by the population of each DWF subcatchment. The population of each DWF subcatchment was determined by using the GIS theme containing population data and intersecting it with the combined subcatchment boundaries. The individual wastewater flow hydrographs from each subcatchment contributing to a monitoring location sum up to the flow observed at the flow meter as a basis of comparison for calibrating the dry weather flow component.

The dry weather flow results for LPN service area indicate that the per capita generation rate of approximately 330 L/c/d for the area. The area is predominately residential where typical design values range from 265 to 350 L/c/d. Flow monitor COM 6 was used to characterize the diurnal flow profiles of LPN study area for the wastewater feature in the model.

Table 19-3 summarizes the wastewater profile used for LPN study area. The calculated rates are within the recommended MOE values.

**Table 19-3: InfoWorks Dry Weather Flow Values**

| Monitoring Station | Total Population | Residential (L/c/d) | Wastewater Profile |
|---|---|---|---|
| 6 (COM) | 3250 | 330 | 1 |

### 19.7 Wet Weather Calibration/Validation

The wet weather and dry weather flow data were combined in order to produce a complete time series of combined sewer flow that represents observed data occurring before, during and after a rainfall event. The data was used for model calibration and validation. Observed wet weather flow time series are included in Appendices A and B with the calibration and validation results. Modelled dry weather flow was used for wastewater flow prior to a wet weather event.

The model was calibrated by matching as best as possible, the modelled flows to the monitored values at several stations, where reasonable flow monitoring data existed. The primary storm event that was used for calibration was the July 08th, 2013 which had a total rainfall depth of 78 mm over 24 hours.

This event was used for calibration as it was the largest storm event recorded according to volume, as well as the most intense over the course of the entire flow monitoring period. The June 10th, 2013, June 28th, 2013, July 07th, 2013 and July 27th, 2013 events were used for model verification.

A summary of modelled versus measured event volumes and peak flows for the combined calibration and validation events are found in Table 19-4 for the July 08th, 2013 event. The results of the calibration and validation curves are found in Appendix J.

In general for the calibration, subcatchment parameters were adjusted so that the peak flow and total volume for the simulated values were within 15% of the monitored data. There is generally good agreement for the July 08th, 2013 event on volume, peak flow and depth with the exception on peak flow for site 5. It might be caused by a malfunction of measuring equipment at that time.

**Table 19-4: Flow Monitoring Station Peak Flow & Volume Summary – July 08, 2013**

| Flow Monitoring Station ID and Location | Volume Model (m3) | Volume Observed (m3) | % Difference | Peak Flow Model (m3/s) | Peak Flow Observed (m3/s) | % Difference |
|---|---|---|---|---|---|---|
| | | | | | | |
| COM 4 – St Leonards Ave | 745 | 670 | 11.2% | 0.194 | 0.191 | 1.6% |
| COM 5 – Buckingham Ave | 1012 | 1138 | 11.1% | 0.158 | 0.117 | 35.0% |
| COM 6 – Roslin Ave | 8466 | 9837 | 13.9% | 1.00 | 1.02 | 2.0% |

A summary of modelled versus measured event volumes and peak flows for the combined validation events are found in Table 19-5 for the June 10, June 28, July 7 and July 27 events. The calibration and validation curves are found in Appendix .

**Table 19-5: Flow Monitoring Station Peak Flow & Volume Summary**

| Flow Monitoring Station ID and Location | Volume Model (m3) | Volume Observed (m3) | Peak Flow Model (m3/s) | Peak Flow Observed (m3/s) |
|---|---|---|---|---|
| **June 10, 2013** | | | | |
| COM 4 – St Leonards Ave | 161 | 101 | 0.032 | 0.023 |
| COM 5 – Buckingham Ave | 133 | 243 | 0.018 | 0.039 |
| COM 6 – Roslin Ave | 1440 | 1385 | 0.200 | 0.236 |
| **June 28, 2013** | | | | |
| COM 4 – St Leonards Ave | 263 | 50 | 0.088 | 0.021 |
| COM 5 – Buckingham Ave | 207 | 100 | 0.060 | 0.044 |
| COM 6 – Roslin Ave | 2071 | 593 | 0.561 | 0.301 |
| **July 07, 2013** | | | | |
| COM 4 – St Leonards Ave | 361 | 185 | 0.078 | 0.033 |
| COM 5 – Buckingham Ave | 561 | 666 | 0.043 | 0.080 |
| COM 6 – Roslin Ave | 4710 | 4079 | 0.517 | 0.520 |
| **July 27, 2013** | | | | |
| COM 4 – St Leonards Ave | 62 | 30 | 0.035 | 0.030 |
| COM 5 – Buckingham Ave | 54 | 52 | 0.007 | 0.022 |
| COM 6 – Roslin Ave | 587 | 346 | 0.176 | 0.202 |

Overall the July 08$^{th}$ event calibration is considered reasonable at all sites. There is reasonable agreement also between observed and modelled flows for the other events. The model predicts the flow results reasonably well on all the events with the exception of June 28th event. The rainfall on June 28th event did not seem to fall as intensively over the study area.

For the purposes of this flood study dealing with extreme storm events, a second validation of model parameters was undertaken using historical events as described in the following section.

### 19.8 Calibration/Verification Using Historic Storm Events

The rainfall on July 8$^{th}$ event recorded during the monitoring period was equivalent to a 25-

year storm event. The calibration /validation of the model to this storm were reasonable. A secondary verification was undertaken to assess the impact of larger storms such as the August 19, 2005 event with the intention of replicating the flooding that occurred in LPN study area for confirmation purpose.

The model was validated with the August 19, 2005 event using rainfall data from the City gauge no. 102. Figure 17.3 shows the location of the City's rain gauge. During this event there were two incidences of flooding which was reported to the City. Figure 19.2 shows the August 19, 2005 historical event model simulation results. Figure 19.2 shows hydraulic issues in the system for this event and a high risk of basement flooding, which is consistent with locations where basement flooding has been reported.. The records are provided by the City or collected from a questionnaire at the initial stage of this study.

For the purpose of evaluating the combined system for the 100-year design storm event the combined system model is considered valid and suitable. As such, the model calibration parameters were considered valid to represent the wet weather response in the system to replicate the flooding that occurred in LPN study area for this event.

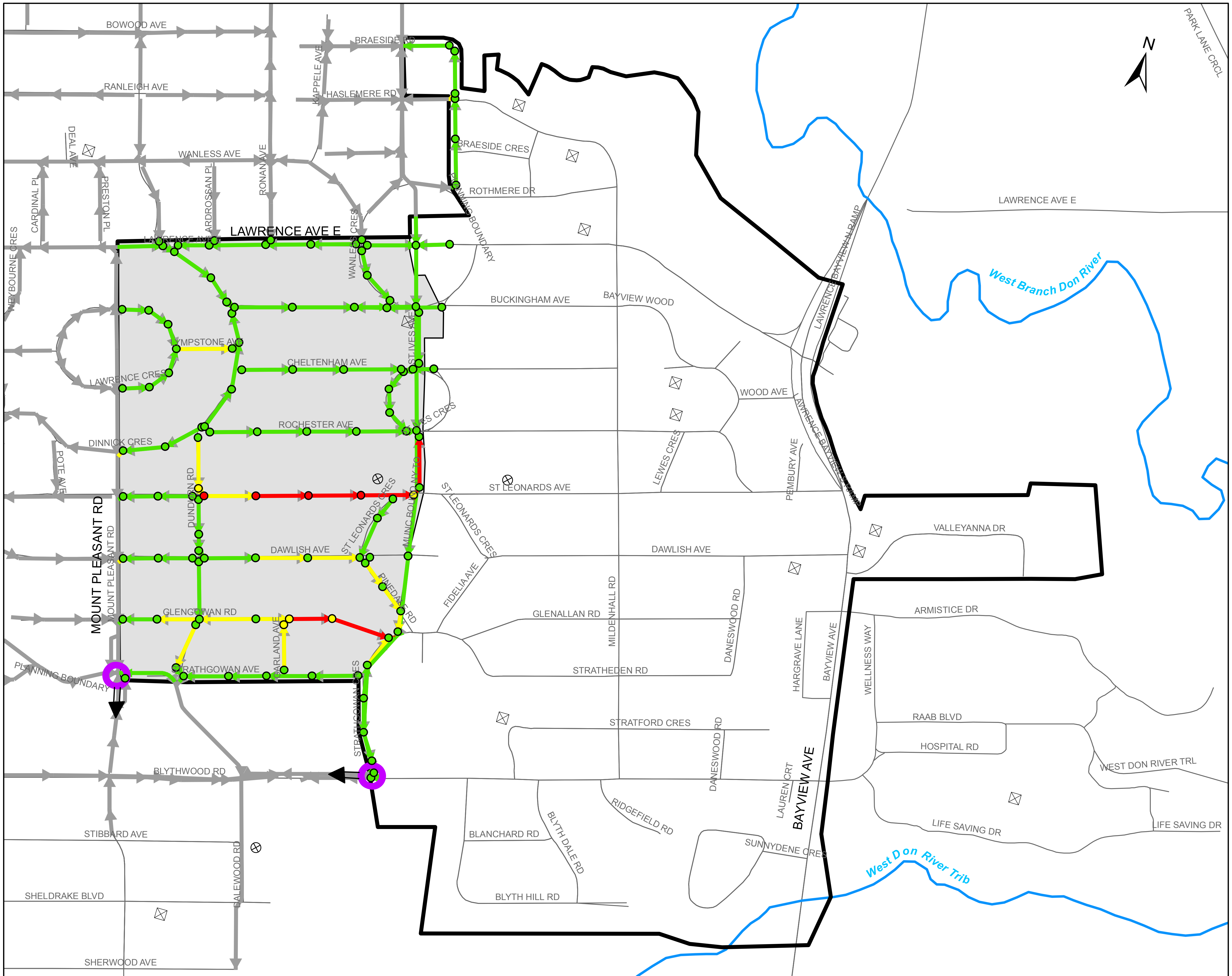
### 19.9 Assessment of Combined System Hydraulic Performance

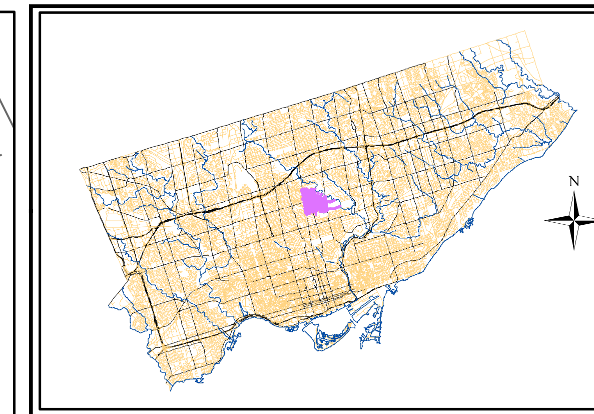
The 100-year design storm event is used for the combined system baseline assessment. For these simulations the per capita average dry weather flow is based on existing dry weather flow conditions.

### 19.10 100-year Design Storm Assessment Event

The model was used to simulate the 100-year design storm event. The event is considered the design or assessment event for the combined sewer system for the basement flooding level of protection criteria. For the assessment event the per capita average dry weather flow is based on existing dry weather flow conditions.

Figure 19.3 shows the simulation results showing surcharging in the combined system and water surface elevations less than 1.8 m below the ground. The model shows the HGL is within 1.8 m of the ground surface in the area including in the vicinity of St. Leonards Avenue and St. Ives Avenue, Glengowan Road and Garland Avenue.. These areas are served only by combined sewers and storm sewer is not installed presently.



