RAMSEY LAKE MODELLING FOR SUB-WATERSHED STUDY & STORMWATER MASTER PLAN

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Aquafor Beech Limited

OBJECTIVES

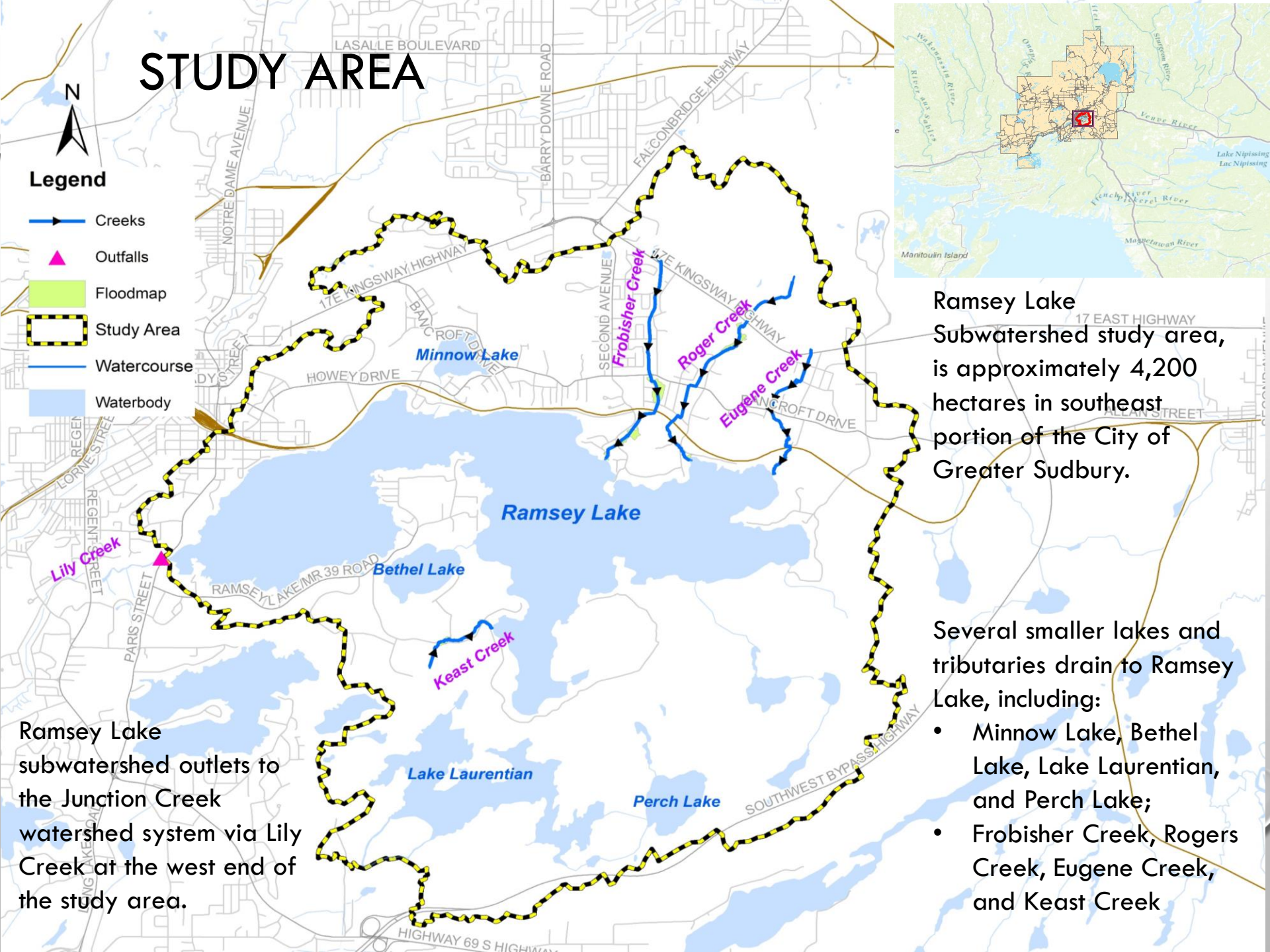
- ***Develop a Subwatershed Management Plan to protect, maintain and enhance the surface water, groundwater, and natural resources of Ramsey Lake and its tributaries through environmentally sound policy and management actions.***

- Phosphorus levels in Ramsey Lake are heavily influenced by near shore developments and urban runoff. Historically, natural background concentrations of phosphorus were probably between about 0.003 and 0.005 mg/L. The phosphorus concentrations in Ramsey lake have been increasing due to runoff from urban land use which have been varied since the 1970's from a low value of 0.010 mg/L to a high value of 0.017 mg/L.

Hutchinson Environnemental Sciences Ltd., 2014
City of Greater Sudbury Lake Water Quality Program 2013)

- Study Area
- Hydrologic Model (PCSWMM)
- Hydraulic Model (GeoHECRAS)
- Pipe capacity Model (PCSWMM)
- Proposed Development Lands Model (PCSWMM)
- Water Quality Model (QUAL-W2)

STUDY AREA



Ramsey Lake Subwatershed study area, is approximately 4,200 hectares in southeast portion of the City of Greater Sudbury.

Several smaller lakes and tributaries drain to Ramsey Lake, including:

