RYERSON UNIVERSITY

Modelling Low Impact Development Potential with Hydrological Response Units

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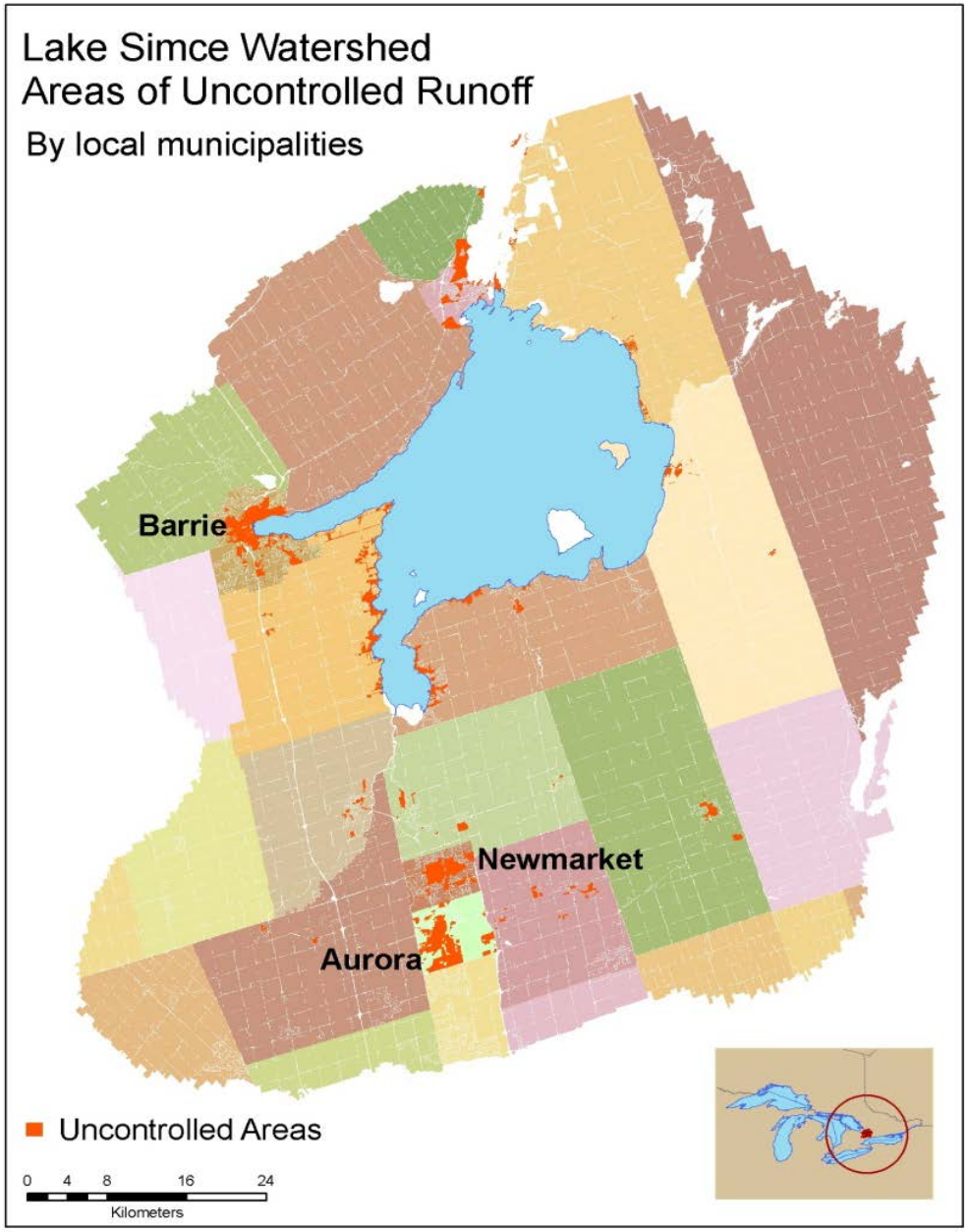
Outline

1. Background and Objective
2. GIS in Screening and Development of LID Opportunities and Development of UHRUs
3. Modelling Methodology
   - UHRU Hydrologic Models
   - Performance Curves
4. Results of Application of the Methodology
5. Conclusions

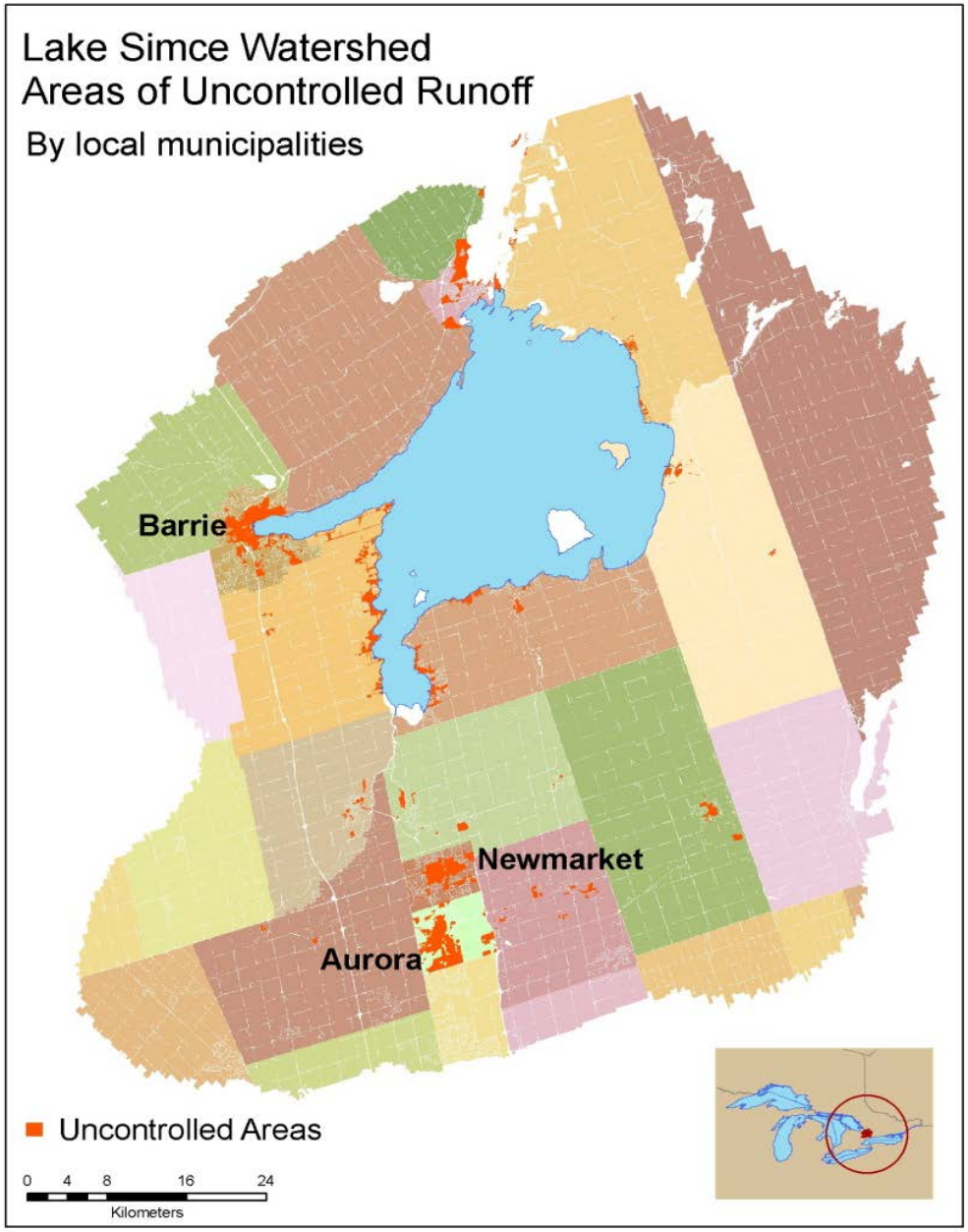
Background

- Lake Simcoe Protection Plan
  - Action Plan
  - Specific Targets – P Loading
- New developments – stormwater management master plans
- Retrofits
  - Controlled/controllable areas (using conventional measures)
  - Uncontrolled areas