LEGEND:

- LPN Study Area
- Watercourses
- Roads
- Outlet

**HistoricalFlooding Layer**

- Aug 19, 2005
- May 12, 2000

**Pipe Surcharge State**

- No Surcharge
- Slope of HGL < Pipe Slope
- Slope of HGL > Pipe Slope

**Depth of Water Level**

- > 1.8m
- 0 - 1.8m
- Flooding
- Combined Service Area

400 200 0 Meters

TORONTO

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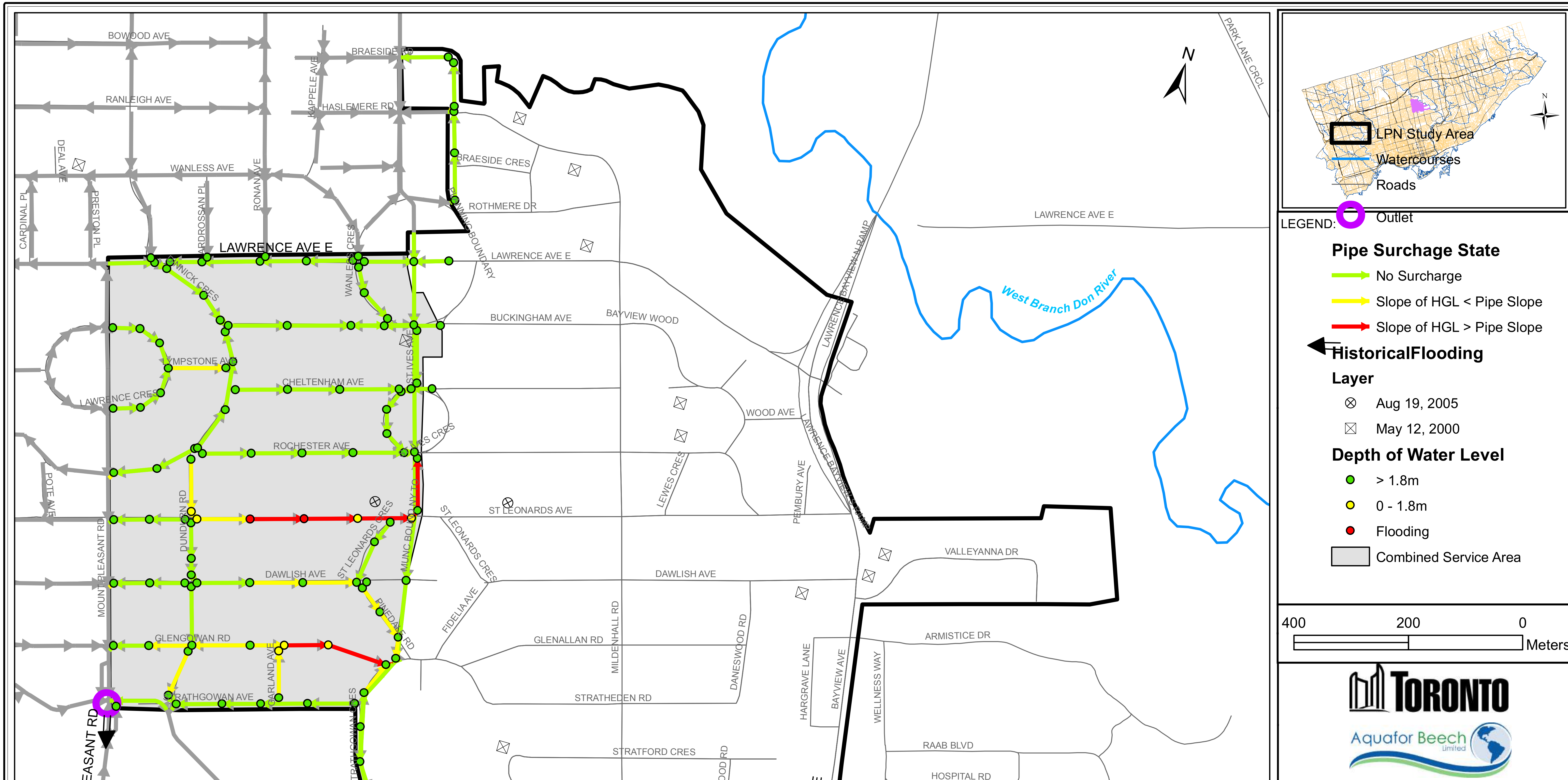
**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Combined Sewer August 19, 2005 Event Depth of Water and Surcharge State**

**FIGURE No.** 19.2

**DATE: APRIL 2014**




**LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA**

**Combined Sewer - 100 Year Design Storm Assessment Event Depth of Water and Surcharge State**

**FIGURE No.** 19.3

**DATE: APRIL 2014**

# 20.0 CONCLUSIONS AND LIMITATIONS

## 20.1 Conclusions

The following conclusions can be drawn from the combined, sanitary and storm system analysis:

## 20.2 Combined System

- Calibration of the combined sewer system model was reasonable, in part aided by the fact that a large event (approximately 1:25 year) occurred during the monitoring process. Two of the monitors were installed in local sewers, with the third being installed in a combined trunk sewer.

- Flooding is generally limited to a few areas which are serviced by the original combined sewer

## 20.3 Sanitary System

- Calibration of the sanitary sewer system was also reasonable. Three monitors were installed at strategic locations within the existing sanitary sewer system.

- The sanitary sewer system, during wet weather events, experiences significant infiltration/inflow. The three primary sources of I/I include downspouts connected to the sanitary sewer, private property sources and stormwater entering manhole covers.

- An undersized sanitary sewer along Valleyanna Drive and a section along Bayview Avenue results in back up of flows which extends into areas west of Bayview Avenue.

### 20.4 Storm System

- Flow monitoring was not undertaken in the storm sewer system as information provided from the plumbing records suggests that foundation drains are not connected to the storm sewer.

- As the surcharge of storm sewers would not cause the runoff backup to the foundation drains and resulted in basement flooding. Thus, the flow monitoring program was undertaken in the sanitary and combined sewer systems.

- The model suggests localized surcharging in the minor system during the 2 and 5-year events and in both the minor and major system during a 100 year design event.

- The primary areas where deficiencies occur are within the former City of North York. Within this area a poor to non-existent major system exists. An insufficient storm drainage system may contribute to flooding as water may enter the sanitary sewer system through manhole covers. In addition, there are numerous reverse grade driveways where stormwater may enter private property due to the lack of difference in change in elevation between the road & top of driveway. This issue will be addressed as part of the road component of the study.

### 20.5 General

As noted above, and as established from the questionnaire flooding may be attributed to both public and private property problems. This study will only address surface and basement flooding that is attributed to public property issues.

### 20.6 Model Limitations and Application

There are some inherent limitations with the use and application of the calibrated models for LPN study area. The best possible information available at the time was used to create, calibrate and validate the model; however, assumptions had to be made to fill the data gaps. The following section discusses the model limitations in detail:

- The connectivity of individual house connections (i.e. roof leaders, foundation drains, etc.) could not be confirmed with 100% certainty. Field investigations were completed to help identify the connectivity of the house connections, but ultimately assumptions were made for implementation in the model.

- The resolution of the DTM, at 15-m grid point spacing, was useful when trying to identify the overland drainage along right-of-ways (ROW), but does not accurately represent the overland drainage and surface storage outside of the ROW as curb and building elevation details are missing.

- In the overland system, there may be small pockets of depression storage that may not have been visible from the DEM data; therefore, they have not been accounted for in the model. In reality, these small depressions would reduce the peak and increase the travel time of the hydrographs.

# Appendix C-2: Technical Memorandum 4 Addendum

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**LIST OF FIGURES**

## 1.0 GENERAL

The figures presented in this addendum area intended to supplement the results presented in Technical Memorandum No. 4.

## 2.0 PREFERRED ALTERNATIVE

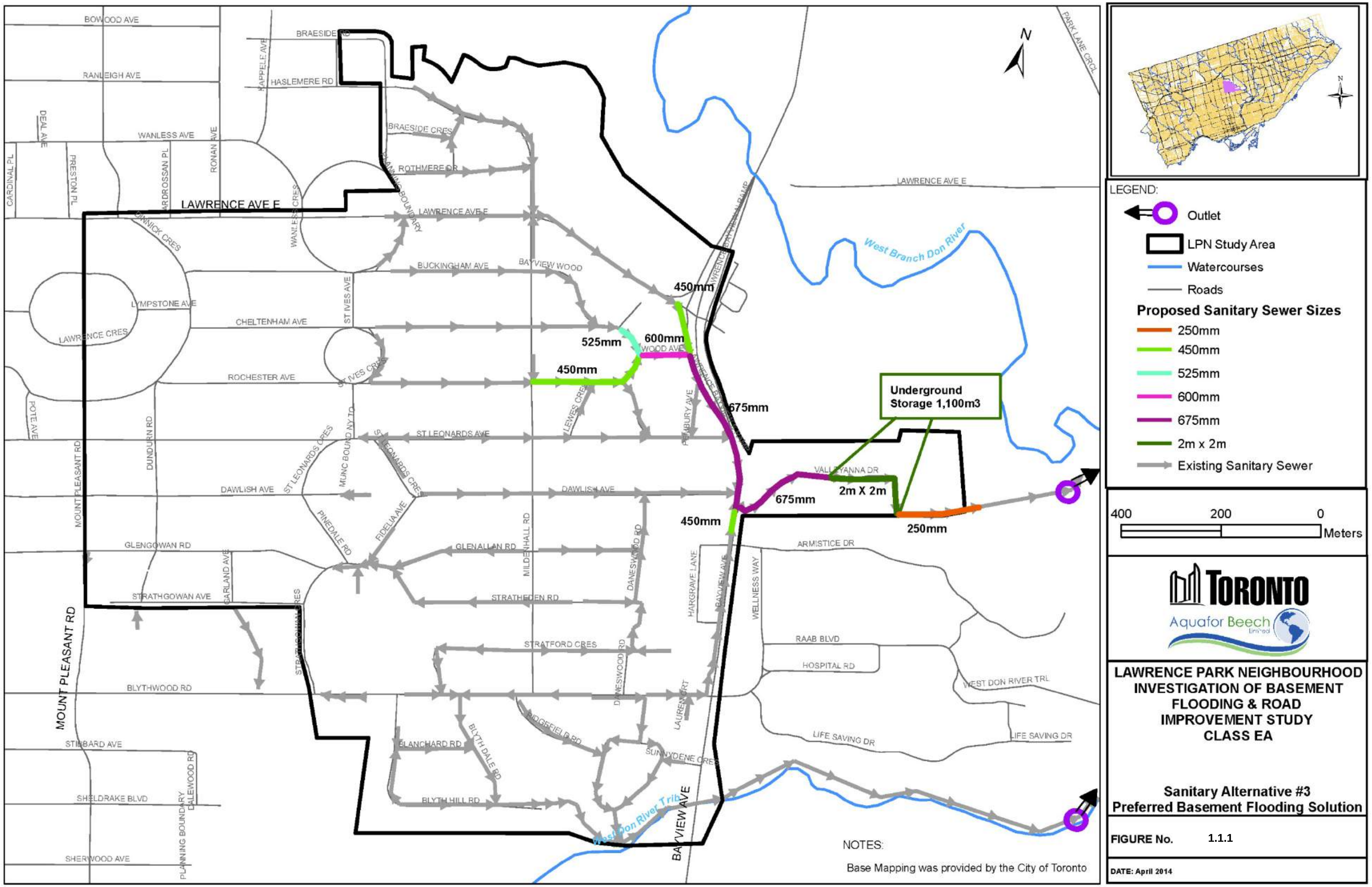
### 2.1 Sanitary Alternative #3

This alternative includes the following remedial measures:

- Mandatory downspout disconnection (a theoretical 75% disconnection rate was assumed as a base condition);
- Sealing sanitary manhole covers in low lying areas to minimize the inflow of storm water into the sanitary system;
- Capacity upgrades on St. Aubyns Crescent to Wood Avenue (525 mm), on Rochester Avenue to Wood Avenue (450 mm) and on Wood Avenue to Bayview Avenue (600 m);
- Capacity upgrades on Bayview Avenue to Wood Avenue (450 mm), Bayview Avenue to Dawlish Avenue (675 mm) and on Bayview Avenue to Armistice Drive (450 mm);
- Capacity upgrades along the sections of sewer on Valleyanna Drive (675 mm);
- In-line storage in the form of a box culvert (2000 mm x 2000 mm – 1100 $m^3$) on Valleyanna Drive; and
- Lowering, and therefore replacement, of the existing 250 mm sanitary sewer east of Valleyanna Drive in order to receive flows from the proposed underground storage facility.

Figure 1.1.1 presents the sanitary system remedial measures for Sanitary Alternative 3 while Figure 1.1.2 presents the model results for the preferred alternative.

This alternative maintains the sanitary system HGL more than 1.8m from the surface for the May 12, 2000 evaluation event as measured at the Oriole Yard gauging station. This alternative also limits flows to the West Don Sanitary Trunk Sewer to existing levels. This alternative may also require work on private property.

