City of Toronto's Green Streets Project:

Green Streets Project Selection Process

September 2021

A. OVERVIEW

Toronto Green Streets aim to enhance the functionality of the public right-of-way through replicating pre-industrialized site hydrology as much as possible. With the addition of vegetation, a Green Street can provide further ecological and environmental benefits to the city and its residents.

The City of Toronto's Green Streets program is implemented using an opportunistic approach based on the city's State of Good Repair (SoGR) Program. Using co-benefits of Green Infrastructure (GI) as the primary driver, candidate projects are selected from the Capital Works Program (CWP) for further GI investigation.

The selection process occurs in three phases, with each phase loosely defined by the resources required. These phases are (1) GIS Analysis, (2) Desktop Analysis, and (3) Stakeholder Consultation.

Phase 1 (GIS Analysis) uses a Geographic Information System (GIS)-based Priority model to score projects based on co-benefits achievable through Green Infrastructure. The model allocates a score for 5 GI co-benefits – Stormwater Management, Air Quality, Tree Canopy Cover, Social Wellness, and Climate Resilience. Projects in the top percentile are then selected for Phase 2. This process is largely automated, and time demand per site scales logarithmically.

Phase 2 (Desktop Analysis) starts looking at the suitability and feasibility of GI implementation from the street level, while incorporating other factors not captured in phase 1. Factors that may increase/decrease priority of a project are space available, soil conditions, existing policies, site coordination conflicts, public visibility, etc. A base case is then built for selected projects, including site information, proposed sites, and proposed GI type. This process is done manually, with a linear scale for time demand per site.

Phase 3 (Stakeholder Coordination) leverages the expertise of the Green Streets Working Group and other implementation agents to identify scope, budget, and coordinate next steps for GI implementation. The main delivery agent for capital Green Streets projects is the Engineering & Construction Services department. Once selected for program delivery, other risks for projects moving forward are inhibitory findings at site survey, coordination conflict (e.g. extension of adjacent construction), etc.

As Green Streets matures as a program, the Project Selection Process will evolve alongside to meet the program's need. Being aware of the upcoming work for Green Streets (e.g. GI Standards, Asset management framework), review of the process will also be done periodically to update data, modify methodology, and streamline with other business process.

(Priority maps are available to view at the end of documents pg. 10-15)

B. GIS Analysis – The Green Infrastructure Priority Model

The main objective of the GI priority model is to take the list of opportunities (e.g. 2022 capital projects) and sort/prioritize the projects in a short amount of time. The list has to be georeferenced, often as a shapefile, and contain a unique ID for each project. A total of six priority maps are developed – five based on the co-benefits of GI and a sixth showing the overall average. These are raster maps with a standard resolution of $10m^2$.The model uses these maps to rank and highlight priority projects. Methodology and rationale of each co-benefit map is further elaborated next page onwards.

Table: Green Infrastructure Co-benefit Maps

CO-BENEFITS	DATA USED
Stormwater Management	1) CSO contributor area; 2) SS-ESA contributor area; 3) Impervious surfaces; 4) Rainfall distribution
Air Quality	5) Density of Senior/Child care facility within TRAP zones
Tree Canopy Distribution	6) Tree Canopy Cover
Social Equity	7) Neighbourhood Improvement Area; 8) Population Density (by Neighborhood); 9) Recreational Green Space per Capita (by Neighborhood)
Climate Resilience	10) Extreme Heat Vulnerability Map 11) Storm-Related Flood Vulnerable Areas

CSO = Combined Sewer Overflow
SS-ESA = Storm Sewers discharging to Environmentally Significant Areas
TRAP = Traffic-Related Air Pollution

The model is developed in ESRI's ArcGIS (Version 10.4.1) model builder and only requires the Spatial Analyst add-on in ArcGIS to operate. However, ArcGIS Advanced license and some Python scripts were used in the development of the tool.

Output Sample:

Inputs into the model (e.g. 2022 Local Roads) will have all six priority scores (5 themes + mean) attached to it at the output. The output maps and lists the projects sorted by overall priority (highest to lowest). For 2022, the top 15% projects in overall priority, and top 10% of each thematic scorers is shortlisted for phase 2. The cut-off percentage can be adjusted as required.