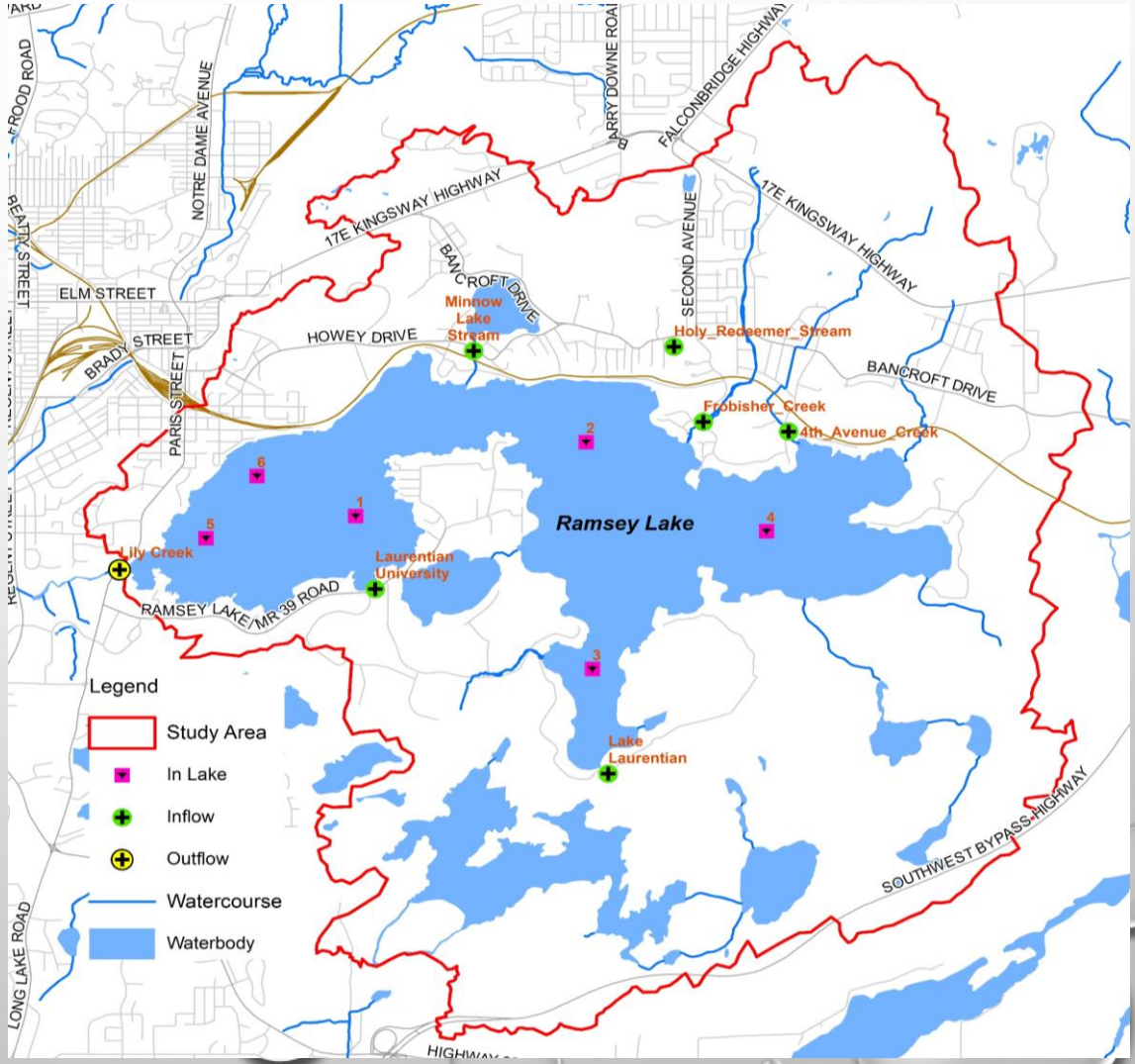
- Minnow Lake, Bethel Lake, Lake Laurentian, and Perch Lake;
- Frobisher Creek, Rogers Creek, Eugene Creek, and Keast Creek

Ramsey Lake subwatershed outlets to the Junction Creek watershed system via Lily Creek at the west end of the study area.

RAMSEY LAKE WATERSHED INFORMATION DATA AVAILABILITY

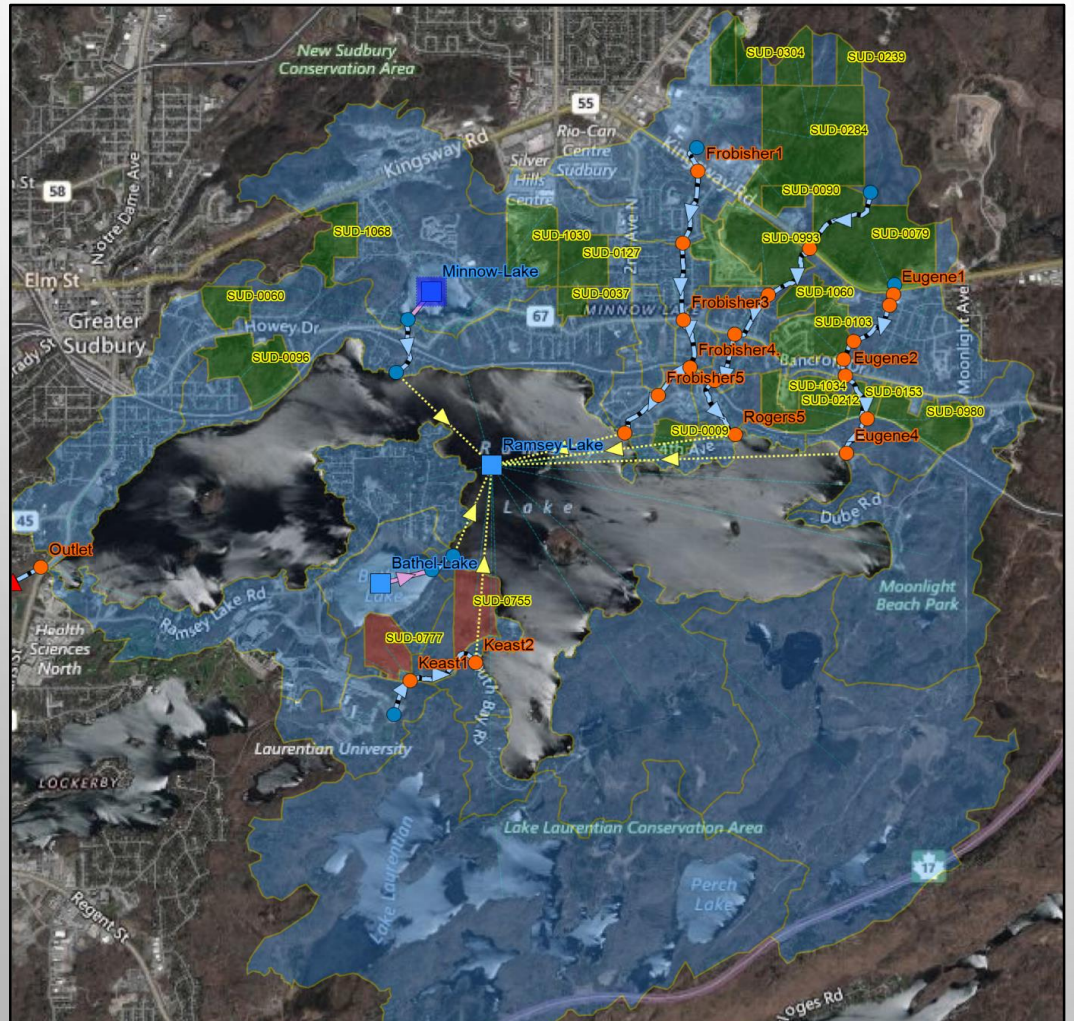
Water Quantity and Quality Stations

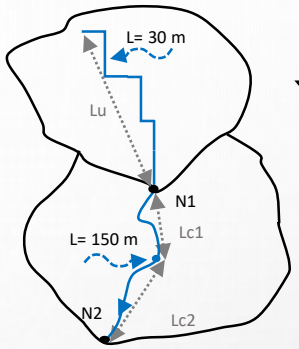
- Water surface elevation at the outlet
- 6 water quality Stations
- 2 flow stations along the Frobisher and Rogers creeks
- Provincial Water Quality Monitoring Network (PWQMN station at the outlet)
- In-lake water quality stations (Kilgour)

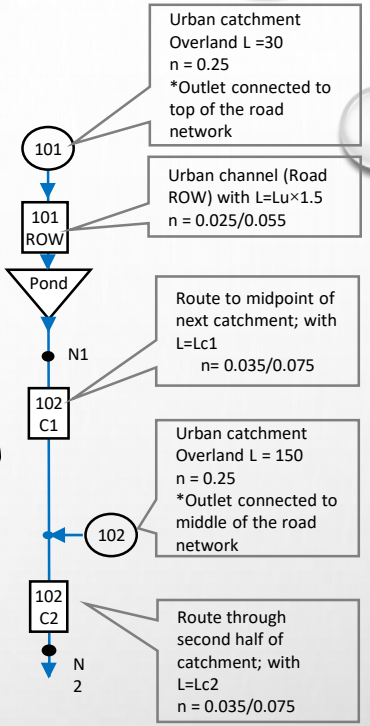


HYDROLOGIC MODEL SETUP

- PCSWMM
- 34 subcatchments







Subcatchment parameters:
width, and length, infiltration, depression storage, imperviousness, manning's roughness...