Objective

- Identify opportunities and estimate the potential benefits of watershed-wide implementation of LIDs (in uncontrolled areas)



Lot Level LID Practices

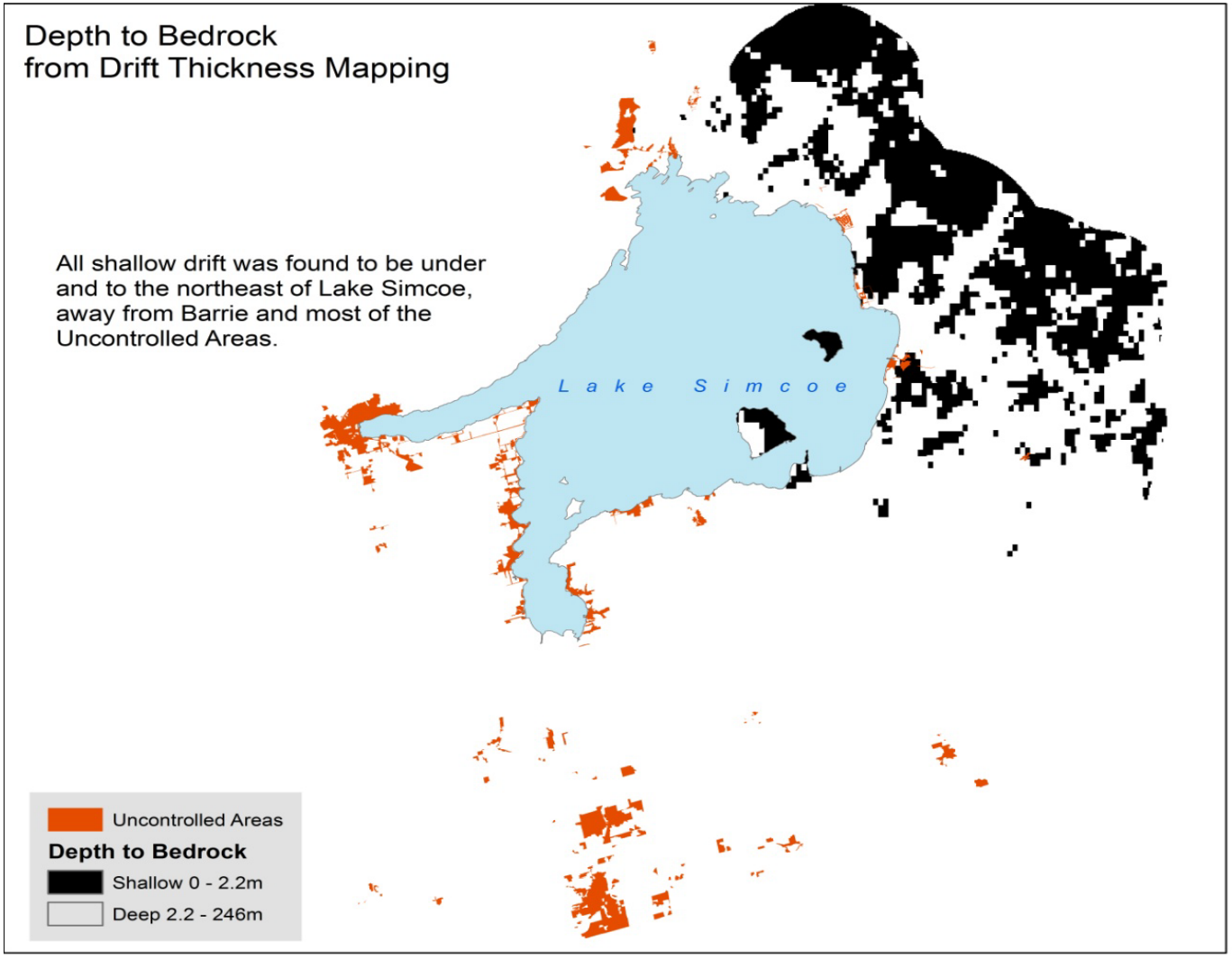
Soakaway pit, dry well, rain harvesting, downspout disconnection, greenroof, bioretention cell, porous pavement, 17 combinations