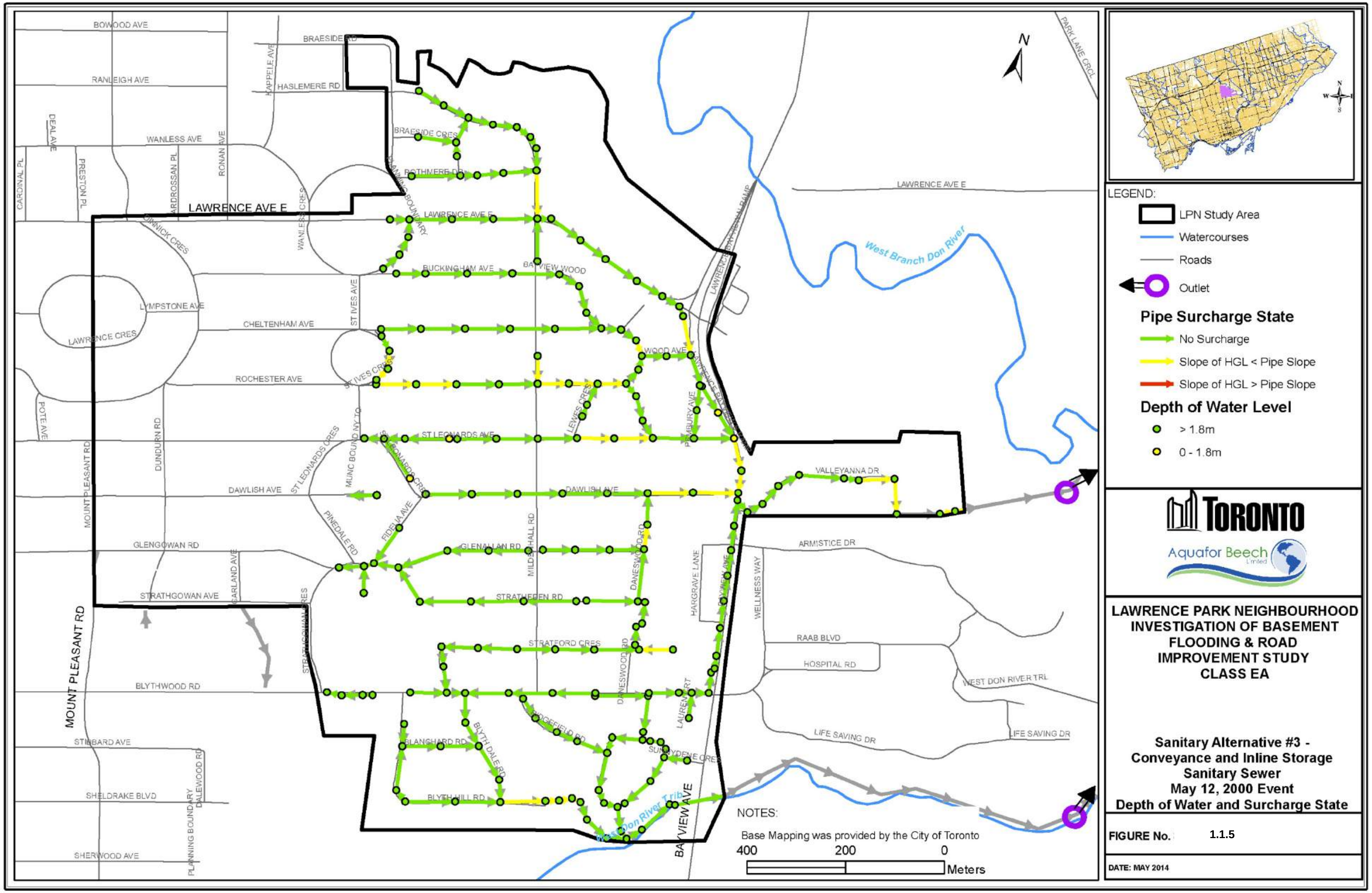



LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA

Sanitary Alternative #3
Preferred Basement Flooding Solution

FIGURE No. 1.1.1

DATE: April 2014


LEGEND:
LPN Study Area
Watercourses
Roads
Outlet
Pipe Surcharge State
No Surcharge
Slope of HGL < Pipe Slope
Slope of HGL > Pipe Slope
Depth of Water Level
> 1.8m
0 - 1.8m
TORONTO
Aquafor Beech
LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA
Sanitary Alternative #3 - Conveyance and Inline Storage Sanitary Sewer May 12, 2000 Event Depth of Water and Surcharge State
FIGURE No. 1.1.5
DATE: MAY 2014
NOTES:
Base Mapping was provided by the City of Toronto
400 200 0 Meters
LAWRENCE AVE E
MOUNT PLEASANT RD
BAYVIEW AVE
West Branch Don River
BLYTHWOOD RD
ROCHESTER AVE
CHELTENHAM AVE
DAWLISH AVE
ST LEONARDS AVE
BUCKINGHAM AVE
GLENALLAN RD
STRATHEDEN RD
STRATFORD CRES
BLYTH HILL RD
BLANCHARD RD
VALLEYANNA DR
ARMISTICE DR
RAAB BLVD
HOSPITAL RD
LIFE SAVING DR
WEST DON RIVER TRL
BOWOOD AVE
RANLEIGH AVE
WANLESS AVE
BRAESIDE RD
HASLEMERE RD
GLENGOWAN RD
STRATHGOWAN AVE
SHELDRAKE BLVD
SHERWOOD AVE
STIBBARD AVE

### 2.2 Combined Alternative #1

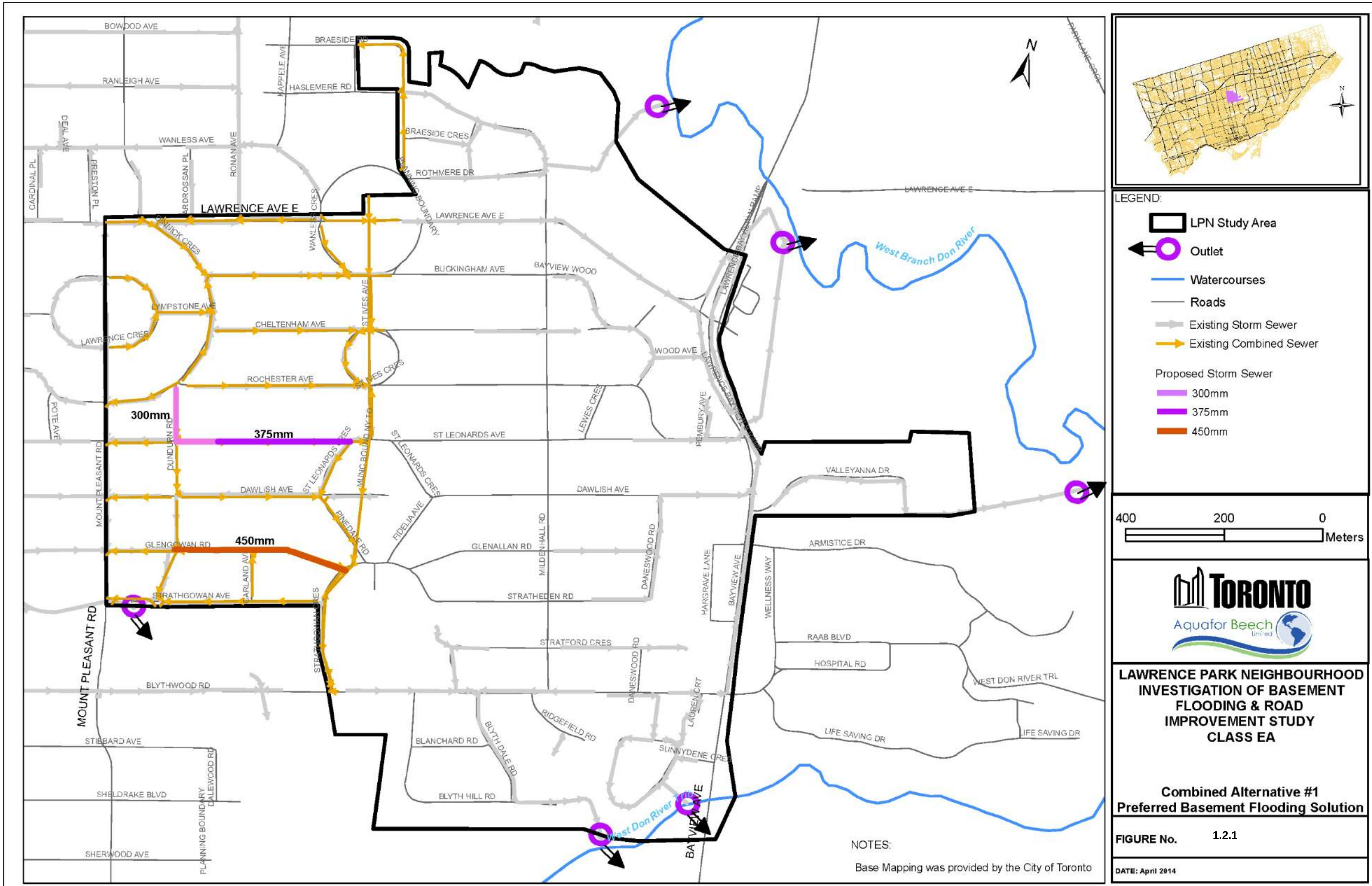
This alternative includes the following remedial measures:

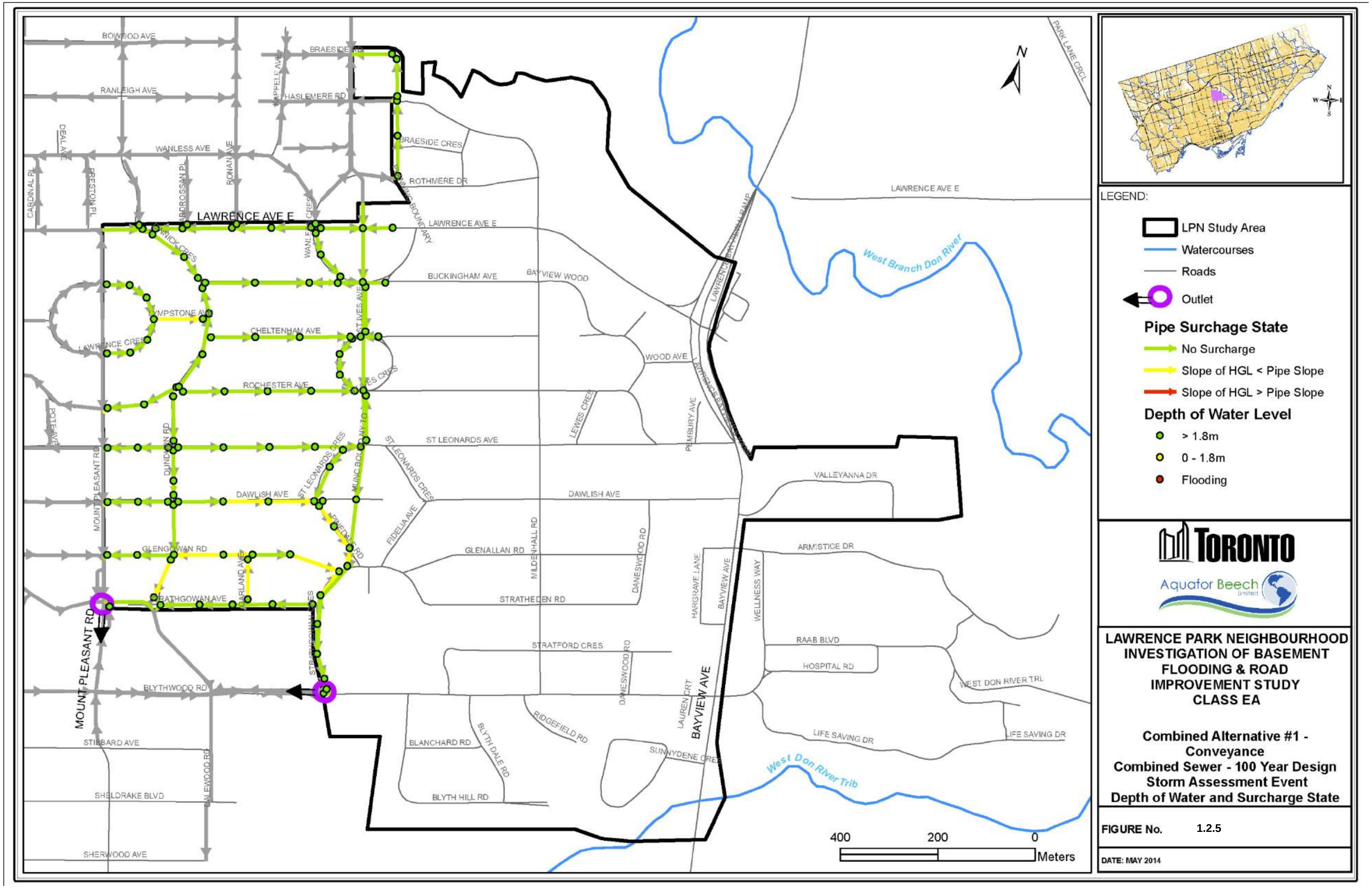
- Mandatory downspout disconnection (a theoretical 75% disconnection rate was assumed as a base condition);
- Sewer separation that includes the installation of a new 300 mm storm pipe on Dundurn Road and disconnection of catchbasins from combined sewers and reconnecting to new storm sewers;
- Sewer separation that includes the installation of new 300 to 375 mm storm pipe on St. Leonards Avenue and disconnection of catchbasins from combined sewers and reconnecting to new storm sewers; and
- Sewer separation including the installation of new 450 mm storm pipe on Glengowan Avenue and disconnection of catchbasins from combined sewers and reconnecting to new storm sewers.