Design Storms (Environment Canada at Science North and Sudbury Airport)

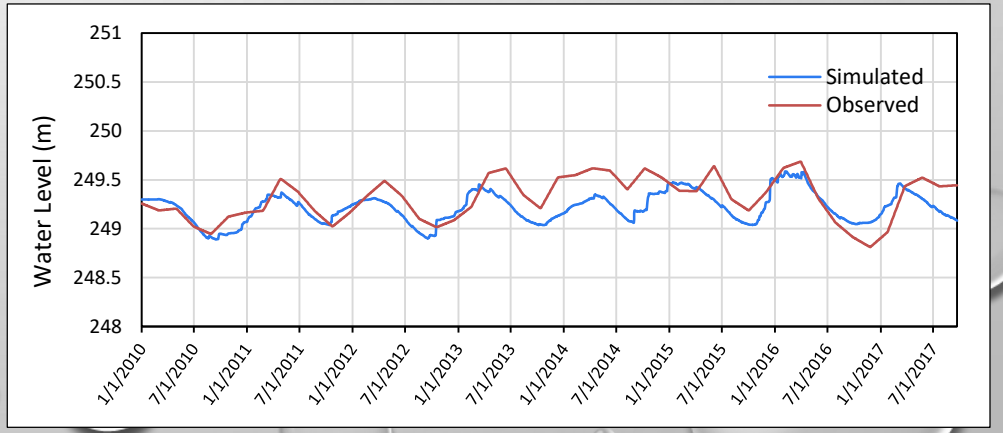
- 24-hr AES
- 6-hr Chicago
- Timmins (regional)

MODELLING RESULTS

- Model calibration
- Simulation period 2010-2017

- Water surface elevation
- Flows at the tributaries

Flow Node	Peak Flow Rate (m^3/s)
	Existing Conditions
Frobisher1	4.44
Frobisher2	15.33
Frobisher3	19.37
Frobisher4	22.28
Frobisher5	26.16
Frobisher6	32.13
Rogers1	0.75
Rogers2	2.05
Rogers3	4.04
Rogers4	5.10
Rogers5	6.20
Eugene1	2.25
Eugene2	9.69
Eugene3	12.39
Eugene4	12.74



HYDRAULIC MODEL

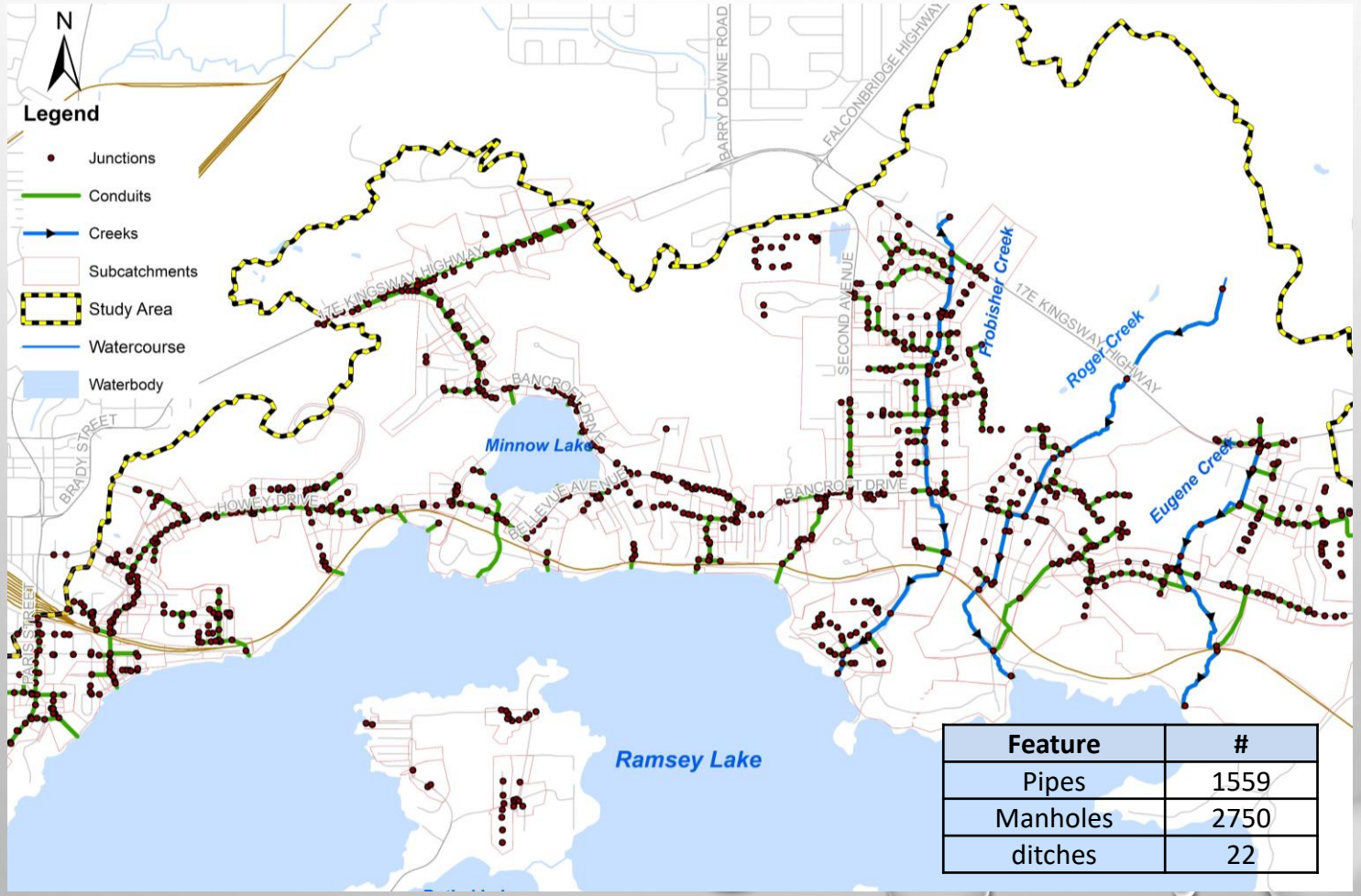
- Potential flooding impact of Frobisher, Roger, Eugene and Keast Creeks within the Ramsey Lake subwatershed (GeoHECRAS)
- Timmins storm (Regional)

FLOODPLAIN OBSERVATIONS

- Under the Regional flood conditions:
- <u>Frobisher Creek:</u>
- The majority of the flooding is contained to the river corridor, with a few exceptions.
- A total of 13 buildings are within the flood limits.
- three roads (Bancroft Road, Rita Street and Greenwood Drive) are overtopped.