GIS in Screening of LID

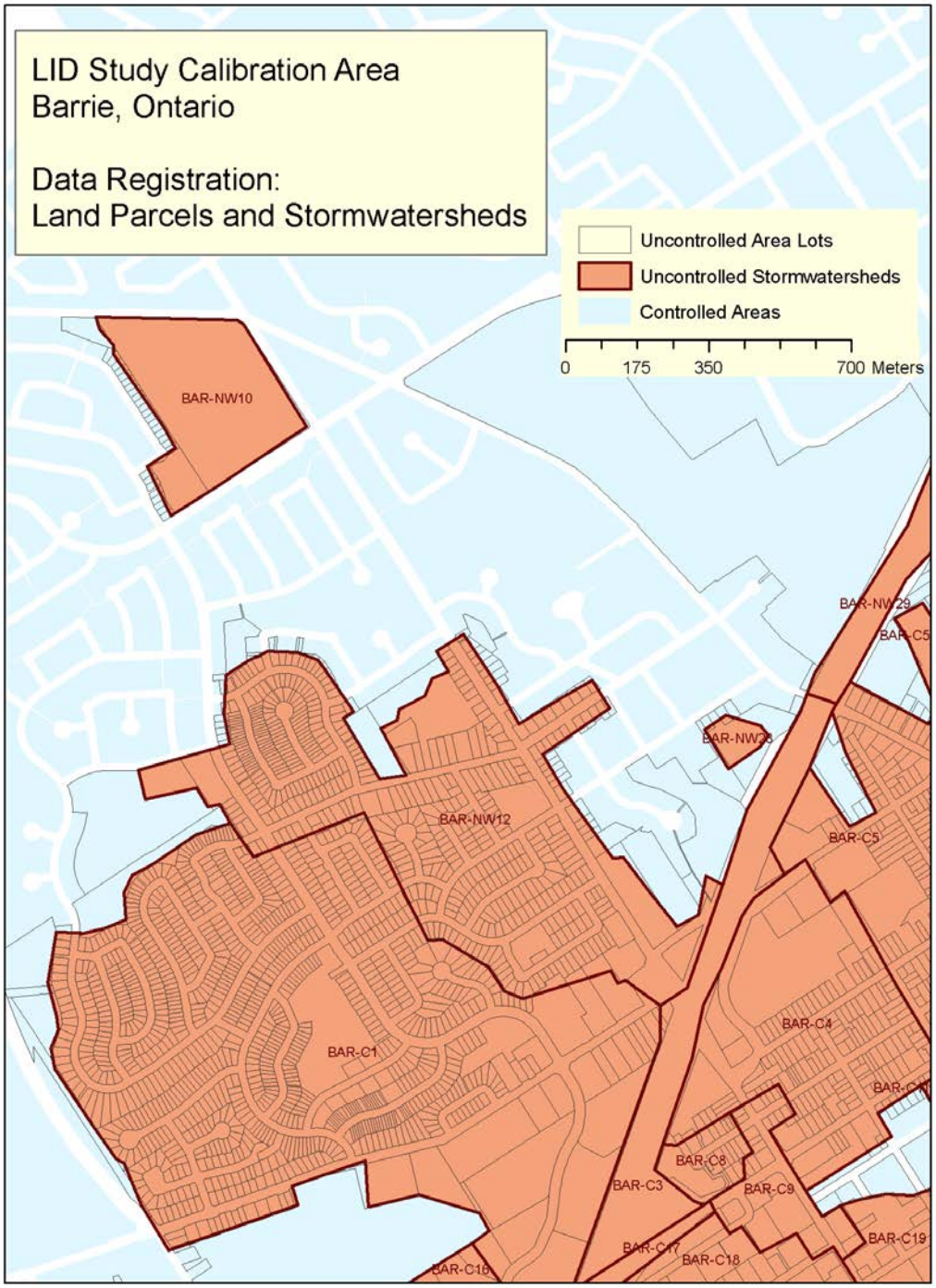
Lot-based LID Retrofit Opportunities

- Essential criteria for identifying potentially appropriate LID procedures for any particular lot:
  - soil depth
  - soil infiltration rate
  - slope steepness
  - land use
  - typical drainage area beyond setbacks
  - building sizes and other building-attribute details
  - land use categories
  - public land ownership

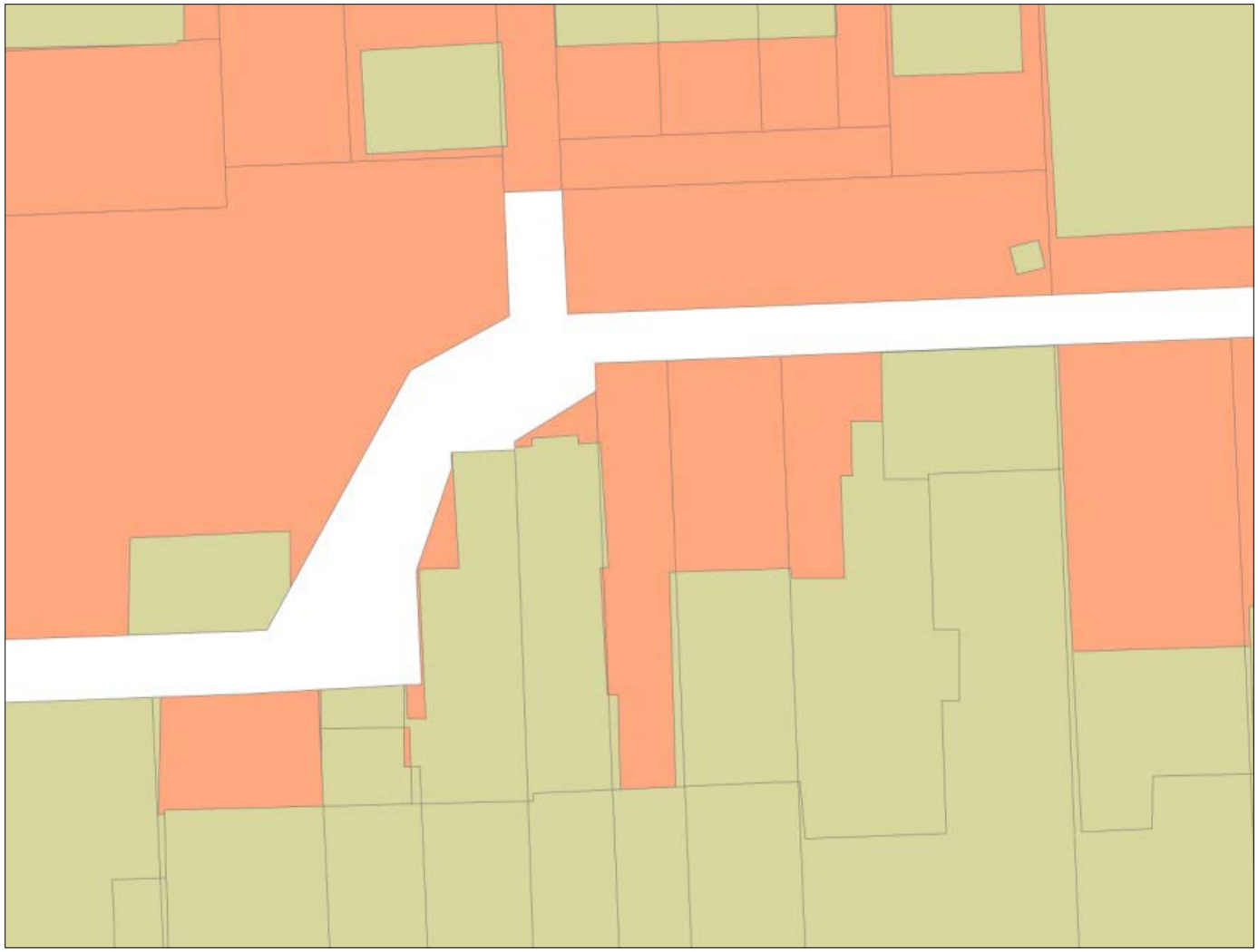
GIS in Screening of LID Opportunities



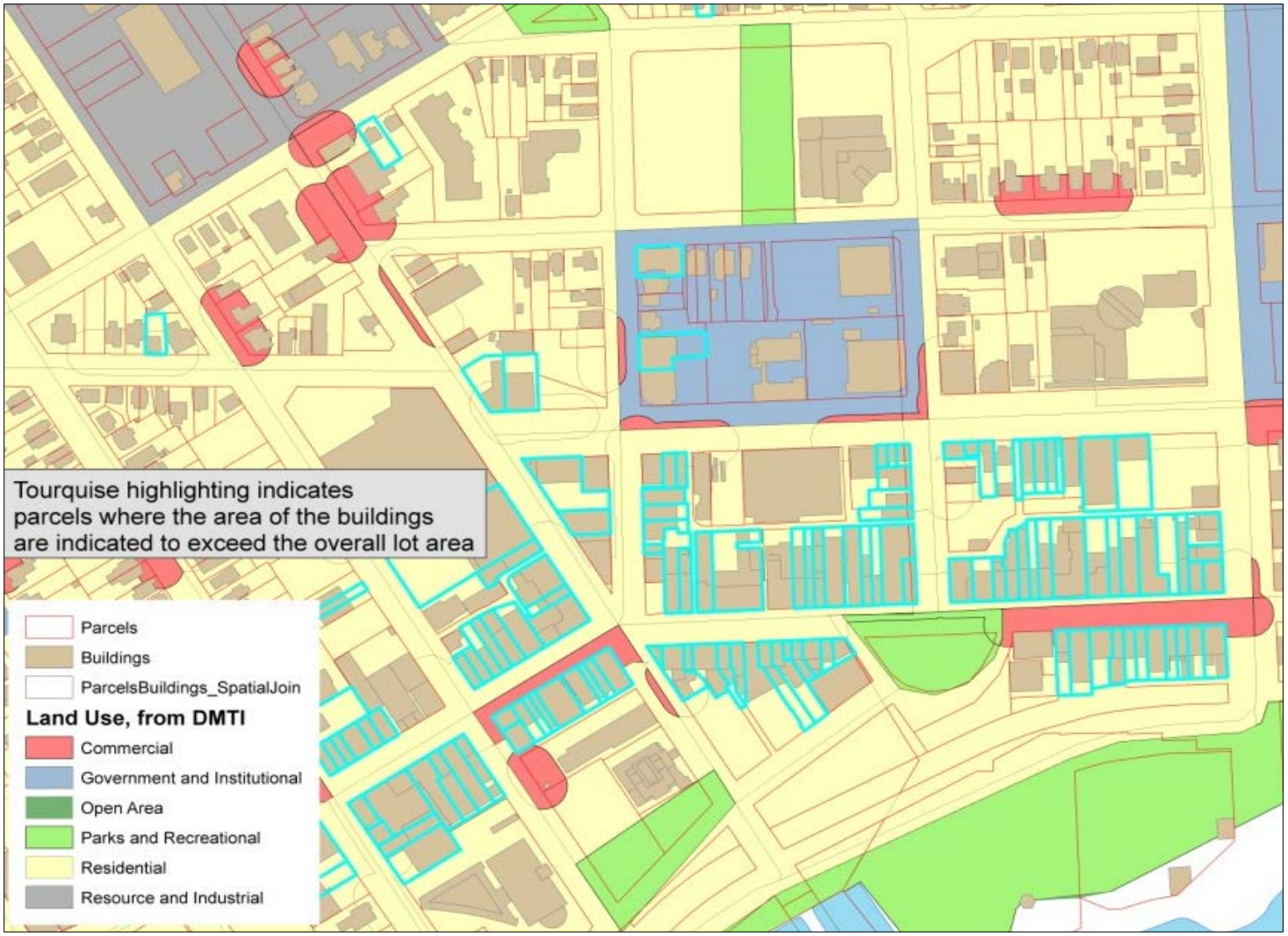
Imperfect conformity between lots and stormwatersheds