Figure 1.2.1 presents the combined sewer system remedial measures for Combined Alternative 1 while Figure 1.2.2 presents the model results for this preferred alternative.

The conveyance improvements control the HGL in the combined sewer to the crown of the pipe for the City’s 100-year design storm event.

This alternative (sewer separation) was one of the strategies developed in the Wet Weather Flow Master Plan. This alternative would increase flow into the existing storm system but the existing storm system is still sufficient to control the HGL to the crown of storm pipe under the 2-year design event.


LEGEND:
LPN Study Area
Outlet
Watercourses
Roads
Existing Storm Sewer
Existing Combined Sewer
Proposed Storm Sewer
300mm
375mm
450mm
400 200 0 Meters
TORONTO
Aquafor Beech
LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA
Combined Alternative #1
Preferred Basement Flooding Solution
FIGURE No. 1.2.1
DATE: April 2014
NOTES:
Base Mapping was provided by the City of Toronto
300mm
375mm
450mm
LAWRENCE AVE E
MOUNT PLEASANT RD
West Branch Don River
West Don River
BAYVIEW AVE
BLYTHWOOD RD
ST LEONARDS AVE
DAWLISH AVE
GLENGOWAN RD
STRATHGOWAN AVE
ROCHESTER AVE
CHELTENHAM AVE
BUCKINGHAM AVE
WANLESS AVE
RANLEIGH AVE
BOWOOD AVE
HASLEMERE RD
BRAESIDE CRES
ROTHMERE DR
GLENALLAN RD
STRATHEDEN RD
STRATFORD CRES
VALLEYANNA DR
ARMISTICE DR
RAAB BLVD
HOSPITAL RD
LIFE SAVING DR
WEST DON RIVER TRL
BLANCHARD RD
BLYTH HILL RD
SUNNYDENE CRES
STIBBARD AVE
SHELDRAKE BLVD
SHERWOOD AVE
WOOD AVE
BAYVIEW WOOD


LEGEND:
LPN Study Area
Watercourses
Roads
Outlet
Pipe Surchage State
No Surcharge
Slope of HGL < Pipe Slope
Slope of HGL > Pipe Slope
Depth of Water Level
> 1.8m
0 - 1.8m
Flooding
TORONTO
Aquafor Beech Limited
LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY CLASS EA
Combined Alternative #1 - Conveyance
Combined Sewer - 100 Year Design Storm Assessment Event
Depth of Water and Surcharge State
FIGURE No. 1.2.5
DATE: MAY 2014
400 200 0 Meters
LAWRENCE AVE E
MOUNT PLEASANT RD
BAYVIEW AVE
West Branch Don River
West Don River Trib

## 3.0 LIMITATIONS

There are some inherent limitations with the use and application of the calibrated models for LPN study area. The best possible information available at the time was used to create, calibrate and validate the model; however, assumptions had to be made to fill the data gaps. The following section discusses the model limitations in detail:

- The connectivity of individual house connections (i.e. roof leaders, foundation drains, etc.) could not be confirmed with 100% certainty. Field investigations were completed to help identify the connectivity of the house connections, but ultimately assumptions were made for implementation in the model.

- The resolution of the DTM, at 15-m grid point spacing, was useful when trying to identify the overland drainage along right-of-ways (ROW), but does not accurately represent the overland drainage and surface storage outside of the ROW as curb and building elevation details are missing.
.

**Appendix C-3: Technical Memorandum 5**

Aquafor Beech Limited

**Aquafor Beech File No.: 65319**

December 23, 2016

Revised January 29, 2018

# TECHNICAL MEMORANDUM NO.5

# LAWRENCE PARK NEIGHBOURHOOD STUDY AREA

Prepared for:
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# 1.0 INTRODUCTION

## 1.1 General

Periodically, the City has experienced both surface and basement flooding in response to relatively infrequent rainfall events. One of the more recent events was the storm of August 19, 2005, an event in excess of 100 year return frequency that resulted in over 3,600 reported basement flooding occurrences across the City. In April 2006, City Council approved a work plan designed to focus on prevention, to the highest economical degree possible of surface flooding and reducing the amount of stormwater entering all sewer systems. The work plan identified chronic basement flooding areas throughout the City.

Basement Flooding Area 20, within the Lawrence Park neighbourhood is one of the areas in Toronto included in the "Basement Flooding Work Plan', approved by City Council to address basement flooding across the City.

Traffic and pedestrian safety issues existing and road drainage systems are also unable to convey stormwater effectively

The City of Toronto initiated a Municipal Class Environmental Assessment (EA) study to address issues relating to deteriorating road conditions, traffic, pedestrian safety, drainage problems and basement in the Lawrence Park neighbourhood.

Figure 1.1 shows the Lawrence Park Neighbourhood (LPN) study area which is generally located in the central part of the City within Ward 25 – Don Valley West. The study area is roughly bounded by Blythwood Road, Ridgefield Road and Sunnydene Crescent to the south, Don River West Branch to the north, Mount Pleasant Road to the west, and Bayview Avenue in the east.

The study area is serviced by a mix of combined, sanitary and road storm. The Lawrence Park Neighbourhood Sewershed has four (4) stormwater outfalls discharging into the tributary of West Branch of the Don River.

The distribution of land use within the study area is approximately 70% single and multiple residential, approximately 10% institutional, commercial and industrial, and 20% park area and roadway. A majority of the commercial developments are located adjacent to Bayview Avenue.

A majority of the homes in area to the west of St. Ives Avenue (former City of Toronto) were initially serviced with combined sewers, which carry both wastewater and stormwater runoff. Throughout the 1960s until the mid 1980s, the City undertook sewer separation programs whereby stormwater runoff from public property was directed to a storm sewer. Subdivisions to the east of St. Ives Avenue (former City of North York) within the study area that were constructed from the 1960's onward are serviced by road ditches as well as a separate storm and sanitary system. Also provided in figure 1.1 are the former municipal boundaries for Cities of Toronto and North York.

As of 2013, approximately 10% of the area is serviced by combined sewers, 20% with partially separated sewers (storm/combined) and 70% with separated sewers (storm/sanitary).

### 1.2 Objective

The objectives of Technical Memorandum #5 are as follows:

- Summarize the targeted level of service for the conceptual design of the proposed works and the model development process; and
- Summarize the storm drainage analysis undertaken to determine the storm sewer sizing associated with the proposed road improvements including the results using the targeted level of service as the primary criterion.

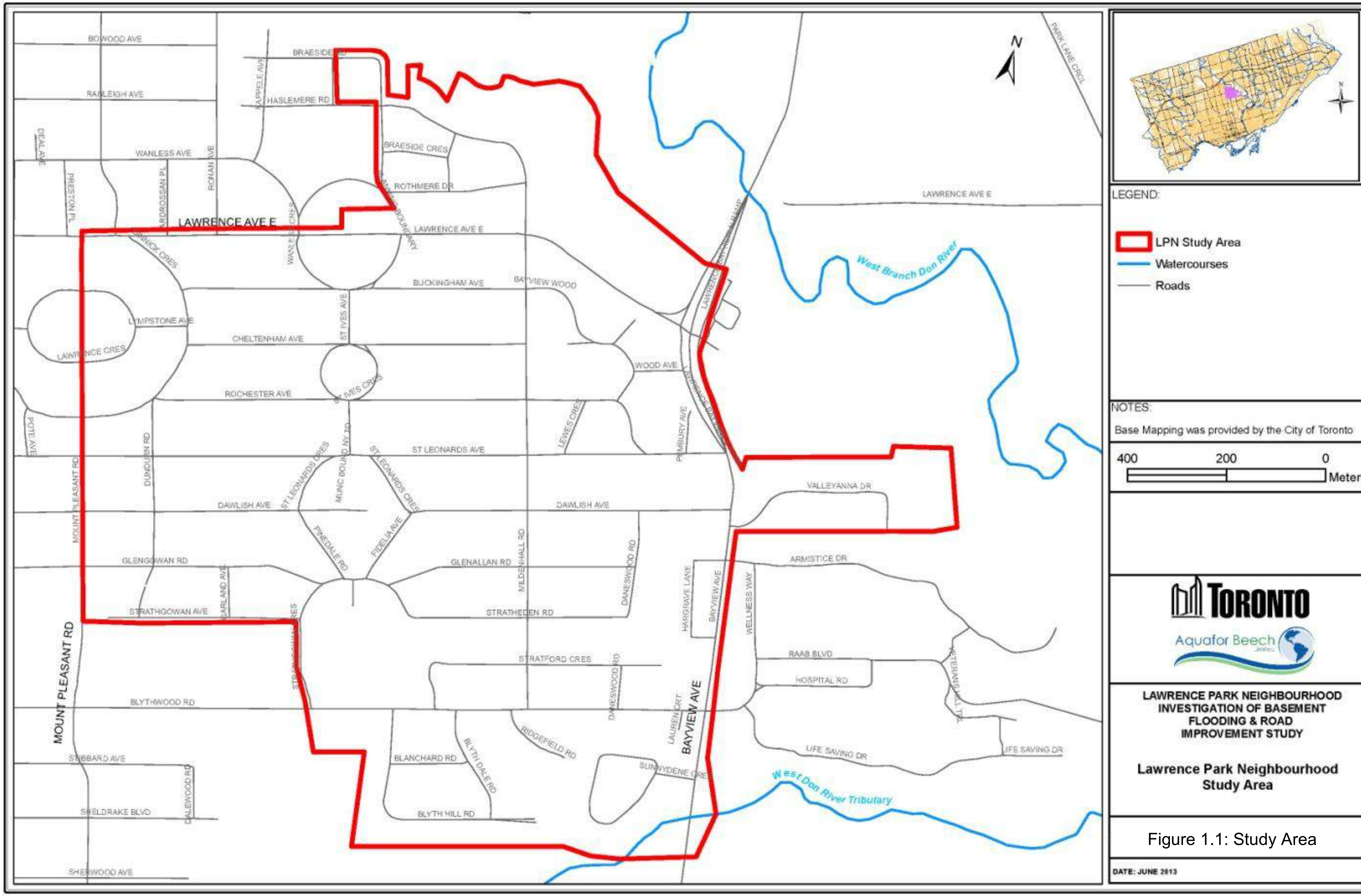



Figure 1.1: Study Area

### 1.3 Target Level of Service for Storm Sewer System

The City of Toronto has defined the following level of service criteria for sanitary, storm and combined sewer systems.

These criteria are defined below for the storm drainage system:

A 100-year level of protection is being targeted for the storm system referencing the Wet Weather Flow Management Guidelines, November 2006.

- Major system flows are to be maintained within the road allowance at no deeper than 300 mm over gutter level. Where reverse-sloped driveways area present, major system flows are to be maintained at no deeper that 150 mm;
- The sewer system shall maintain a no surcharge level where feasible for local streets;
- Where no surcharge is not possible, the maximum HGL is to be maintained at or below 1.8 m based on the City of Toronto (Draft) InfoWorks CS Basement Flooding Model Studies Guideline..

These criteria were used as a basis for defining level of service and subsequent remedial works. The criteria were further refined to address the conditions within the study area as follows:

## 2.0 STORM SEWER SIZING CRITERIA

The City identified the level of service criterion for storm system remedial works to mitigate basement and surface flooding.

Surface and Basement Flood Mitigation

Flood mitigation design criteria within the road cross section included:

- 2-year (6-hour Chicago) storm conveyance by the minor system (i.e. no surcharging); and
- 100-year (6-hour Chicago) storm flows within the road right-of-way to a maximum storm flow depth of 0.3m above curb and 0.15m above curb where reverse sloped driveways are present and the HGL maintained below 1.8m;

Currently, the City of Toronto InfoWorks CS Basement Flooding Model Studies Guideline, 2014 (referred to as the BF Guidelines) identifies the level of service criteria to be targeted in developing and sizing remediation alternatives to alleviate basement and surface flooding. For the Storm Drainage System, the 100-year level of protection is being targeted.

The maximum HGL of the storm sewer system is to be maintained at a no-surcharge level where feasible. Where no surcharge level is not feasible, the maximum HGL is to be maintained at an elevation a least 1.8 m below surface elevation. The depth of the remedial works is kept below a minimum cover of 2.1 m from the obvert where feasible in order to maintain the criteria of a minimum 1.8 m HGL. Part of achieving the criteria involves attaining a downspout disconnection of 75% in order to mitigate storm flows directly into the minor system.

Catch basin inlet capacities are according to the BF Guidelines and the Design Criteria for Sewers and Watermain. The standard rating curve to be used for catch basins is contained in the BF Guidelines. A catch basin rating curve of 55 L/s was used for road drainage as well as at reverse sloped driveways.