TRUNK SEWER HYDRAULICS CAPACITY ASSESSMENT

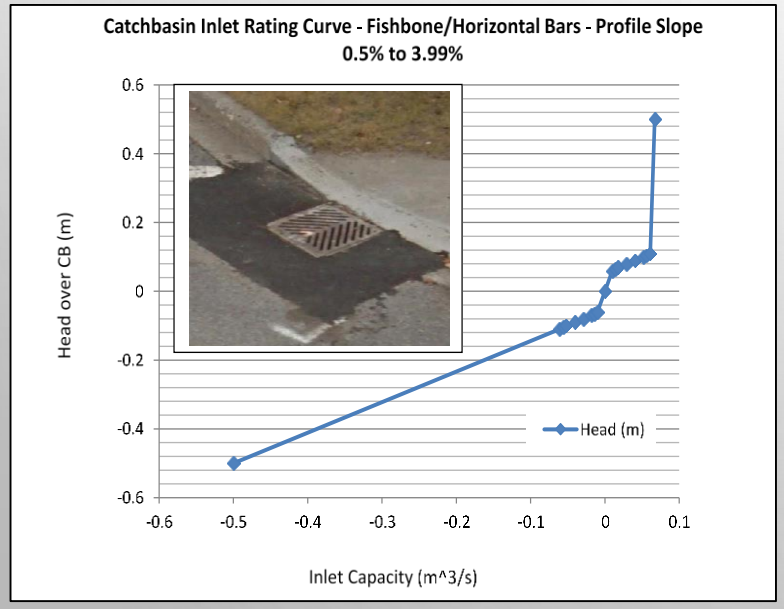
- PCSWMM model; to identify and assess the hydraulics of the minor and major systems and identify any capacity deficiencies

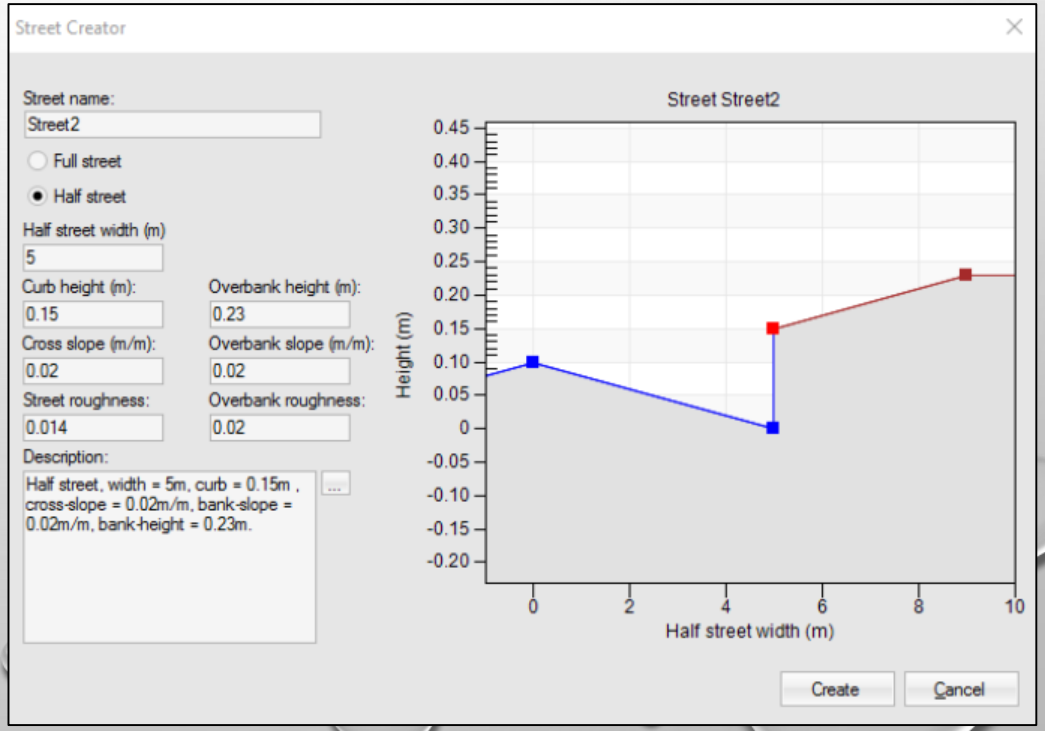


Feature	#
Pipes	1559
Manholes	2750
ditches	22

TRUNK SEWER HYDRAULICS CAPACITY ASSESSMENT

- Dual drainage (major and minor) system
  - Roads cross-sections
  - Inlet control (catchbasins)





DESIGN CRITERIA

- The design of the minor system, the design storm shall be based on the classification of the road to be serviced.

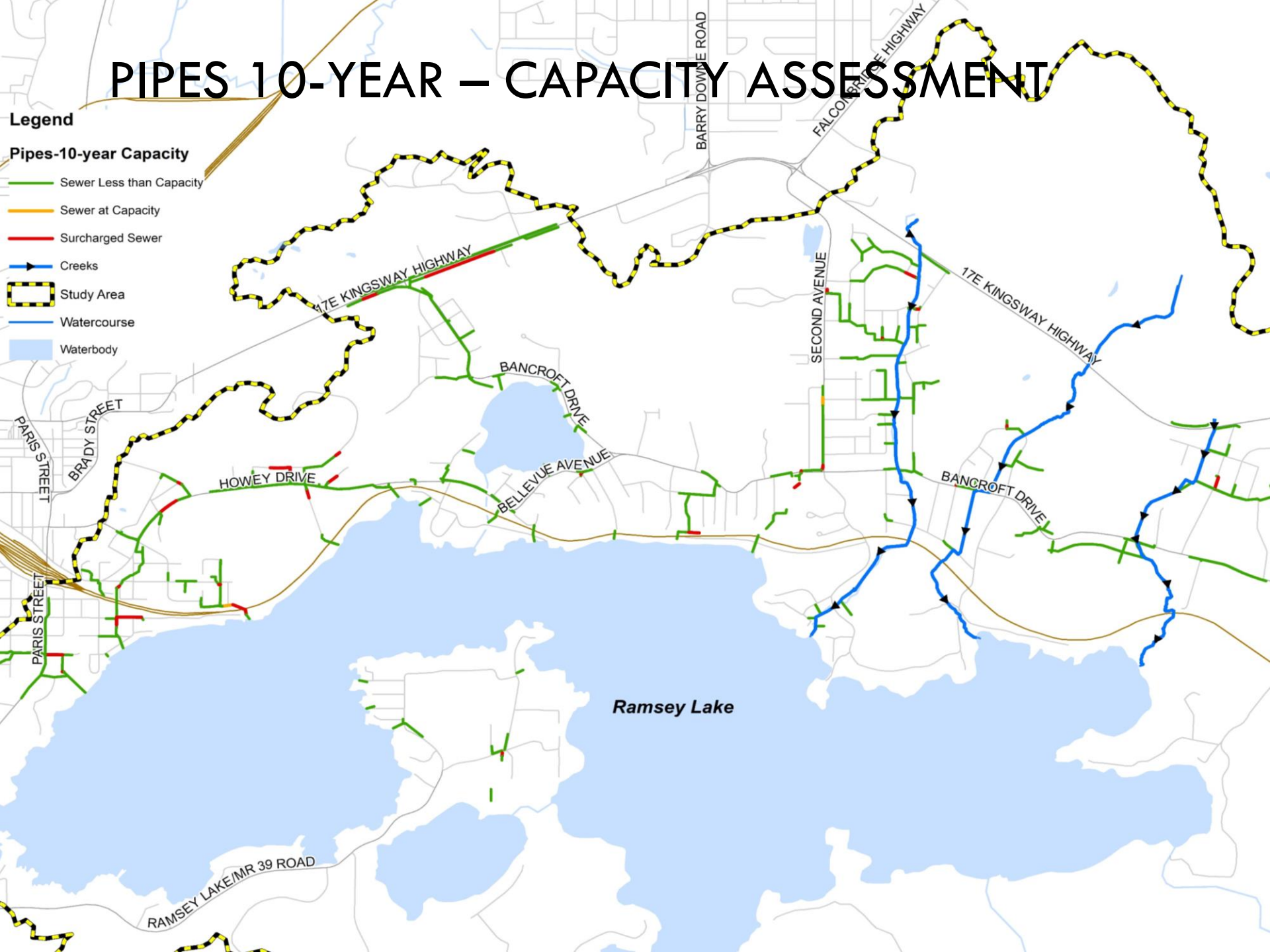
Road Classification	Design Storm Return Period
Urban Arterial	10 Year
Rural Arterial / Collector Road	5 Year
Local Road	2 Year