Imperfect registration of buildings (green) on lots (orange)



Buildings identified as being larger than their lots were clipped to lot bundaries



Buildings by size; the smallest (darkest) buildings were removed for screening some LIDs

Parking lots (turquoise) were largely unclosed polygons which are unsuited for calculating impermeable portions of lots.

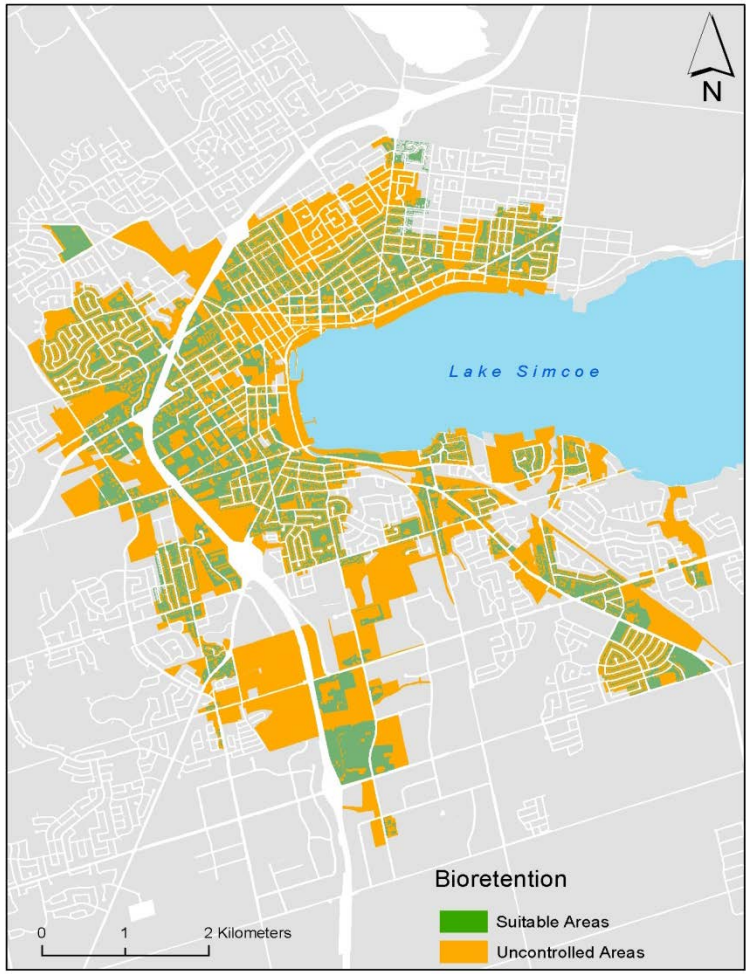
GIS in Screening of LID Opportunities

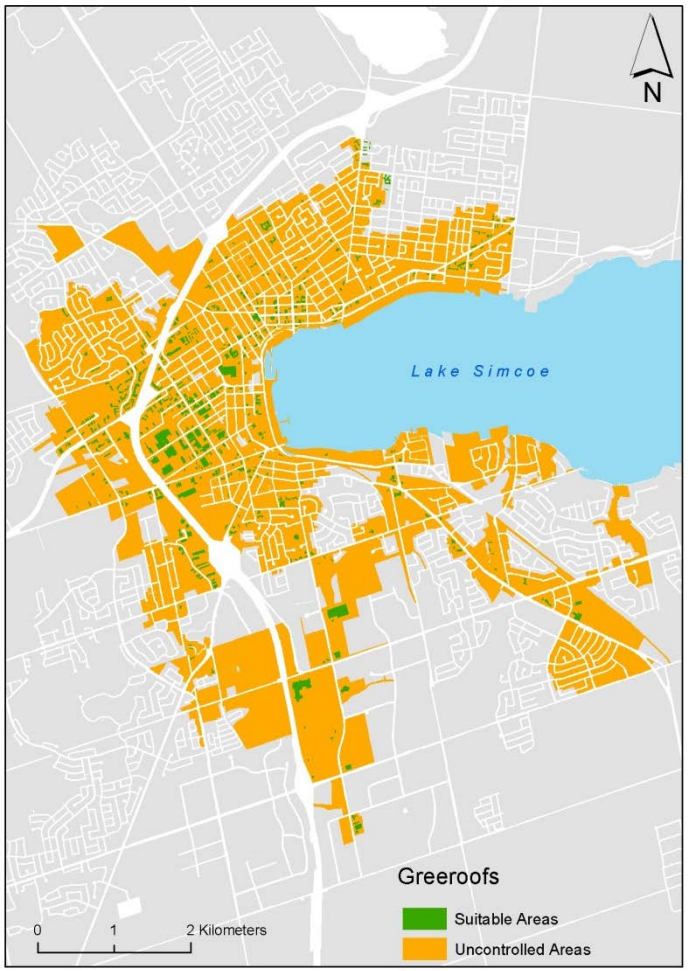
Layers	Barrie	Newmarket	East Gwillimbury	Aurora
Parcels	Comprehensive (from LSRCA/Teranet)			
Parking	Completed	Present	None	None
Driveways	Present	None	None	None
Buildings	Comprehensive (except attributes)	Comprehensive (except attributes)	None	None
Land Use	Satisfactory (from LSRCA and DMTI)			Comprehensive
Sidewalks	Present	Require restructuring (lines)	None	Incomplete, lines
Soils	Complete (Hydrographic Classes and Depths, from LSRCA)			
Roads	Completed (lines)	Require restructuring (lines)	Present (lines)	Present (lines)
Storm Drainage System	Present (lines)	Comprehensive	Present	Present
Ditches	Present	None	None	None
Parks	Present	Present	from LSRCA	Present
DEM/DTM	from LSRCA			