Storm Sewer Sizing for the Proposed Works

The criteria as noted above were used as a basis for the design of the preferred storm sewer works associated with the proposed road improvements. The following design guidance was used in order to develop conceptual designs:

- Mandatory 75% downspout disconnection rate as per City target;
- Urban road cross-section assumed for major system;
- Maintaining storm pipe obvert depths at a minimum cover of 2.1 m where feasible to ensure that the HGL stays below 1.8 m;
- Maintaining storm pipe slopes between 0.2% and 2% where feasible;
- Ensuring that the depth of overland flow does not exceed 150 mm where there are reverse slope driveways present and 300 mm elsewhere;
- Standard catch basin inlet capacity of 55 L/s;
- Requirement of additional catch basin inlets where necessary; and,
- Maintain a maximum spacing between maintenance holes at 90 m where feasible.

## 3.0 OVERVIEW OF MODEL

An overview of the model development is presented in this Technical Memorandum. This section is intended to provide details on the development of the hydrologic and hydraulic modelling tools used to assess surface and basement flooding in the LPN study area. InfoWorks CS software by Innovyze was selected by the City for this assignment and is used for the sanitary, combined and storm models. The version of InfoWorks used for this assignment is InfoWorks CS 11.5. For more detail, refer to Technical Memorandum 3.

As indicated in Technical Memorandum 3, flow monitoring was not undertaken for the storm sewer system as foundation drain records received at the time indicated that there was no foundation drains connected to the storm sewer system. As no flow monitoring was undertaken for the storm sewer system, the model is not calibrated. Design storms were run to evaluate the existing condition (see Technical Memorandum 3) and to determine effectiveness of the preferred solution.

### 3.1 Modelling Objectives

A detailed hydrologic/hydraulic model assessment of the proposed storm sewer works using InfoWorks was undertaken with the following objectives:

- To aid in the development and evaluation of alternatives based on the City's target level of service/performance;
- Extend the storm sewer collection system to areas where none currently exist;

Throughout the development process every effort has been made to document assumptions and to base assumed parameters on available documentation, guidance and experience.

### 3.2 Data Sources and Compilation

To meet the modelling objectives of this study, it is necessary for the sewer system model to reasonably represent the physical systems. The details of the data sources and compilation are detailed in Technical Memo 3.

### 3.3 Reverse Sloped Driveways

A reverse sloped driveway was modelled using a gully node set 1 m below road surface elevation with a standard catchbasin (herring bone) with an inlet capacity of 55 L/s and a weir connection to the upstream maintenance hole. The overland contribution of each reverse slope driveway was subtracted from the total contribution to overland flow for each subcatchment area.

## 4.0 PROPOSED STORM WORKS MODEL

The following section outlines the development and calibration of the proposed storm system model for Lawrence Park Neighbourhood (LPN) Study Area. Figures in this section are located at the end of the section.

### 4.1 Description of Storm Drainage Areas

Figure 4.1 shows the four storm drainage areas and locations of storm outfalls. The overall storm study area is approximately 160 ha. The 160 ha LPN study area consists of approximately 1300 properties. The LPN study area is primarily single-family detached residential landuse developed in the 1920's to 1950's. A significant percentage of the houses have been renovated or torn down and rebuilt. The storm drainage system for the study area drains to the West Don River.

The existing conditions for each of the sites are detailed below:

Site 1 drains an area in the northern part of the Lawrence Park Neighbourhood. The existing conditions for the area's storm drainage include the following:

- The existing area conveys flows from several streets located west of Mildenhall Road. Flows are conveyed through an easement located at the north limit of the Toronto French School;
- The existing sewer located within the easement is undersized and requires a capacity upgrade. Furthermore, a field investigation showed that the sewer may be in a state of disrepair and may be causing erosion within the ravine; this sewer is also undersized and requires a capacity upgrade;
- The existing easement agreement allows the City to enter the lands along the sewer alignment for the purposes of constructing and maintaining the storm sewer;
- There are four properties with reverse sloped driveways along Mildenhall Road.

The drainage area for Site 2 is the largest of the drainage areas in the Lawrence Park Neighbourhood covering approximately 40 ha. The existing conditions include the following:

- The existing area conveys flows from several streets east of Bayview Avenue area east of Bayview Avenue. Flows are conveyed across Bayview Avenue at St. Leonard's Avenue through the York University's Glendon College campus at 2275 Bayview Avenue into a ravine with an outfall at the West Don River;

- The existing sewer conveying flows through the Glendon campus is undersized and requires a capacity upgrade. Furthermore, the upstream sewer in the ravine lands will need to be deepened to allow for upgrading of the storm sewer through the campus property;
- There is currently no existing easement through the Glendon campus that allows for upgrading of the storm sewer (at the time of this report);
- There are 67 properties with reverse sloped driveways throughout the drainage area. The majority of the reverse driveways are located along Dawlish Avenue, Rochester Avenue and St. Leonard's Avenue.

Site 3 drains an area in the southern part of the Lawrence Park Neighbourhood south of Stratford Crescent. The existing conditions include the following:

- The existing streets drain down Blyth Hill Road and are conveyed through the property of 70 Blyth Hill Road into a ravine that is an environmentally sensitive area;
- The existing sewer conveying flows on Blyth Hill Road through 70 Blyth Hill Road is undersized for the 100-year design storm with the HGL between 0 and 1.8 m depth.
- There are 37 properties with reverse sloped driveways in the drainage area.

Site 4 drains an area in approximately the middle of the Lawrence Park Neighbourhood towards the southwest. The existing conditions include the following:

- Many of the existing streets drain towards a low point near the centre of the drainage area at Strathden Road and Strathgown Crescent; these flows should be conveyed out of the low point and west to the open channel at the west limit of Strathgowan Avenue;
- There are 13 reverse sloped driveways scattered throughout the drainage area.

Technical Memorandum #3 details the development and assessment of the existing storm system. Much of the drainage is via overland flow systems (ditches) and a pipe network with insufficient capacity to convey the 100-year design storm.

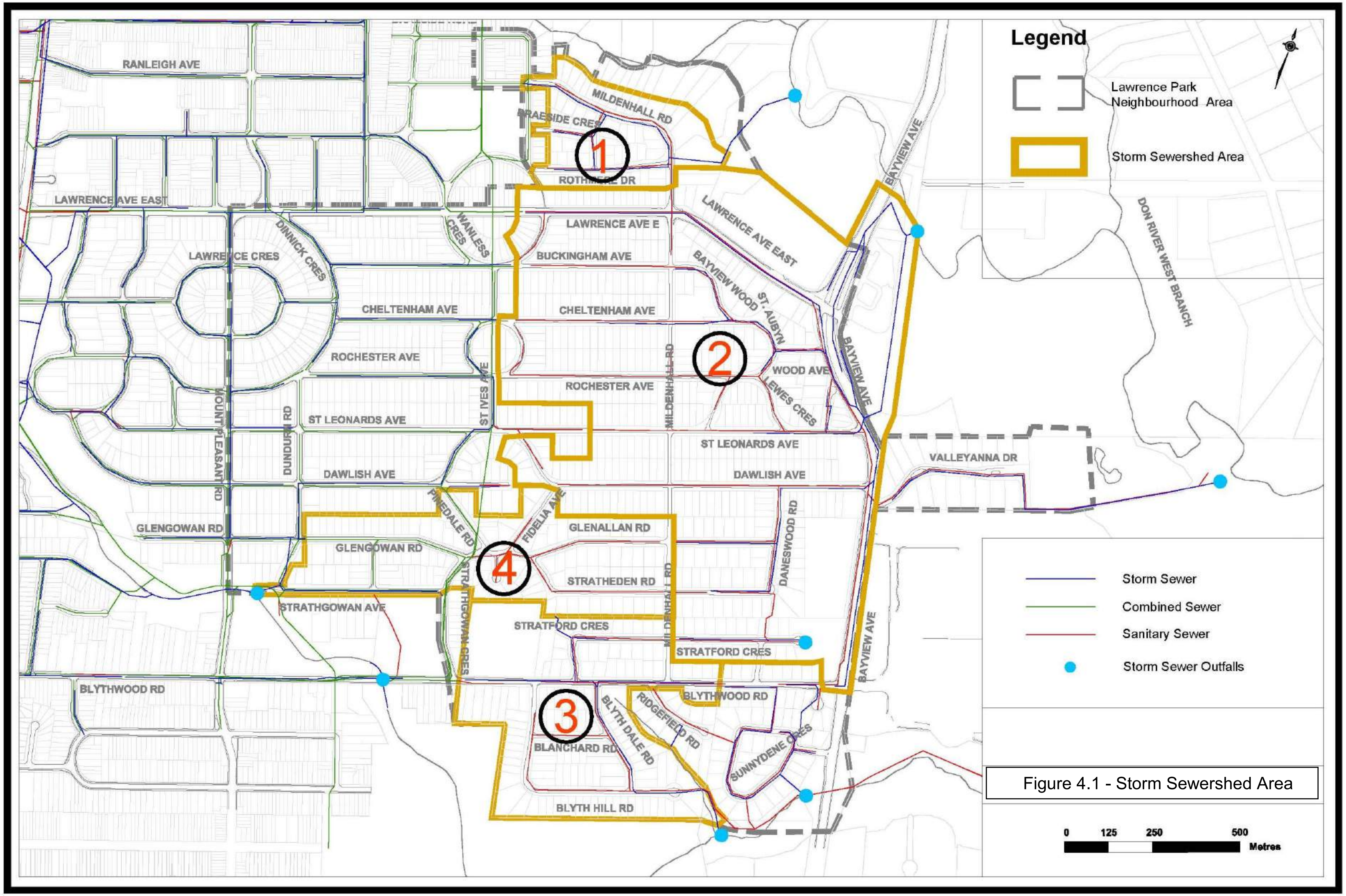


Figure 4.1 - Storm Sewershed Area

### 4.2 Model Development

The following section describes the InfoWorks hydrologic/hydraulic model developed to simulate the performance of the existing storm drainage system. The model was developed to assess existing sewers associated with the proposed road improvements and overland drainage capacity under varying rainfall events, and is the basis for developing and evaluating remedial measures.

Basement flooding from the storm sewer system is considered possible if the following condition exists:

- The surcharge level in the storm sewer is higher than 1.8 m below the surface elevation, which coincides with the assumed basement elevation for homes and the sanitary service lateral;
- Surcharging of shallow storm sewers that increases the risk of I&I into the sanitary system

The surcharge level, or maximum HGL has been represented at model nodes is categorized and colour-coded as follows:

- Green: The HGL is below 1.8 m from the surface, the theoretical basement elevation, or for shallow sewers that are within 1.8 from the surface, the water level remains in the pipe.
- Yellow: The HGL is above 1.8 m below surface but below the ground elevation.
- Red: The HGL is at or above the ground surface and flooding from the sewer to the street occurs.

Furthermore, the slope of the HGL at each pipe segment can indicate whether the cause of surcharge is from the sewer being under-capacity (i.e. bottleneck) or the result of backwater from another downstream sewer. Therefore, the “surcharge state” of each pipe in the sewer system is defined in included and colour-coded in three categories as follows:

- Green: The Pipe is not surcharged;
- Yellow: The Pipe is surcharged, and the slope of the HGL is flatter than the pipe slope, meaning the surcharge is due to backup as a result of an over-loaded downstream pipe.;
- Red: The Pipe is surcharged, and the slope of the HGL is shallower than the pipe slope, meaning the surcharge is caused by the pipe, which is over-loaded and is acting as a bottleneck (flow exceeds its capacity).

### 4.3 Network Data

The storm dual drainage water collection system consists of two components; the major and minor systems. The major system represents overland flow paths such as roadways and ditches, while the minor system is predominately defined as the underground pipe network. The major system is connected to the minor system through catchbasins, which are defined as a "gully" in the InfoWorks model.

The following highlights the development of the minor and major systems. Catchbasins inlet capacity was assumed at 55 L/s with additional catch basins added where necessary.

### 4.4 Minor System

The existing storm sewer model was assembled using the database provided by the City and considering every manhole as a node as per Technical Memorandum 3. The existing storm sewer network was used as a basis for the proposed storm sewer works. The proposed works are tabulated in Table 4.4.1. Maintenance Hole (MH) ID's were automatically generated either from existing storm sewers or parallel sanitary sewers where no storm sewers previously existed. The outfall water level was not specified as all outfalls were assumed to be at a free level (no backwater condition).

Impact on Basement Flooding Solutions

The sizing of the minor system for the conceptual design developed for road drainage has impacts the Basement Flooding solutions in the combined sewer area west of St. Ives Crescent. The proposed sewer works for Glengowan Road as developed in the Basement Flooding solutions has a storm sewer draining against the road grade from an easterly to westerly direction. As part of the conceptual for road drainage, the conceptual design along Glengowan Road developed for the Basement Flooding solutions is revised to a proposed storm sewer that follows the road grade draining west to east and conveys flows to a proposed sewer along Strathgowan Crescent.