- The design of the major system, the design peak flow of 100-year design storm

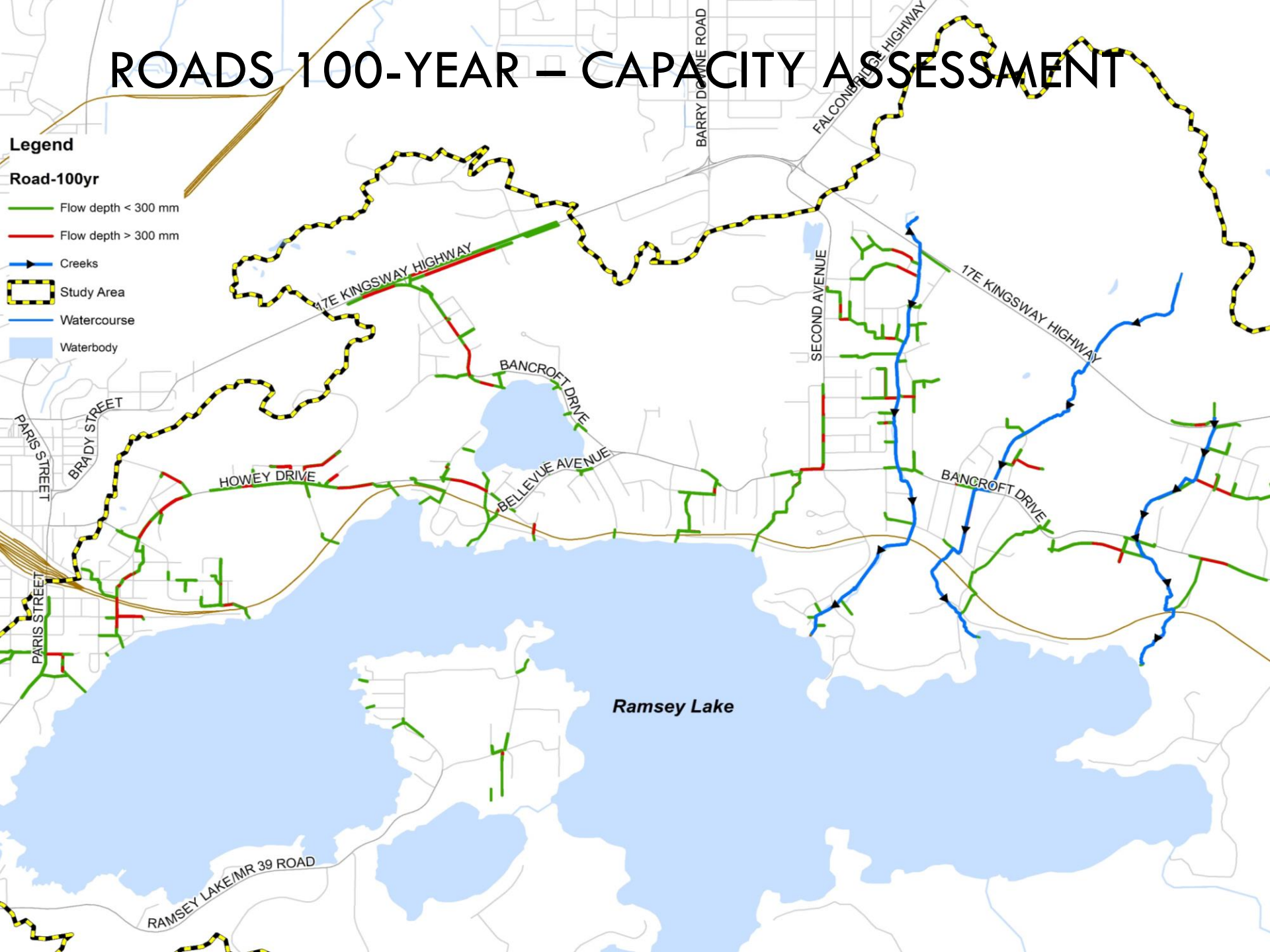
The Ramsey Lake Hydraulic and Hydrologic Model was applied to assess the performance of the minor system (state of surcharge of the sewers) as well as to assess the major system flow depths under the 100-year storm.

Source: The City of the Greater Sudbury Official Plan Stormwater Background study (2006)