GIS in Screening of LID Opportunities

LID Screening

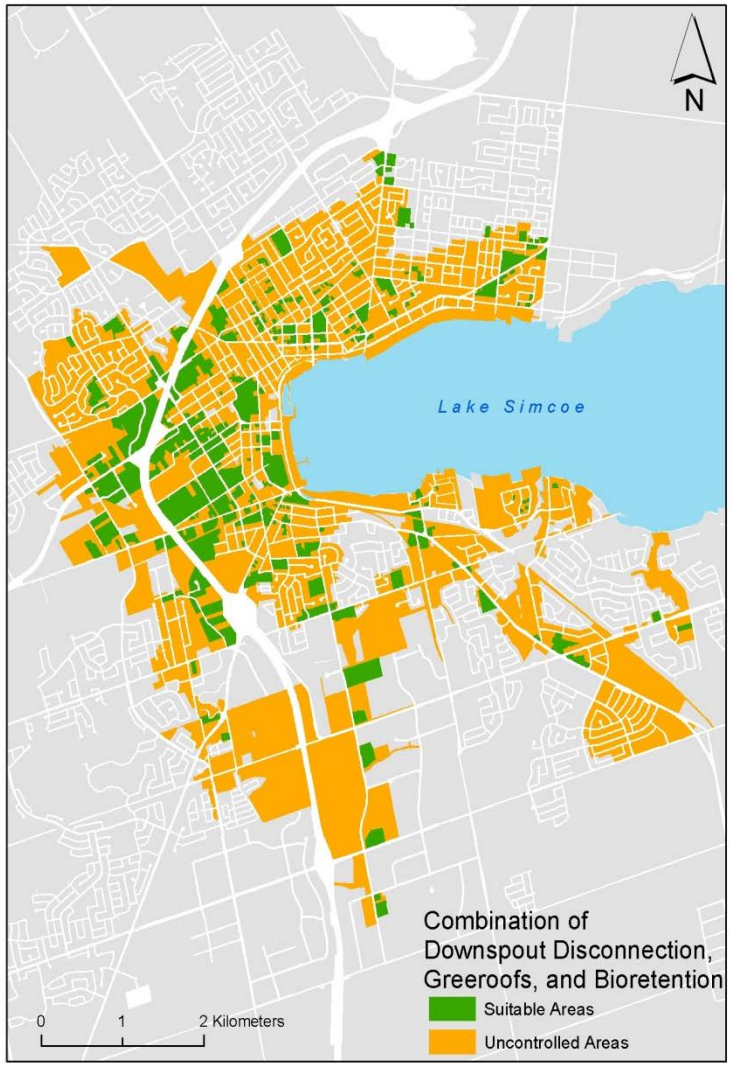
Screening of sites suited to each individual lot-based LID have been mapped, demonstrating that conditions are appropriate and choices exist