Table: Example output

#	SCOPE	YEAR	STREET	FROM_STRT	TO_STRT	ALL	SW	AQ	TC	SE	CR
1	LRRC	2022	BALDWIN ST	SPADINA AVE	[98 m W] SPADINA AVE	9.9	9.8	9.3	9.1	7.0	8.0
2	LRRC	2022	KENSINGTON AVE (TO)	DUNDAS ST W	FITZROY TER	9.2	9.4	7.7	8.9	7.0	7.2
3	LRRC	2022		FITZROY TER	KENSINGTON PL	7.3	9.1	6.6	0.0	7.0	8.0
4	LRRC	2022	LIPPINCOTT ST	NASSAU ST	OXFORD ST (TO)	9.3	9.1	7.6	9.0	7.0	8.0
5	LRRC	2022		OXFORD ST (TO)	COLLEGE ST (TO)	9.1	9.0	8.1	8.3	6.9	7.8
6	LRRC	2022	WILLIS ST	BATHURST ST	MARKHAM ST	9.2	9.5	8.1	9.0	7.0	6.9

7	LRRC	2022	OXFORD ST (TO)	AUGUSTA AVE	BELLEVUE AVE	7.6	9.1	7.3	0.0	7.0	8.0

Breakdown #1: Stormwater Management (SW/SWM)

GI in Toronto is built to divert and retain runoff from traditional sewer system. By reducing runoff in the city, we are able to (1) reduce peak flow of stormwater, thus reducing flooding risk, and (2) reduce pollutant loads of stormwater to our natural waters.

Objectives:

1. Water Quality: Improve quality of SW running into natural waterbodies by prioritizing GI in areas where run-off contributes to Combined Sewer Overflows (CSO) and storm sewers discharging into Environmentally Significant Areas (ESA).

	Data Set & Format	Source	Analysis
A	Outfall *(Point)*	Toronto Water Asset Geodatabase (TWAG)	i. Select CSO outfalls ii. Select outfalls located within ESA polygon
B	Sewer Lines & Catchbasins *(Polyline & Point)*	Toronto Water Asset Geodatabase (TWAG)	i. Select sewer lines connected to outfalls selected above. ii. Exclude streets where catchbasins are not connected to selected sewer.
C	Environmentally Significant Area *(Polygon)*	City Geospatial Database (GCCView)	Used to identify outfalls within ESA
D	City of Toronto Basemap *(Basemap)*	City Geospatial Database (GCCView)	Spatial Reference of Streets & watercourse.
		GIS Function	
	Priority Scoring:	Euclidean Distance	10: Within 10m of centreline 8 : 11m to 50m 6 : 51m to 100m 4 : 101m to 250m 3 : 251m to 500m 2 : 501m to 1000m 1 : 1000m +

2. Water Quantity: Reduce urban runoff by increasing local stormwater infiltration, and prioritize implementation in areas of high imperviousness.

	Data Set	Source	Analysis
A	Impervious Area	Toronto Open Data	No modification is made.
		GIS Function	
	Priority Scoring:	Reclassification	10: Impervious Surface 1 : Others

Breakdown #2: Air Quality (AQ)

Traffic-Related Air Pollution, (a.k.a. TRAP) are harmful pollutants (i.e. PM2.5, NO, NO2, ultrafine particulates) prominent along major roads and highways. By incorporating GI containing trees and/or waxy-leaf shrubs, these GI act as a natural air filter, trapping particulate matter and reducing TRAP exposure to other road-users.
Objective:

1. TRAP Zones: Reduce local levels of TRAP by prioritizing TRAP zones as defined by study performed by TPH & EED.

	Data Set & Format	Source	Analysis
A	TRAP Zones *(Polygon)*	Toronto Public Health	Merge TRAP zone polygons i. <100m from an arterial; ii. <150m from selected streets ii. <500m from an expressway
		GIS Function	
	Priority Scoring:	Reclassification	10: TRAP zone EXCLUDED: Non-TRAP zone

2. TRAP Vulnerability: Reduce exposure of TRAP to vulnerable population by prioritizing TRAP zones with higher density of schools, child care, senior care, and long-term care facilities.