Table 4.1 - Proposed Storm Sewers

| Street | Improvement | Proposed Conceptual Design | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Upstream MH | Downstream MH | Length | Shape | Width (mm) | Height (mm) | Gradient (m/m) | Pipe Full Capacity (m3/s) |
| Site 1 | | | | | | | | | |
| BRAESIDE CRES | Replace | 4303813649 | 4304913731 | 81.9 | CIRC | 300 | 300 | 0.03126 | 0.171 |
| MILDENHALL RD | Replace | 4311313563 | 4312713629 | 67.7 | CIRC | 600 | 600 | 0.00851 | 0.566 |
| MILDENHALL RD | Replace | 4310013745 | 4310013785 | 39.8 | CIRC | 900 | 900 | 0.00678 | 1.491 |
| MILDENHALL RD | Replace | 4310013785 | 4310613851 | 66.2 | CIRC | 900 | 900 | 0.00604 | 1.407 |
| MILDENHALL RD | Replace | 4311013680 | 4310013745 | 65.3 | CIRC | 900 | 900 | 0.00495 | 1.273 |
| MILDENHALL RD | Replace | 4312713629 | 4311013680 | 53.3 | CIRC | 900 | 900 | 0.00593 | 1.394 |
| MILDENHALL RD | Replace | 4310613851 | 4307713884 | 44.5 | CIRC | 1050 | 1050 | 0.00449 | 1.831 |
| MILDENHALL RD | Replace | 4305313891 | 4307413997 | 98 | CIRC | 1200 | 1200 | 0.0051 | 2.785 |
| MILDENHALL RD | Replace | 4307413997 | STMA0110 | 23.3 | CIRC | 1200 | 1200 | 0.04532 | 8.301 |
| MILDENHALL RD | Replace | 4307713884 | 4305313891 | 24.4 | CIRC | 1200 | 1200 | 0.0041 | 2.496 |
| MILDENHALL RD | Replace | 4312014005 | 4320914046 | 97.9 | CIRC | 1200 | 1200 | 0.06016 | 9.564 |
| MILDENHALL RD | Replace | 4320914046 | 4324714102 | 68.8 | CIRC | 1200 | 1200 | 0.03968 | 7.767 |
| MILDENHALL RD | Replace | STMA0110 | 4312014005 | 23.6 | CIRC | 1200 | 1200 | 0.04805 | 8.547 |
| PROCTOR CRES | Replace | 4298613754 | 4304913731 | 67.1 | CIRC | 300 | 300 | 0.01341 | 0.112 |
| PROCTOR CRES | Replace | 4304913731 | 4310013745 | 53 | CIRC | 600 | 600 | 0.02698 | 1.009 |
| ROTHMERE DR | Replace | 4296313674 | 4298613754 | 83 | CIRC | 375 | 375 | 0.03513 | 0.329 |
| ROTHMERE DR | Replace | 4298613754 | 4300813818 | 67.5 | CIRC | 450 | 450 | 0.01001 | 1.812 |
| ROTHMERE DR | Replace | 4300813818 | 4303513897 | 83.3 | CIRC | 1050 | 1050 | 0.0084 | 2.504 |
| ROTHMERE DR | Replace | 4303513897 | 4305313891 | 19.2 | CIRC | 1200 | 1200 | 0.00521 | 2.814 |
| Site 2 | | | | | | | | | |
| BAYVIEW AVE | Replace | 4252014466 | 4254114480 | 25.4 | CIRC | 1500 | 1500 | 0.00394 | 13.384 |
| BAYVIEW AVE | Replace | 4254114480 | 4260114472 | 60.5 | CIRC | 1500 | 1500 | 0.00331 | 16.274 |
| BAYVIEW AVE | Replace | 4260114472 | 4265114425 | 68.6 | CIRC | 1500 | 1500 | 0.00292 | 15.283 |
| BAYVIEW AVE | Replace | 4263714424 | 4265114425 | 13.3 | CIRC | 1500 | 1500 | 0.00376 | 7.049 |
| BAYVIEW N LAWRENCE RAMP | Replace | 4265114425 | 4265714424 | 6.8 | CIRC | 2400 | 2400 | 0.00735 | 9.858 |
| GLENDON CAMPUS | Replace | 4265714424 | 4268214453 | 37.6 | CIRC | 2100 | 2100 | 0.00266 | 5.929 |
| GLENDON CAMPUS | Replace | 4268214453 | 4282814432 | 147.6 | CIRC | 2100 | 2100 | 0.00054 | 2.676 |
| BAYVIEW WOOD | Install | 4277114104 | 4278314159 | 57.1 | CIRC | 1500 | 1500 | 0.00525 | 30.636 |
| BAYVIEW WOOD | Install | 4278914076 | 4277114104 | 32.9 | CIRC | 1200 | 1200 | 0.00608 | 16.631 |
| BAYVIEW WOOD | Install | 4282813911!! | 4283913968! | 95.2 | CIRC | 825 | 825 | 0.00525 | 1.04 |
| BAYVIEW WOOD | Install | 4283714046 | 4278914076 | 56.1 | CIRC | 1200 | 1200 | 0.00535 | 15.599 |
| BAYVIEW WOOD | Install | 4283913968! | 4285014008 | 41 | CIRC | 1200 | 1200 | 0.00122 | 7.449 |
| BAYVIEW WOOD | Install | 4285014008 | 4285114029 | 20.5 | CIRC | 1200 | 1200 | 0.00244 | 10.535 |
| BAYVIEW WOOD | Install | 4285114029 | 4283714046 | 22.8 | CIRC | 1200 | 1200 | 0.00439 | 14.127 |
| BUCKINGHAM AVE | Install | 4276313685!! | 4277913741!! | 59 | CIRC | 300 | 300 | 0.01644 | 0.124 |

| Street | Improvement | Proposed Conceptual Design | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Upstream MH | Downstream MH | Length | Shape | Width (mm) | Height (mm) | Gradient (m/m) | Pipe Full Capacity (m3/s) |
| BUCKINGHAM AVE | Install | 4277913741!! | 4280213823!! | 84.8 | CIRC | 450 | 450 | 0.01179 | 0.31 |
| BUCKINGHAM AVE | Install | 4280213823!! | 4282813911!! | 91.6 | CIRC | 600 | 600 | 0.01059 | 1.146 |
| CHELTENHAM AVE | Install | 4268813846a | 4268813846b | 70.7 | CIRC | 450 | 450 | 0.01273 | 0.322 |
| CHELTENHAM AVE | Install | 4268813846b | 4268813846c | 69.8 | CIRC | 600 | 600 | 0.01289 | 0.697 |
| CHELTENHAM AVE | Install | 4268813846c | 4268813846d | 48.1 | CIRC | 600 | 600 | 0.01455 | 0.741 |
| CHELTENHAM AVE | Install | 4268813846d | 4268813846e | 49 | CIRC | 600 | 600 | 0.01531 | 0.76 |
| CHELTENHAM AVE | Install | 4268813846e | 4272713981! | 43.5 | CIRC | 600 | 600 | 0.01379 | 0.721 |
| DANESWOOD RD | Replace | 4226414341 | 4236214327 | 98.7 | CIRC | 525 | 525 | 0.01996 | 0.608 |
| DANESWOOD RD | Replace | 4236214327 | 4241414319 | 52.5 | CIRC | 600 | 600 | 0.00952 | 2.665 |
| DANESWOOD RD | Replace | 4241414319 | 4247614296! | 61.3 | CIRC | 675 | 675 | 0.00878 | 2.559 |
| DAWLISH AVE | Install | 4237613955! | 4240214044! | 92.7 | CIRC | 450 | 450 | 0.02956 | 0.49 |
| DAWLISH AVE | Install | 4240214044! | 4242814131! | 91.2 | CIRC | 450 | 450 | 0.0364 | 0.544 |
| DAWLISH AVE | Install | 4242814131! | 4245314218! | 90 | CIRC | 450 | 450 | 0.03578 | 0.539 |
| DAWLISH AVE | Install | 4245314218! | 4247614296! | 82.1 | CIRC | 525 | 525 | 0.01096 | 0.643 |
| DAWLISH AVE | Install | 4247614296! | 4249714385 | 87.6 | CIRC | 1500 | 1500 | 0.00342 | 12.483 |
| DAWLISH AVE | Replace | 4249714385 | 4252014466 | 83.9 | CIRC | 1500 | 1500 | 0.00596 | 16.467 |
| GLENALLAN RD | Replace | 4230314123 | 4232314190 | 70.2 | CIRC | 375 | 375 | 0.04601 | 0.376 |
| GLENALLAN RD | Replace | 4232314190 | 4234214257 | 69.5 | CIRC | 450 | 450 | 0.03554 | 0.538 |
| GLENALLAN RD | Replace | 4234214257 | 4236214327 | 72.2 | CIRC | 525 | 525 | 0.02438 | 0.672 |
| LEWES CRES | Install | 4261314129! | 4266114138! | 48.2 | CIRC | 300 | 300 | 0.00394 | 0.061 |
| LEWES CRES | Install | 4261414246! | 4256414217 | 41.1 | CIRC | 1500 | 1500 | 0.00487 | 1.263 |
| LEWES CRES | Install | 4265814220! | 4261414246! | 50.8 | CIRC | 1500 | 1500 | 0.00394 | 1.136 |
| LEWES CRES | Install | 4267714194! | 4265814220! | 32.7 | CIRC | 1500 | 1500 | 0.00306 | 1.001 |
| MILDENHALL RD | Install | 4268114006! | 4262714021!! | 56.4 | CIRC | 300 | 300 | 0.00177 | 0.041 |
| MILDENHALL RD | Install | 4272713981! | 4274914054 | 76 | CIRC | 675 | 675 | 0.00658 | 0.682 |
| MILDENHALL RD | Install | 4286513952! | 4283913968! | 54 | CIRC | 300 | 300 | 0.00185 | 0.051 |
| ROCHESTER AVE | Install | 4253613707! | 4255913785! | 80.9 | CIRC | 600 | 600 | 0.00865 | 0.571 |
| PEMBURY AVE | Replace | 4265814344 | 4266214353 | 10.5 | CIRC | 375 | 375 | 0.0100 | 0.092 |
| PEMBURY AVE | Replace | 4266214353 | 4260514359 | 57.2 | CIRC | 300 | 300 | 0.00909 | 0.102 |
| PEMBURY AVE | Replace | 4268614339 | 4265814344 | 28.4 | CIRC | 375 | 375 | 0.0100 | 0.092 |
| ROCHESTER AVE | Install | 4254513706! | 4253613707! | 8.7 | CIRC | 600 | 600 | 0.0023 | 0.104 |
| ROCHESTER AVE | Install | 4255913785! | STMA210 | 41.1 | CIRC | 600 | 600 | 0.01217 | 0.677 |
| ROCHESTER AVE | Install | 4258113863! | STMMHA0211 | 43.5 | CIRC | 600 | 600 | 0.01195 | 0.671 |
| ROCHESTER AVE | Install | 4260513946! | 4262714021!! | 78 | CIRC | 600 | 600 | 0.00641 | 0.492 |
| ROCHESTER AVE | Install | 4262714021!! | 4264514082! | 63.6 | CIRC | 600 | 600 | 0.00314 | 0.344 |
| ROCHESTER AVE | Install | 4264514082! | 4266114138! | 58 | CIRC | 600 | 600 | 0.00345 | 0.361 |
| ROCHESTER AVE | Install | STMA210 | 4258113863! | 40.1 | CIRC | 600 | 600 | 0.01247 | 0.686 |
| ROCHESTER AVE | Install | STMMHA0211 | 4260513946! | 43.2 | CIRC | 600 | 600 | 0.00486 | 0.428 |
| ROCHESTER AVE | Install | 4266114138! | 4267714194! | 58.1 | CIRC | 600 | 600 | 0.00516 | 0.441 |