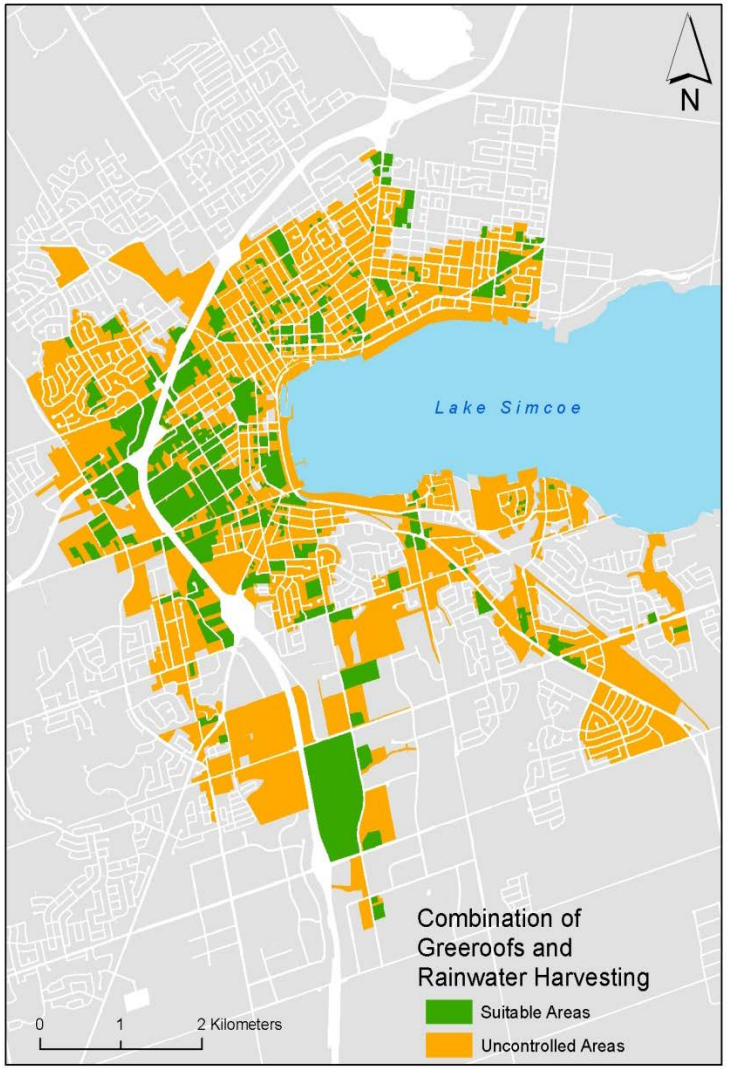




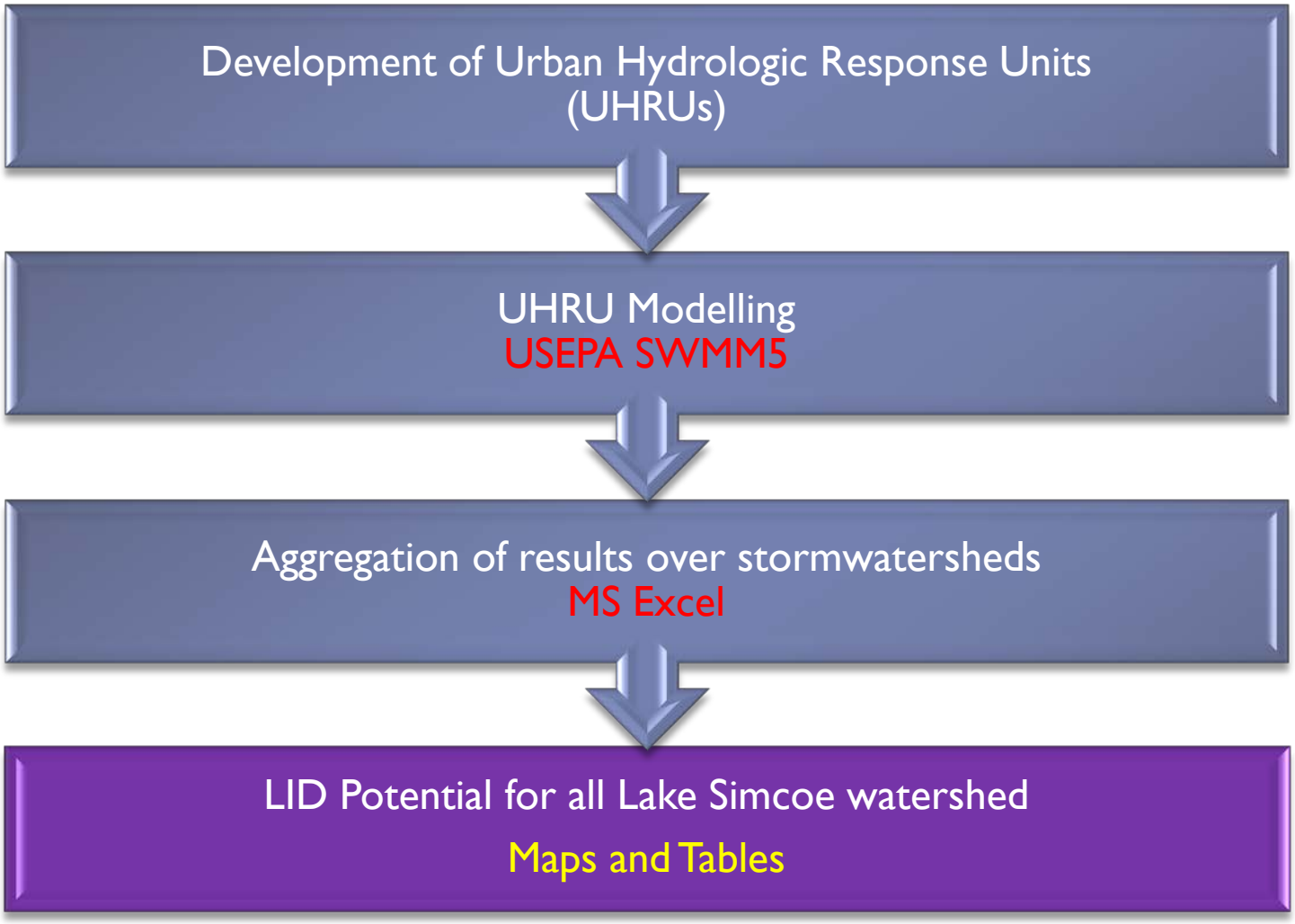
GIS in Screening of LID Opportunities

LID Screening sites for combinations of lot-based LIDs have now been demonstrated to be appropriate:





Modelling Methodology

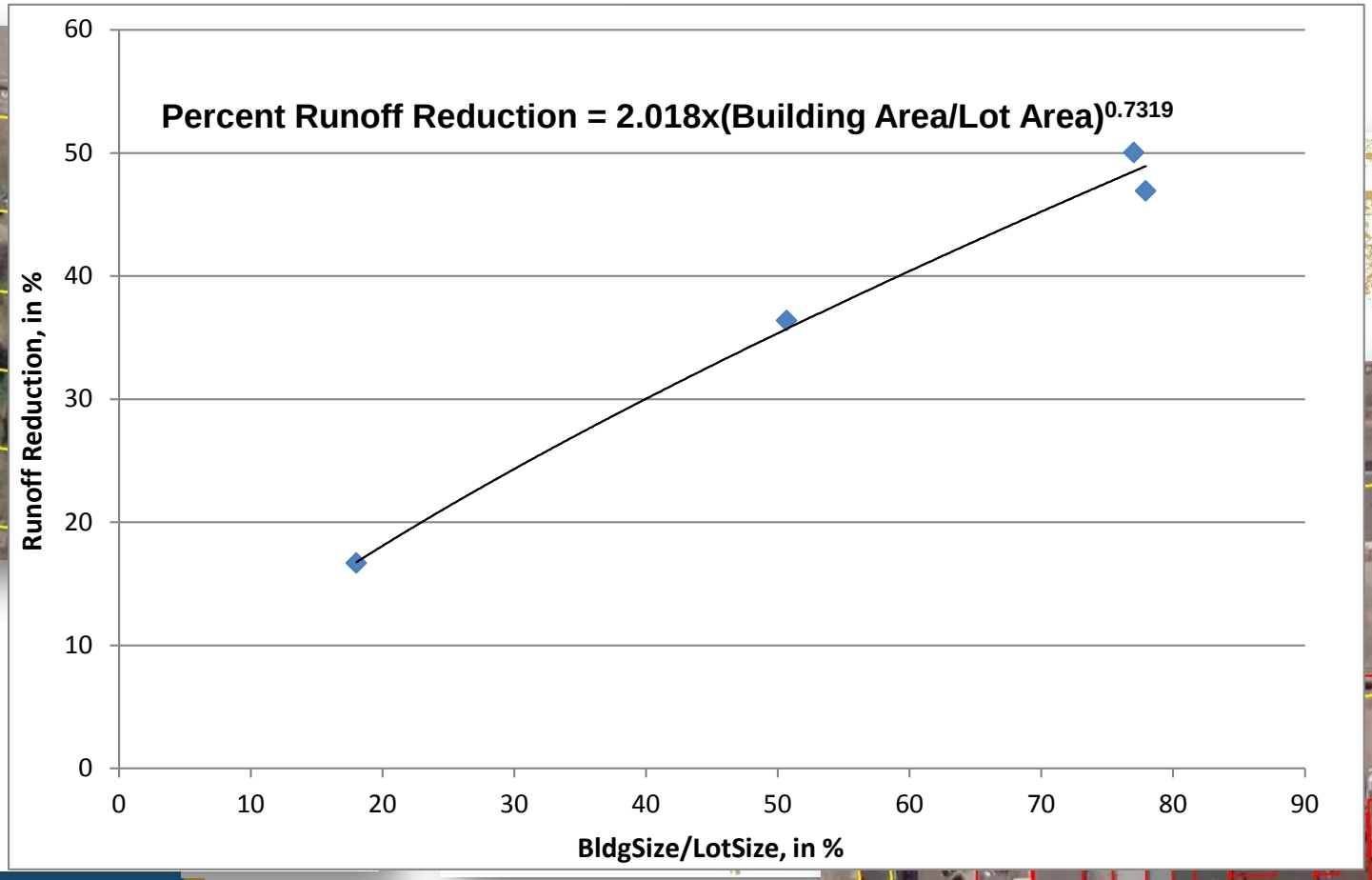


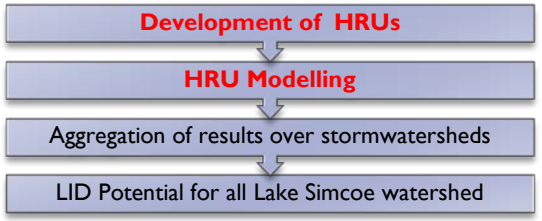
Lot-Based UHRUs

- Lot as a basic unit
- Use of GIS screening results
  - Hydrologic similarity
  - LID opportunities
- Procedure
  - Examine the distribution of lots produced by screening
  - Select three regions, based on lot properties
  - Select one lot to be modeled from each region
  - Model selected lots (existing and with LID)
  - Develop UHRU performance curves
    - Runoff reduction
    - Pollutant loading reduction (TSS, P, Zn)

Areas for Modeling

- Example: Soakaway pits in residential areas
  - Examining and selection of lots in each region



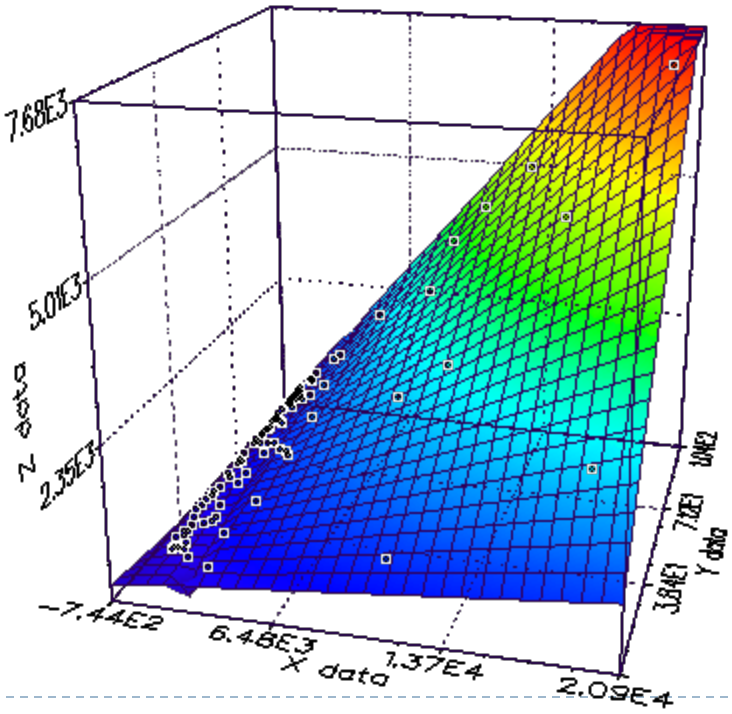


Modelling Inputs

- Rainfall Data
  - Hourly records 1968-2003 for local gauge analyzed
  - Average year (1985) precipitation used
- Evapotranspiration
  - Provided by LSRCA
- Pollutant concentrations
  - EMC based on Toronto WWFMMP Study (no local data available)
- LID Sizing assumptions
  - 2003 Ontario Ministry of Environment guidelines
- Typical pollutant removal assumed (literature)