PIPES 10-YEAR – CAPACITY ASSESSMENT



ROADS 100-YEAR – CAPACITY ASSESSMENT



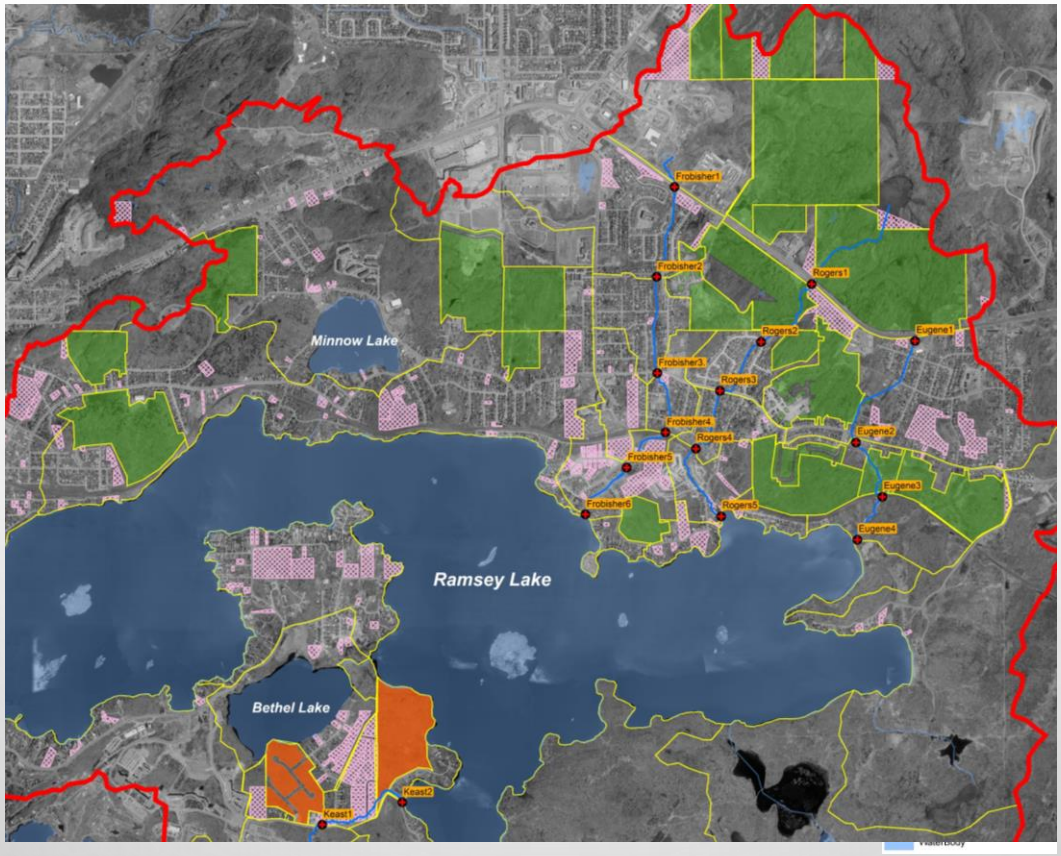
RESULTS

- Model Results for Existing Design Storm for Minor System

Scenario (Level of Service)	Length of Storm Sewer at Full Capacity / Surcharged (m)	
	Full Capacity	Surcharged
2-yr Design Storm	229	975
5-yr Design Strom	221	1,343
10-yr Design Storm	302	1,834

- Under the 100-year Chicago Design Storm., the model indicates that 5,003 m of the road right-of-way is flooded;

PROPOSED DEVELOPMENT LANDS

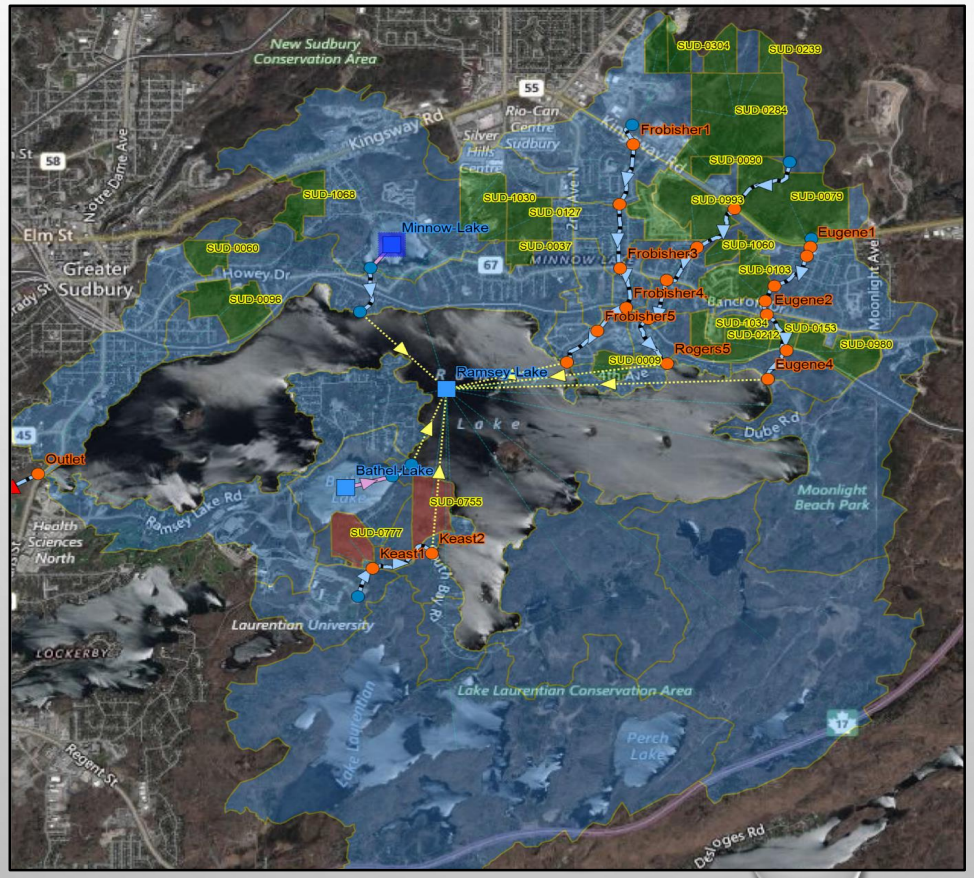


- The evaluation of Stormwater management strategies for proposed development lands focuses on development sites that are greater than five (5) ha in total area.
- There are 24 new development sites within the Ramsey Lake subwatershed that are greater than five (5) ha in total area.

Source: The City of the Sudbury Official Plan Stormwater Background study (2006)