| Street | Improvement | Proposed Conceptual Design | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Upstream MH | Downstream MH | Length | Shape | Width (mm) | Height (mm) | Gradient (m/m) | Pipe Full Capacity (m3/s) |
| ST AUBYNS CRES | Install | 4273814213 | 4269014197 | 49.9 | CIRC | 1500 | 1500 | 0.00401 | 26.758 |
| ST AUBYNS CRES | Install | 4278314159 | 4273814213 | 73 | CIRC | 1500 | 1500 | 0.00411 | 27.095 |
| ST AUBYNS CRES | Install | 4269014197 | 4267714194! | 25.2 | CIRC | 1500 | 1500 | 0.00397 | 26.618 |
| ST AUBYNS CRES | Install | 4274914054 | 4277114104 | 54.3 | CIRC | 1500 | 1500 | 0.00313 | 0.47 |
| ST IVES CRES | Install | 4257313721! | 4254513706! | 32.1 | CIRC | 300 | 300 | 0.00779 | 0.085 |
| ST IVES CRES | Install | 4260913715! | 4257313721! | 36.8 | CIRC | 300 | 300 | 0.00408 | 0.062 |
| ST LEONARDS AVE | Install | 4247513895! | 4249713972! | 79.4 | CIRC | 300 | 300 | 0.01272 | 0.109 |
| ST LEONARDS AVE | Install | 4249713972! | 4252114052! | 83.7 | CIRC | 375 | 375 | 0.01254 | 0.196 |
| ST LEONARDS AVE | Install | 4252114052! | 4254314128! | 79.6 | CIRC | 450 | 450 | 0.01043 | 0.291 |
| ST LEONARDS AVE | Install | 4254314128! | 4256414201! | 75.2 | CIRC | 450 | 450 | 0.00758 | 0.248 |
| ST LEONARDS AVE | Install | 4256414201! | 4256414217 | 78.4 | CIRC | 525 | 525 | 0.00574 | 0.326 |
| ST LEONARDS AVE | Replace | 4256414217 | 4260014341 | 128.6 | CIRC | 1800 | 1800 | 0.00389 | 2.431 |
| ST LEONARDS AVE | Replace | 4260014341 | 4260514359 | 17.9 | CIRC | 1800 | 1800 | 0.00447 | 2.607 |
| ST LEONARDS AVE | Replace | 4260514359 | 4262114411 | 54.9 | RECT | 1800 | 1800 | 0.00146 | 8.143 |
| ST LEONARDS AVE | Replace | 4262114411 | 4263714424 | 22.3 | CIRC | 1800 | 1800 | 0.00538 | 8.433 |
| ST LEONARDS CRES | Install | 4235013865! | 4237613955! | 93.4 | CIRC | 450 | 450 | 0.00343 | 0.203 |
| ST LEONARDS CRES | Install | 4237213825!! | 4235013865! | 60.4 | CIRC | 300 | 300 | 0.03312 | 0.221 |
| ST LEONARDS CRES | Install | STM_MH_A0201 | 4237213825!! | 62.7 | CIRC | 300 | 300 | 0.02554 | 0.194 |
| STRATFORD CRES | Replace | 4212014191 | 4215014298 | 110.8 | CIRC | 300 | 300 | 0.01949 | 0.135 |
| STRATFORD CRES | Replace | 4215014298 | 4217214376 | 80.7 | CIRC | 525 | 525 | 0.02776 | 0.717 |
| STRATFORD CRES | Replace | 4217214376 | 4218914433 | 59.9 | CIRC | 750 | 750 | 0.01503 | 1.365 |
| STRATFORD CRES | Replace | 4218914433 | 4218514439 | 7.3 | CIRC | 450 | 450 | 0.0137 | 1.303 |
| STRATHEDEN RD | Replace | 4223214226 | 4226414341 | 119.7 | CIRC | 375 | 375 | 0.05038 | 0.394 |
| Site 3 | | | | | | | | | |
| BLANCHARD RD | Install | 4184613960! | 4186714035! | 77.7 | CIRC | 600 | 600 | 0.00386 | 0.382 |
| BLANCHARD RD | Install | 4186714035! | 4188814116 | 77.6 | CIRC | 900 | 900 | 0.00644 | 1.453 |
| BLYTH DALE RD | Replace | STM_A0366 | 4179314196 | 19 | RECT | 4200 | 2400 | 0.00789 | 67.853 |
| BLYTH HILL RD | Replace | 4179314196 | STM_A0302 | 54.2 | RECT | 4200 | 2400 | 0.00467 | 52.175 |
| BLYTH HILL RD | Replace | STM_A0302 | STM_A0303_OR | 1.1 | CIRC | 600 | 600 | 0.04093 | 1.51 |
| BLYTH HILL RD | Replace | STM_A0303_OR | 4181514269 | 15.6 | CIRC | 1200 | 1200 | 0.00712 | 3.828 |
| BLYTH HILL RD | Install | 4174013997! | 4176814094! | 101.4 | CIRC | 450 | 450 | 0.00986 | 0.283 |
| BLYTH HILL RD | Install | 4175713973! | 4184613960! | 88.7 | CIRC | 375 | 375 | 0.00902 | 0.167 |
| BLYTH HILL RD | Replace | 4176814094! | 4179314196 | 91.5 | CIRC | 1200 | 1200 | 0.01093 | 4.076 |
| BLYTH HILL RD | Install | 4189013951! | 4184613960! | 45.1 | CIRC | 600 | 600 | 0.00421 | 0.399 |
| Site 4 | | | | | | | | | |
| DAWLISH AVE | Replace | 4230413723 | 4228413654! | 90 | CIRC | 450 | 450 | 0.00398 | 0.18 |
| DAWLISH AVE | Replace | 4231213750 | 4230413723 | 28.7 | CIRC | 300 | 300 | 0.00976 | 0.096 |
| FIDELIA AVE | Install | 4227013833! | 4218613803! | 88.5 | CIRC | 300 | 300 | 0.03469 | 0.18 |

| Street | Improvement | Proposed Conceptual Design | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Upstream MH | Downstream MH | Length | Shape | Width (mm) | Height (mm) | Gradient (m/m) | Pipe Full Capacity (m3/s) |
| GARLAND AVE | Replace | 4204713561!! | 4212513539! | 81.8 | CIRC | 300 | 300 | 0.02001 | 0.137 |
| GLENALLAN RD | Replace | 4225213939! | 4219213853! | 104.7 | CIRC | 300 | 300 | 0.02407 | 0.15 |
| GLENALLAN RD | Replace | 4227514019! | 4225213939! | 83.6 | CIRC | 300 | 300 | 0.00431 | 0.063 |
| GLENALLAN RD | Install | 4229714097! | 4227514019! | 80.8 | CIRC | 250 | 250 | 0.00421 | 0.039 |
| GLENGOWAN RD | Install | 4209913401 | 4209413387 | 15.3 | CIRC | 250 | 250 | 0.11046 | 0.198 |
| GLENGOWAN RD | Install | 4212113488! | 4213813545! | 60.2 | CIRC | 300 | 300 | 0.01538 | 0.12 |
| GLENGOWAN RD | Install | 4212513539! | 4213813545! | 14.4 | CIRC | 300 | 300 | 0.01757 | 0.128 |
| GLENGOWAN RD | Install | 4213813545! | 4216013619! | 76.9 | CIRC | 375 | 375 | 0.00765 | 0.153 |
| GLENGOWAN RD | Install | 4216013619! | 4215413726! | 106.7 | CIRC | 600 | 600 | 0.00619 | 0.483 |
| PINE FOREST RD | Install | 4212313800! | 4217613785! | 54.8 | CIRC | 450 | 450 | 0.01825 | 0.385 |
| PINEDALE RD | Install | 4220613733! | 4217013739! | 37.3 | CIRC | 450 | 450 | 0.01421 | 0.34 |
| PINEDALE RD | Install | 4224013690! | 4220613733! | 54.6 | CIRC | 450 | 450 | 0.01529 | 0.353 |
| PINEDALE RD | Install | 4227213649! | 4224013690! | 52 | CIRC | 450 | 450 | 0.01512 | 0.351 |
| PINEDALE RD | Install | 4228413654! | 4227213649! | 12.9 | CIRC | 450 | 450 | 0.00566 | 0.215 |
| STRATHEDEN RD | Install | 4216714013! | 4213813914! | 103.5 | CIRC | 300 | 300 | 0.02155 | 0.142 |
| STRATHEDEN RD | Install | 4219614116! | 4216714013! | 106.9 | CIRC | 300 | 300 | 0.00402 | 0.061 |
| STRATHGOWAN AVE | Install | 4198513389! | 4196413337! | 100.2 | CIRC | 900 | 900 | 0.00299 | 0.991 |
| STRATHGOWAN AVE | Install | 4200613463! | 4198513389! | 76.9 | CIRC | 900 | 900 | 0.01339 | 2.095 |
| STRATHGOWAN AVE | Install | 4200613463 | 4200613463! | 5 | CIRC | 300 | 300 | 0.03961 | 0.241 |
| STRATHGOWAN AVE | Install | 4202613531! | 4200613463! | 71.4 | CIRC | 900 | 900 | 0.0134 | 2.096 |
| STRATHGOWAN AVE | Install | 4202613531 | 4202613531! | 4.8 | CIRC | 300 | 300 | 0.01892 | 0.133 |
| STRATHGOWAN AVE | Install | 4204913610! | 4202613531! | 82.7 | CIRC | 900 | 900 | 0.0134 | 2.096 |
| STRATHGOWAN AVE | Install | 4204913610 | 4204913610! | 4.7 | CIRC | 300 | 300 | 0.01272 | 0.109 |
| STRATHGOWAN AVE | Install | 4207113689! | 4204913610! | 81.2 | CIRC | 900 | 900 | 0.00724 | 1.541 |
| STRATHGOWAN AVE | Install | 4209713702! | 4207113689! | 15.6 | CIRC | 900 | 900 | 0.0134 | 2.096 |
| STRATHGOWAN AVE (BLYTHWOOD RAVINE PARK) | Install | 4196413337! | 1404824D3! | 5.6 | CIRC | 900 | 900 | 0.0375 | 3.506 |
| STRATHGOWAN CRES | Install | 4213813914! | 4219213853! | 81.8 | CIRC | 900 | 900 | 0.00024 | 0.283 |
| STRATHGOWAN CRES | Install | 4215413726! | 4209713702! | 62.4 | CIRC | 900 | 900 | 0.0134 | 2.096 |
| STRATHGOWAN CRES | Install | 4217013739! | 4215413726! | 10.8 | CIRC | 900 | 900 | 0.01343 | 2.098 |
| STRATHGOWAN CRES | Install | 4217613785! | 4217013739! | 50.8 | CIRC | 900 | 900 | 0.00039 | 0.359 |
| STRATHGOWAN CRES | Install | 4218613803! | 4217613785! | 20.7 | CIRC | 900 | 900 | 0.00242 | 0.89 |
| STRATHGOWAN CRES | Install | 4219213853! | 4218613803! | 50.4 | CIRC | 900 | 900 | 0.00575 | 1.373 |

### 4.5 Major System – Overland Flow

Surface area characteristics were considered for every subcatchment which was described on a manhole to manhole basis. The overland runoff system was then added as an additional link between nodes as represented by the street cross sections.

The streets were modelled as wide shallow open channels to reflect the appropriate geometry, cross section and channel roughness. The overland channel invert levels were set at the manhole cover levels such that flows in the overland channels can occur when there is flooding out of the manholes from the minor drainage system or when the flow is restricted into the minor system at the catchbasin based on the catchbasin inlet capture capacity.

The typical roadway channels defined to represent local and collector roads consisted of user defined cross sections. Two typical cross sections were used in the study area including a road right-of-way (ROW) width of 20.1 metres with a height of 0.30 metres for local roads, and a ROW width of 26.1 metres and a height of 0.30 metres for collector roads. Adjustments were made to the network as necessary, such as additional nodes, overland segments, invert adjustments, etc., to replicate the overland flow paths predominately associated with roadways.

For the conceptual design, all roadways were assumed to use an urban cross section with standard curb and gutter.

The major system is connected to the minor system through inlets, or catchbasins. The number of catchbasins was adjusted in the database and the type of catchbasin cover was considered using the information obtained from the field survey. Catchbasin capacity was considered in the model as a head discharge relationship and limited to 55 L/s which was provided based on the road drainage study entitled “Road and Bridge Deck Drainage Systems, J. Marsalek, 1982”. The inlet characteristics and number of catchbasins associated with a subcatchment and overland flow segment are defined at model nodes defined as “gully” nodes.

### 4.6 Catchment Delineation

The storm system catchment delineation process is described in Technical Memorandum 3 for the existing system. New subcatchments were created to be associated with links where none previously existed (overland flow - roadway within the right-of-way) in the model to mimic the runoff from the roof to the roadway.

For each subcatchment, the total contributing area was split to represent the portion that contributes directly to the sewer (minor) system, and the portion that contributes to the overland (major) system. The connected portion would include roof and driveway drains that are connected through a storm lateral to the storm sewer.

The balance of the catchment area was connected to an overland flow segment and consists of pervious and impervious areas associated with grassed areas, driveways, roadways, and disconnected downspouts. The overland flow would only enter the minor system through a model node defined as a “gully”.

The subcatchment takeoffs quantified roof area, impervious surfaces (roads, driveways, sidewalks) and pervious surfaces (grass, open space). The area survey information, in combination with the connection history, was used to identify roof tops connected to the storm sewer or discharging to the surface. This information is used to prepare the InfoWorks catchment dataset and storm system hydrology. The subcatchment is structured using four “runoff area”.