Existing Conditions Runoff

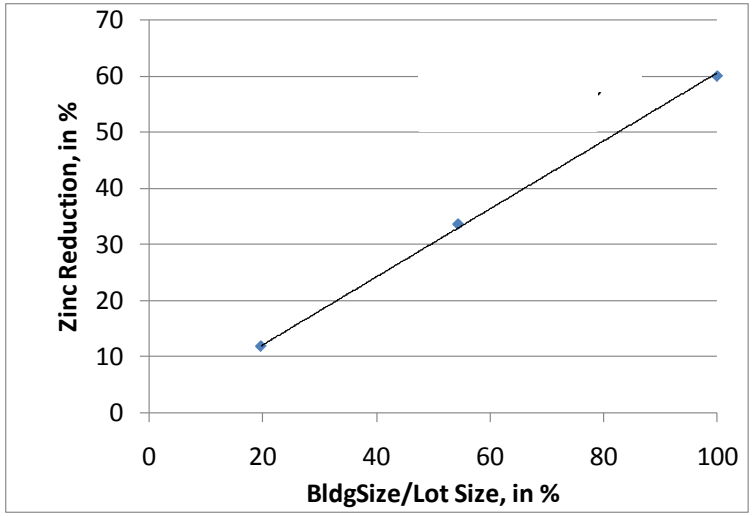
- Aggregation of modeled lot results
- Functional relationship using lot area and percent imperviousness



Aggregation of Results

- Spreadsheet model
  - LID performance on stormwatershed basis (e.g. greenroof)

Stormsewershed ID	Stormsewershed Area, in m^2	Applicable Area of LIDs	
		in m^2	in %
BAR-C1	1,071,533	257,125	24.0



RUNOFF VOLUME CALCULATION				
Total Runoff per Stormsewershed, in m^3	Runoff of Applicable Area, in m^3		Runoff Reduction	
	(no LID)	(with LID)	in m^3	in %
157,130	64,963	58,275	6,688	4.3

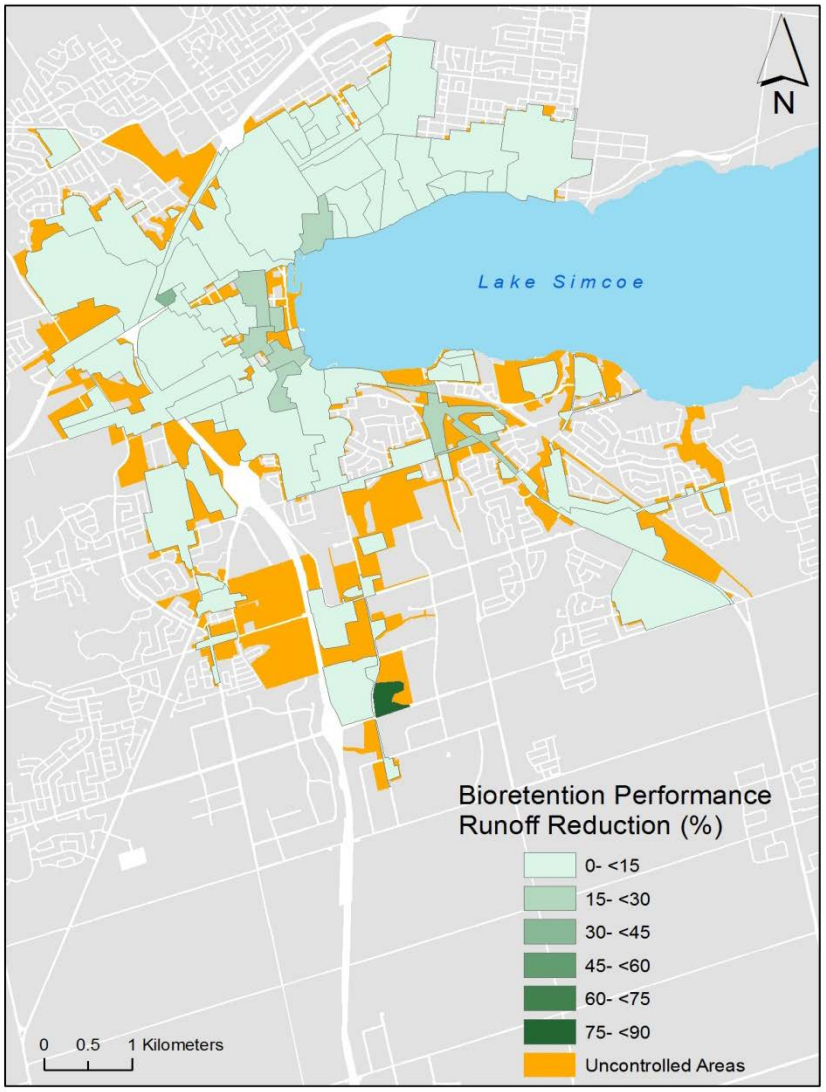
TOTAL PHOSPHORUS (TP) LOADING				
TP per Stormsewershed, in kg/yr	TP of Applicable Area, in kg/yr		TP Loading Increasing	
	(no LID)	(with LID)	in kg/yr	in %
108.1	35.9	36.4	-0.48	-0.44

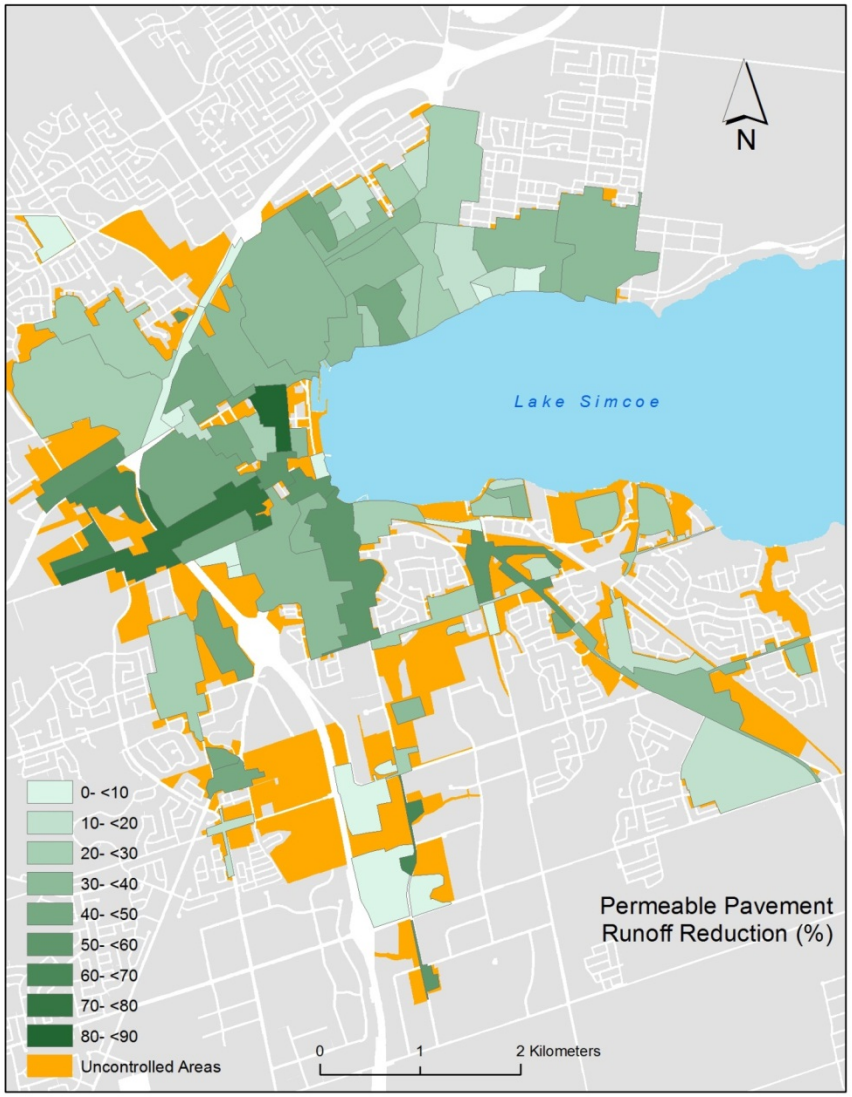
TOTAL SUSPENDED SOLID (TSS) LOADING				
TSS per Stormsewershed, in kg/yr	TSS of Applicable Area, in kg/yr		TSS Loading Reduction	
	(no LID)	(with LID)	in kg/yr	in %
24,572	4,779	3,596	1,184	4.8