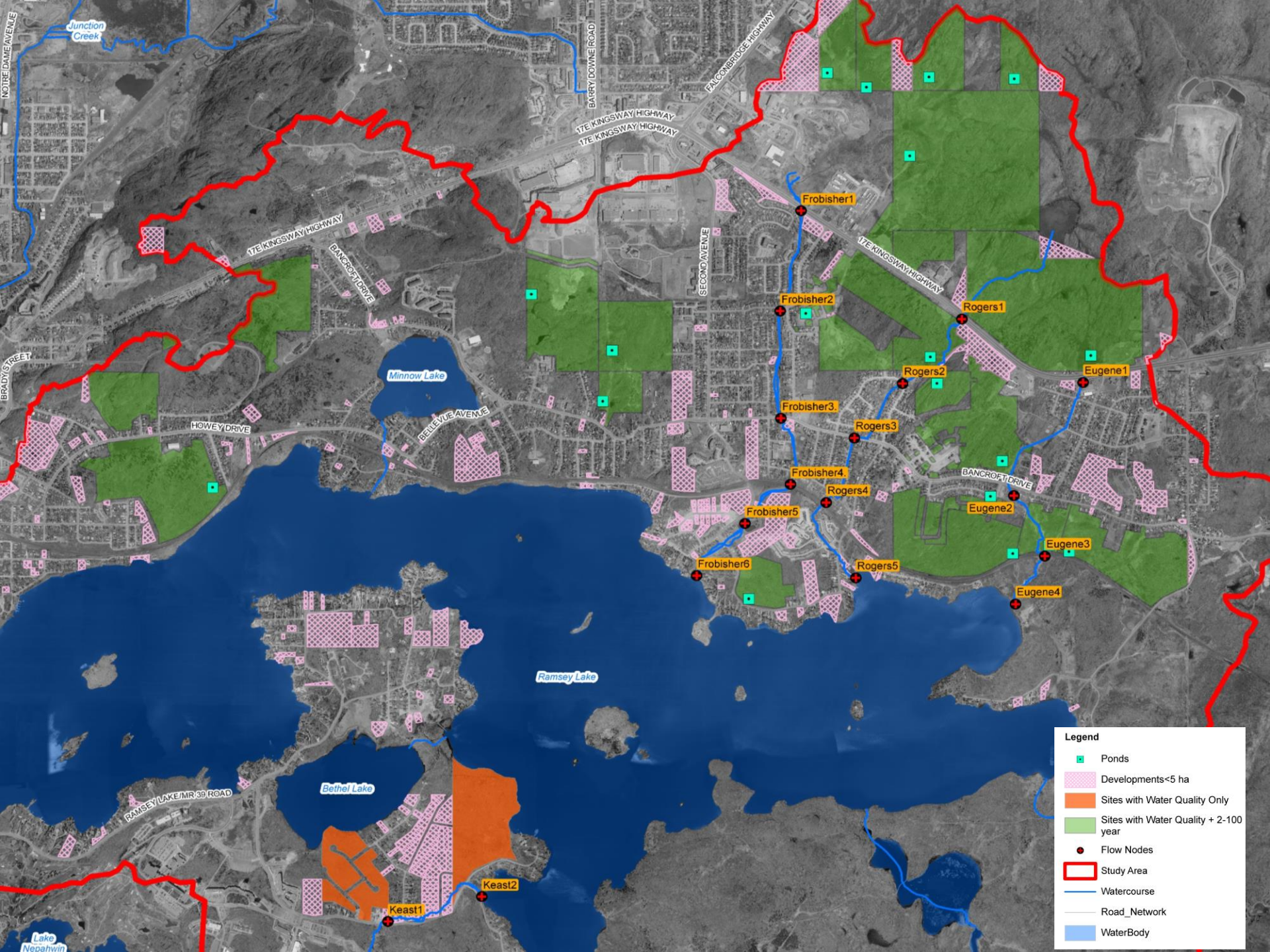
PCSWMM MODEL

- A "**traditional stormwater management**" approach relying on end-of-pipe facilities for water quality and water quantity control.
- A "**traditional stormwater management and LID approach**" relying primarily on source and conveyance controls to provide water quality control while relying on end-of-pipe facilities for flood mitigation requirements.



SCENARIO 2) TRADITIONAL

- Ponds for each new development area were incorporated into the hydrologic model using the following approach.
  - A stormwater management facility was allocated to each of the new development areas larger than five (5) ha
  - Post-development impervious percentages were assumed based on proposed development type.
  - Water quality storage requirements were calculated using impervious percentages, development areas (ha) and required storage volume rates (m^3/ha) from MOE Guideline, 2003. An orifice equation was used to model the required 24-hour (minimum) detention time of the water quality volume
  - For new development areas requiring quantity control, post-development peak flow rates for the 1:2-year precipitation event, were reduced to pre-development peak flow rates via an additional orifice and extended detention
  - For new development areas requiring quantity control, post-development peak flow rates for the 1:100-year precipitation event, were reduced to pre-development peak flow rates via an outlet weir and extended detention


Junction Creek
NOTRE DAME AVENUE
BARRY DOWNE ROAD
FALCONBRIDGE HIGHWAY
17E KINGSWAY HIGHWAY
17E KINGSWAY HIGHWAY
17E KINGSWAY HIGHWAY
BANCROFT DRIVE
SECOND AVENUE
BRADY STREET
Minnow Lake
HOWEY DRIVE
BELLEVUE AVENUE
Frobisher1
Frobisher2
Frobisher3.
Frobisher4.
Frobisher5
Frobisher6
Rogers1
Rogers2
Rogers3
Rogers4
Rogers5
Eugene1
Eugene2
Eugene3
Eugene4
BANCROFT DRIVE
Ramsey Lake
Bethel Lake
RAMSEY LAKE/MR 39 ROAD
Keast1
Keast2
Lake Nepahwin
Legend
Ponds
Developments<5 ha
Sites with Water Quality Only
Sites with Water Quality + 2-100 year
Flow Nodes
Study Area
Watercourse
Road_Network
WaterBody

SCENARIO 3) LID-ONLY

- A subwatershed-level modelling exercise was conducted to determine the impact of Low Impact Developments on flow rates at specific nodes in the subwatershed.

LID Type: Etobicoke Exfiltration System (Perforated Pipes)

LID Type: Perforated Pipe

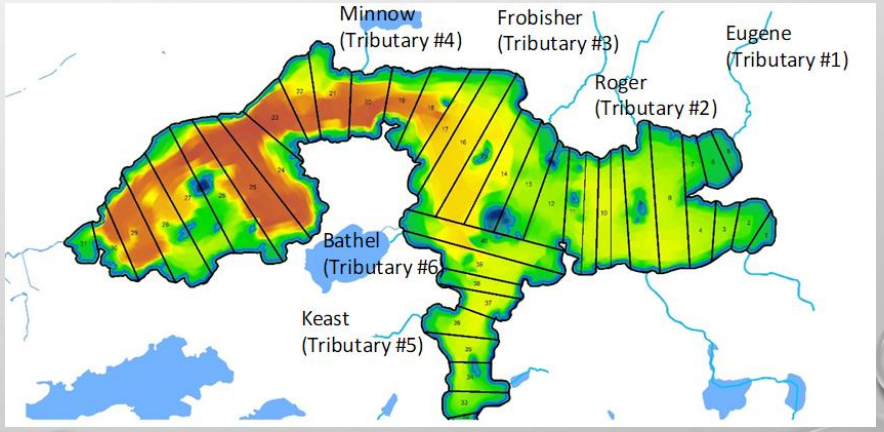
Parameters	Value in the Model	Unit	Description
Berm height	100	mm	Maximum depth to which water can pond within the unit before overflow occurs (in inches or mm).
Vegetation volume (fraction)	0.0	-	The fraction of the volume within the storage depth filled with vegetation. Assuming perforated pipes are in the road way.
Surface roughness	0.3	-	Manning's n for overland flow over the surface.
Surface slope (%)	0.25	(%)	Slope
Thickness of Storage	450	(mm)	Thickness of the storage
Void Ratio of Storage	0.45	-	The volume of void space relative to the volume of solids. Typical values range from 0.5 to 0.75.
Seepage Rate	Varies (1.5-25)	(mm/hr)	The maximum allowable rate at which water infiltrates into the native soil below the layer (in inches/hour or mm/hour). This would typically be the Saturated Hydraulic Conductivity of the surrounding area.