Four different surface flow depth categories that are outlined in these figures for the 100-year design event that includes:

1. From surface to 150 mm above surface. This indicates that the flow is contained within the street pavement.
2. From 150 mm to 300 mm above surface. This indicates the water is above the pavement but contained within the street right-of-way.
3. More than 300 mm above surface. This indicates potential surface flooding of private properties, and hence potential basement flooding from surface runoff.

### 4.7 Assessment of Storm System Hydraulic Performance

The 100-year assessment event is presented as the storm system assessment event as part of the problem definition.

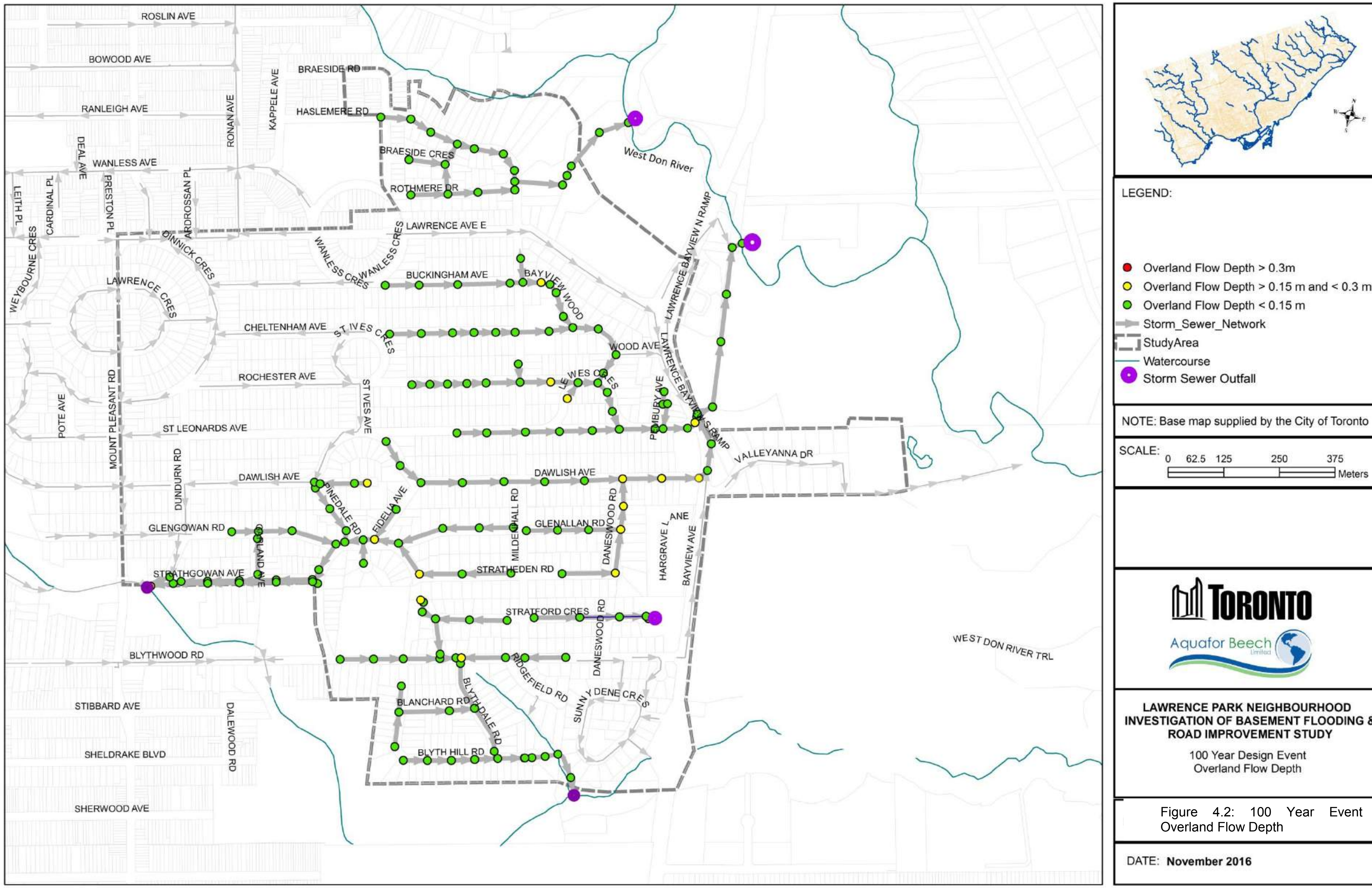
### 4.8 100-Year Design Event

The City assessment event for the storm system is the 100-year design storm. The result of the model simulation is presented in Figure 4.2 and 4.3 showing overland flow depth and minor system surcharge respectively.

Figure 4.2 shows the overland flow depth below the 150 mm threshold in areas of reverse sloped driveways. Other areas show the overland flow depth exceeding 150 mm but less than 300 mm.

Figure 4.3 shows the storm pipe network has a surcharge in parts of the system of the system. In areas where surcharging is indicated, the 1.8 m HGL threshold is not exceeded with the exception of the following

- Bayview Avenue and Dawlish Avenue: The model indicates and HGL level of 1.78 m below ground. The proposed sewer obvert in the intersection at this point is 1.8 m. The topography indicates that this a low point along Bayview Avenue. Deeping the proposed pipe would reduce the slope of the pipe downstream to less than 0.2%.
- Bayview Avenue and St. Leonard's Avenue: The model indicates and HGL level of 1.77 m below ground. The topography indicates that this a low point along Bayview Avenue. The node at which this HGL level occurs is at the junction of the proposed trunk sewers along St. Leonard's Avenue and Bayview Avenue after which the flows are conveyed through 2275 Bayview Avenue towards the outfall. The drawings for this area indicate several utilities underground that include sanitary and storm sewers, watermain , gas utilities and hydro for which sizing and depth of the proposed sewer took into account
- Blyhwood Ravine Park: The model indicates the HGL rising above 1.8m for the proposed pipe at the foot of Strathgowan Crescent within the park area towards the proposed outfall.


LEGEND:
Overland Flow Depth > 0.3m
Overland Flow Depth > 0.15 m and < 0.3 m
Overland Flow Depth < 0.15 m
Storm_Sewer_Network
StudyArea
Watercourse
Storm Sewer Outfall
NOTE: Base map supplied by the City of Toronto
SCALE: 0 62.5 125 250 375 Meters
TORONTO
Aquafor Beech Limited
LAWRENCE PARK NEIGHBOURHOOD INVESTIGATION OF BASEMENT FLOODING & ROAD IMPROVEMENT STUDY
100 Year Design Event Overland Flow Depth
Figure 4.2: 100 Year Event Overland Flow Depth
DATE: November 2016
West Don River
WEST DON RIVER TRL
LAWRENCE AVE E
BUCKINGHAM AVE
CHELTENHAM AVE
ROCHESTER AVE
ST LEONARDS AVE
DAWLISH AVE
GLENGOWAN RD
STRATHGOWAN AVE
BLYTHWOOD RD
STIBBARD AVE
SHELDRAKE BLVD
SHERWOOD AVE
MOUNT PLEASANT RD
BAYVIEW AVE
VALLEYANNA DR
STRATFORD CRES
BLYTH HILL RD
BLANCHARD RD
STRATHEDEN RD
GLENALLAN RD
ROSLIN AVE
BOWOOD AVE
RANLEIGH AVE
WANLESS AVE
HASLEMERE RD
BRAESIDE RD
BRAESIDE CRES
ROTHMERE DR

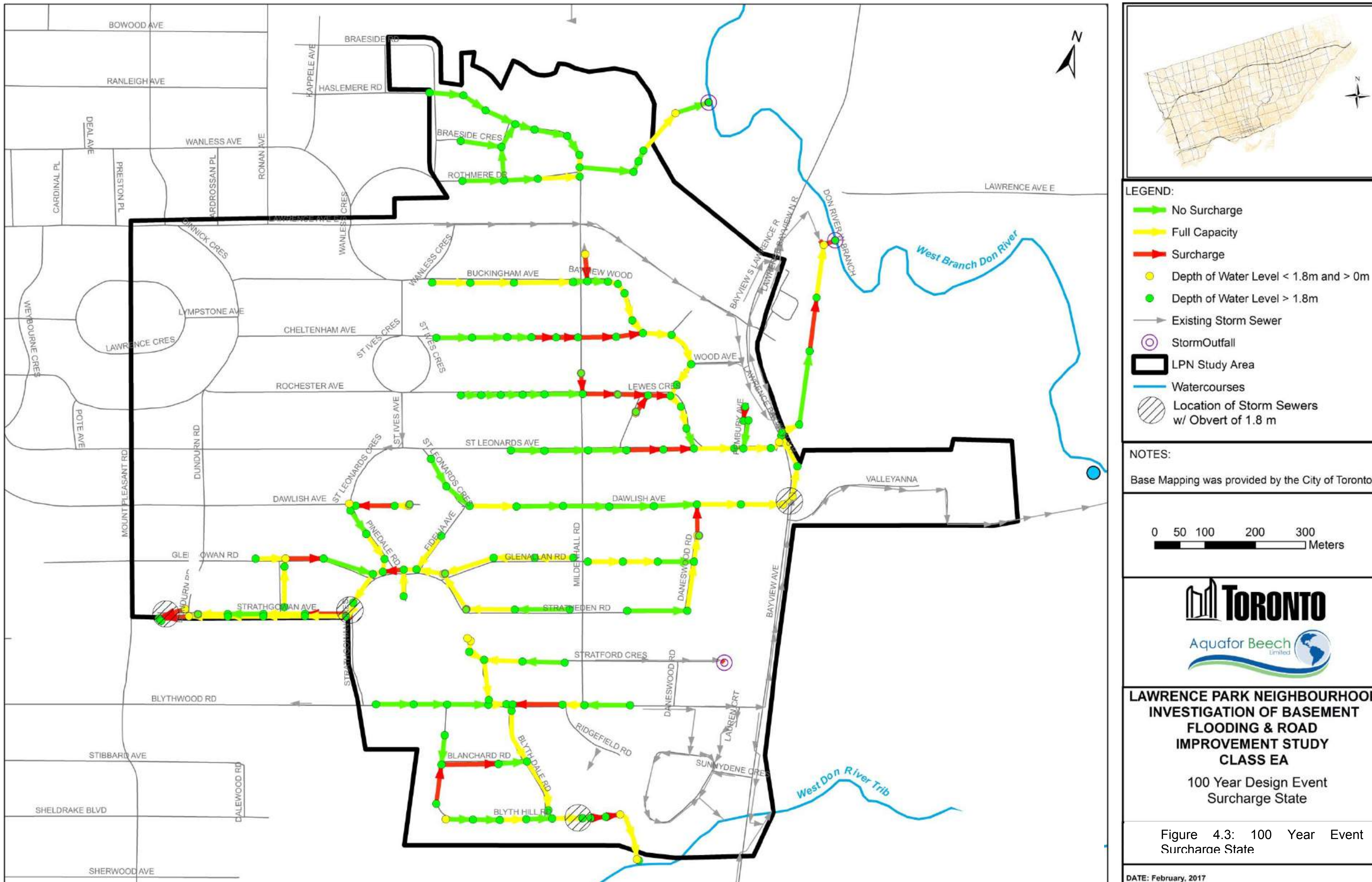



Figure 4.3: 100 Year Event Surcharge State

## 5.0 CONCLUSIONS AND LIMITATIONS

### 5.1 Conclusions

The following conclusions can be drawn from the proposed system assessment:

- The model suggests that the overland flow depths follow the BF guidelines for the proposed works;
- The model suggests localized surcharging in the minor system during the 100 year design event for the proposed system, however areas where surcharge is indicated, the HGL is generally kept below 1.8 m.
- At the low points (Bayview Avenue and Dawlish Avenue and Bayview Avenue and St. Leonard’s Avenue), the model indicates an HGL level of slightly above 1.8 m within the intersections at nodes that are major sewer junctions and the pipe obvert is close to the 1.8 m depth.

### 5.2 Model Limitations and Application

There are some inherent limitations with the use and application of the calibrated models for LPN study area. The best possible information available at the time was used to create, calibrate and validate the model; however, assumptions had to be made to fill the data gaps. The following section discusses the model limitations in detail:

- The connectivity of individual house connections (i.e. roof leaders, foundation drains, etc.) could not be confirmed with 100% certainty. Field investigations were completed to help identify the connectivity of the house connections, but ultimately assumptions were made for implementation in the model.
- The resolution of the DTM, at 15-m grid point spacing, was useful when trying to identify the overland drainage along right-of-ways (ROW), but does not accurately represent the overland drainage and surface storage outside of the ROW as curb and building elevation details are missing.
- New catchment areas delineated with the development of a minor system required information on pervious and impervious areas derived from the existing catchment areas.
- The assessment is limited to the streets/sewers where road reconstruction is proposed.