ZINC LOADING				
Zinc per Stormsewershed, in kg/yr	Zinc of Applicable Area, in kg/yr		Zinc Loading Reduction	
	(no LID)	(with LID)	in kg/yr	in %
43.2	26.0	20.7	5.2	12.1

Aggregation of Modeling Results in Barrie

- Performance Maps: Lot-based: Individual LIDs

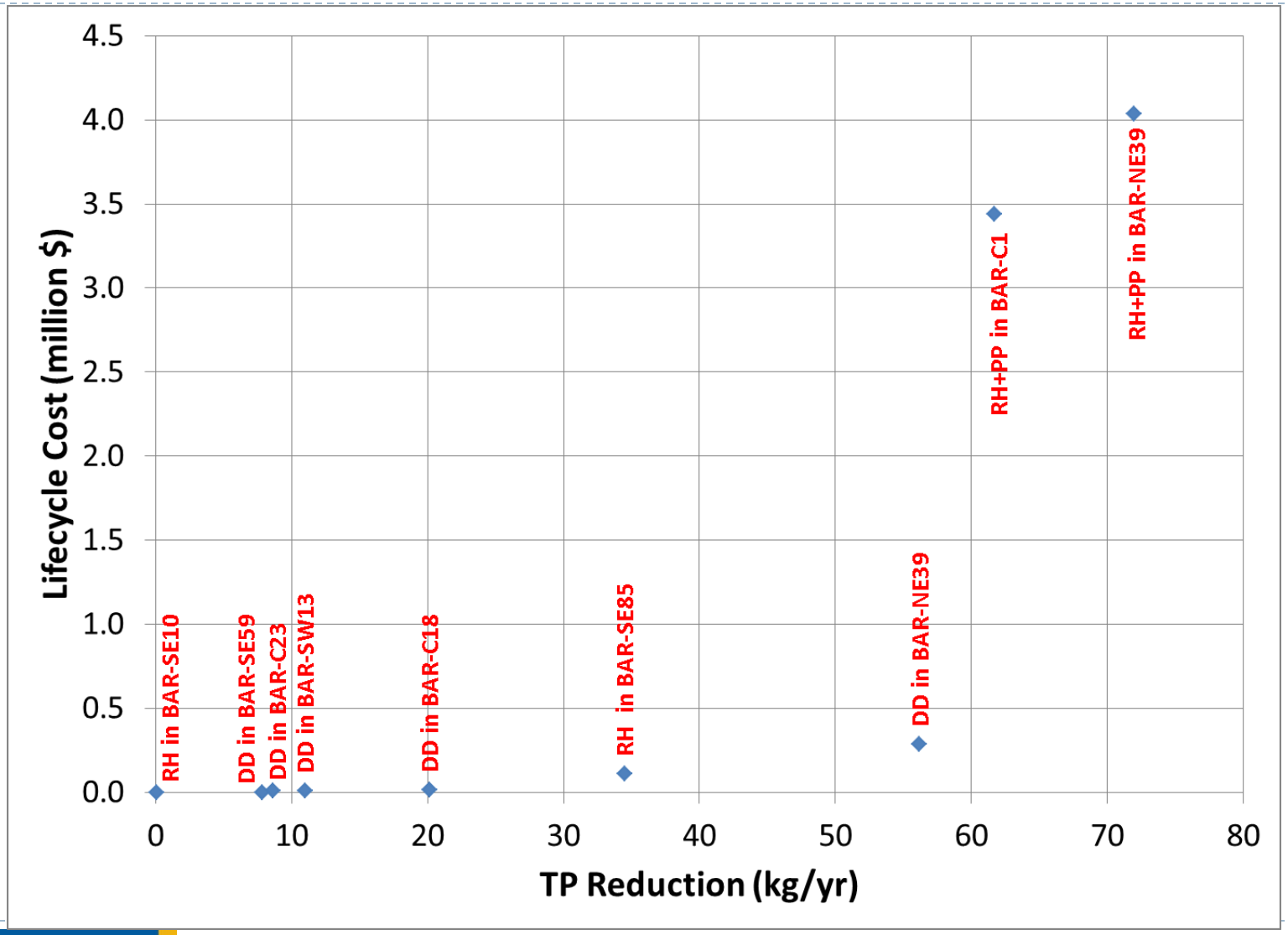




Reduction (%) values for runoff and pollutant reduction

	Overall Reduction							
	Runoff		TP		TSS		Zinc	
LID Types	m^3	%	t/y	%	t/y	%	t/y	in %
RH	437940	17.69	0.5884	34.42	129.4	33.07	0.2505	37.11
DD	355711	14.37	0.4956	29	115.1	29.43	0.1899	28.13
DW	386677	15.62	0.3471	20.31	85.57	21.88	0.1866	27.65
GR	141950	5.734	-0.01103	-0.6455	33.74	8.627	0.1	14.82
SP	258322	10.43	0.544	31.83	174.5	44.61	0.1263	18.71
PP	986709	39.86	0.6566	38.42	140.8	36	0.000174	0.02573
BR	202018	8.161	0.2838	16.61	11.54	2.95	0.008585	1.272
BR+PP	637274	25.74	0.4512	26.4	120	30.68	0.1363	20.2
DW+BR	325362	13.14	0.3421	20.02	104.3	26.66	0.1081	16.02
DW+PP	721235	29.13	0.5963	34.89	170.1	43.48	0.1513	22.42
GR+DD	215003	8.685	0.2485	14.54	43.77	11.19	0.1432	21.21
GR+DW	197244	7.968	0.03769	2.205	41.27	10.55	0.1328	19.68
GR+PP	339392	13.71	0.209938	12.28	66.502	17	0.095362	14.13
GR+RH	175004	7.069	0.43263	25.31	38.897	9.945	0.12923	19.15
GR+SP	193066	7.799	0.05101	2.985	41.77	10.68	0.1307	19.36

Cost vs. Runoff Reduction for all Stormwatersheds



Summary and Conclusions

- UHRU approach
  - Allows watershed evaluation of implementation of small scale practices
  - Flexible
    - Range of LID practices
    - Choice of hydrologic modelling tools
  - Prioritization and ranking of future efforts
- Current / Future work
  - Refinement of performance curves
    - Clustering (according to lot properties)
    - Sensitivity analyses
    - Uncertainty