RESULTS OF THE SCENARIOS

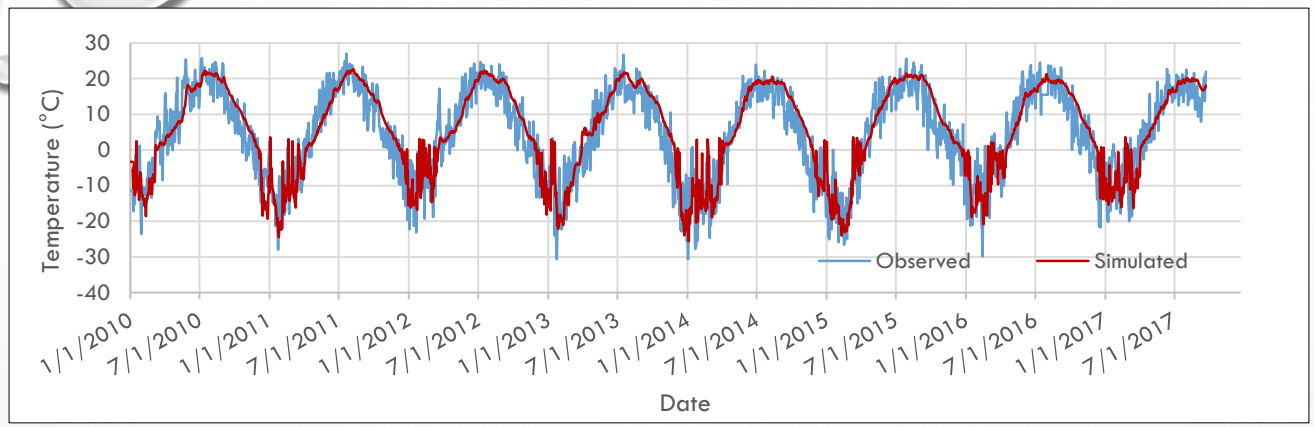
Flow Node	Peak Flow Rate (m^3/s)				
	Existing Conditions	Future Conditions	Future Conditions	Future Conditions with LIDs	Future Conditions with LIDs + SWM Facilities
Frobisher1	4.44	14.51	14.51	12.61	4.52
Frobisher2	15.33	23.29	23.29	21.98	15.79
Frobisher3	19.37	28.06	28.06	26.40	19.26
Frobisher4	22.28	30.55	30.55	29.04	22.03
Frobisher5	26.16	33.82	33.82	32.43	25.89
Frobisher6	32.13	39.58	39.58	38.20	31.01
Rogers1	0.75	0.75	0.75	0.75	0.51
Rogers2	2.05	3.30	3.30	2.87	0.13
Rogers3	4.04	5.46	5.46	5.00	2.31
Rogers4	5.10	6.41	6.41	6.02	3.79
Rogers5	6.20	7.32	7.32	6.98	5.28
Eugene1	2.25	16.54	16.54	15.37	1.47
Eugene2	9.69	16.95	16.95	16.83	8.20
Eugene3	12.39	27.35	27.35	24.50	7.58
Eugene4	12.74	28.36	28.36	25.54	8.66

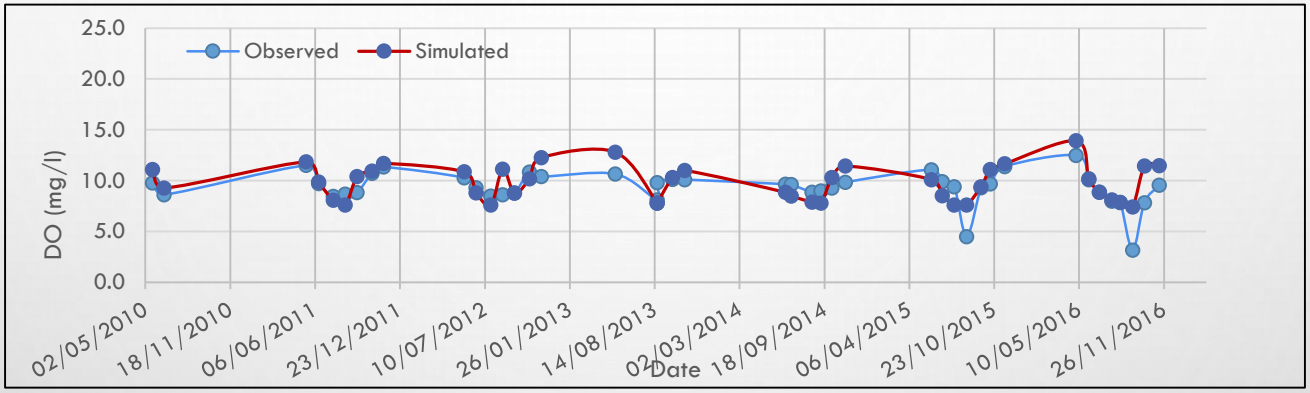
WATER QUALITY MODEL

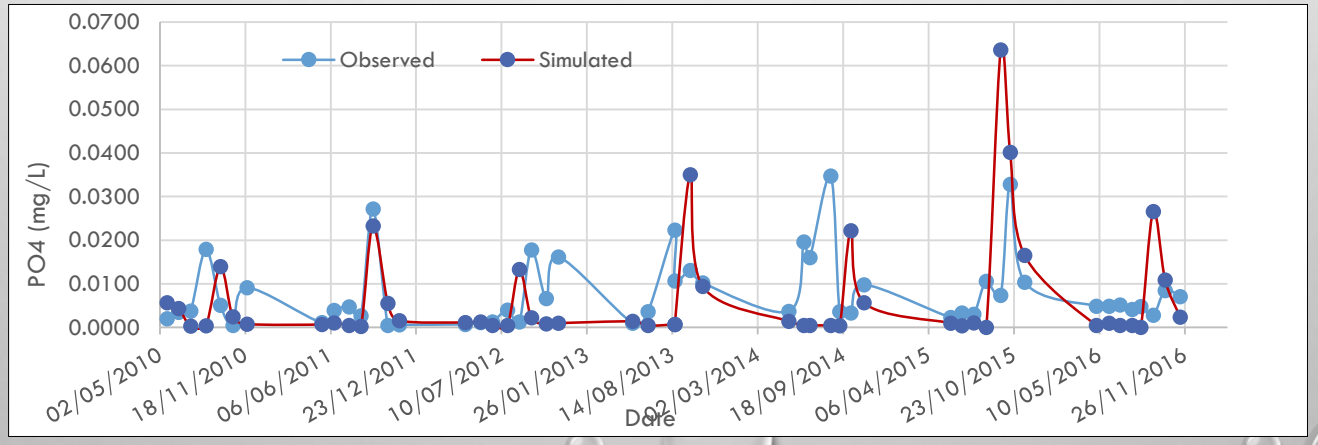
- The model selected for water quality modelling of Ramsey Lake was CE-QUAL-W2.
- The model was set up and calibrated for the 2010-2017.
  - Sub-daily meteorological and climate data
  - Branches and tributary daily inflows;
  - Water quality data;
  - Ramsey Lake outflow daily water level (m);
  - Outlet structure, and
  - Bathymetry.



Col and Wells, 2017, Portland State University and the Corps of Engineers Waterways Experiment Station


Temperature (°C)
30
20
10
0
-10
-20
-30
-40
Observed
Simulated
1/1/2010
7/1/2010
1/1/2011
7/1/2011
1/1/2012
7/1/2012
1/1/2013
7/1/2013
1/1/2014
7/1/2014
1/1/2015
7/1/2015
1/1/2016
7/1/2016
1/1/2017
7/1/2017
Date


DO (mg/l)
25.0
20.0
15.0
10.0
5.0
0.0
Observed
Simulated
02/05/2010
18/11/2010
06/06/2011
23/12/2011
10/07/2012
26/01/2013
14/08/2013
02/03/2014
18/09/2014
06/04/2015
23/10/2015
10/05/2016
26/11/2016
Date


PO4 (mg/L)
0.0700
0.0600
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
Observed
Simulated
02/05/2010
18/11/2010
06/06/2011
23/12/2011
10/07/2012
26/01/2013
14/08/2013
02/03/2014
18/09/2014
06/04/2015
23/10/2015
10/05/2016
26/11/2016
Date

Questions?