	Data Set & Format	Source	Description
A	TRAP Zones *(Polygon)*	Toronto Public Health	This data contains TRAP zones which are i. <100m from an arterial; ii. <150m from selected streets ii. <500m from an expressway
B	Vulnerable Population Facilities: - Long term care; - Senior home; - Childcare centre; - Retirement home; - Schools *(Point)*	City Geospatial Database (GCCView)	i. TRAP Score appointed to facility point based on number of TRAP zones overlapping. ii. Point density analysis done in 500m radius.
		GIS Function	
	Priority Scoring:	Reclassification	Priority of TRAP score based on quantile ranking (of 10). Max: 22.92 Median: 1.258 Mean: 0

NOTE: TRAP Score is used (opposed to a simple point count density) to include TRAP exposure into the weighting. The motive of this method is to increase priority on facilities where multiple TRAP zone intersect (e.g. a school beside a major road and a highway.).

Breakdown #3: Tree Canopy Distribution (TC)
In line of the objectives of the city's Ravine Strategy, Parkland Strategy and Strategic Forest Management Plan, Green Infrastructure can increase tree canopy cover of the city, bringing with it environmental, ecological, social, cultural, and economic benefits. In the 2018 Toronto Tree Canopy Study, street trees were identified to bring proportionally more value to residents than any other type of trees.

Objective:

1. Increase city-wide accessibility to the ecological, social, and health benefits of trees by prioritizing areas with low tree cover.

	Data Set	Source	Analysis
A	Forest & Land Cover 2018 *(Raster)*	Parks Forestry & Recreation	Tree canopy already identified in dataset.
		GIS Function	
	Priority Scoring:	Reclassification	10: Tree Canopy 5: Shrubs 3: Grass 1 : Others

Note:

i. When scoring streets, a buffer polygon is synthesized by adding 5-15m from the road centreline. The score of the road is calculated by averaging the pixel value within the sample polygon. This is to ensure that boulevard spaces of local roads are captured.

Breakdown #4: Social Wellness (SW/SOC)
Implemented well, GI offers an opportunity to enhance the social wellness of a neighborhood. On top of improving neighbourhood aesthetics, GI may include urban design aspects (e.g. art, benches, etc.), creating a vibrant community space for social activities. Greenery is also known to be beneficial to the perceived value and mental health of residents in a neighbourhood. This resonates with the City's Parkland Strategy and aims to relieve the "Green Demand" for areas where parkland acquisition may be challenging.

Objective:

1. Bring forward social benefits of GI (e.g. health, sense of community, aesthetics) to Neighborhood Improvement Areas (NIA).

	Data Set	Source	Analysis
A	Neighborhood Improvement Area *(Polygon)*	Toronto Open Data	Priority Scoring: Yes = 10 No = 1

2. GREEN SPACE PER CAPITA: Increase per-capita accessibility to public recreational green space by prioritizing neighborhoods with low Green Area per capita ratios.

	Data Set	Source	Analysis
A	Neighborhood Profile 2014 *(CSV & Polygon)*	Toronto Open Data	Use "Population_2016" column to define neighborhood population
B	Recreational Green Space (Excluding ravines & golf course). *(Polygon)*	City Geospatial Database (GCCView)	i. Convert polygon to raster. ii. Calculate area of green space using neighborhoods are geometrical dividers. iii. Divide green space by population to obtain area/capita
		GIS Function	
	Priority Scoring:	Reclassification	Priority of Green Space/capita based on quantile ranking (of 10).

3. Maximize social value of GI by prioritizing neighborhood with high population density.

	Data Set	Source	Analysis
A	Neighborhood Profile 2014 *(CSV & Polygon)*	Toronto Open Data	i. Calculate area of neighborhood ii. Divide neighbourhood population/population area.
		GIS Function	
	Priority Scoring:	Reclassification	Priority of population density based on quantile ranking (of 10).

Breakdown #5: Climate Resilience (CR)
As the climate continues to change, the number of extreme heat and extreme precipitation events are projected to increase in Toronto. During extreme heat days, the thermal buffering function of vegetative evapotranspiration may cool the streets while providing shade. At scale, GI is also able to mitigate the severity of urban flooding through the reduction of stormwater peak flow.

Objective:

1. Improve resilience to extreme heat events through shade & evapotranspiration of GI components, prioritizing areas most susceptible to extreme heat.

	Data Set	Source	Analysis
A	Census Tract Temperature Exposure Data *(Polygon)*	Toronto Public Health	Analysis done by TPH.
		GIS Function	
	Priority Scoring:	Reclassification	Priority of Heat Exposure based on quantile ranking (of 10).

2. Improve resilience towards storm-related food impacts by prioritizing GI in areas vulnerable to flooding tendancies.

	Data Set	Source	Analysis
A	Basement Flooding Complaint Intensity *(Point)*	Toronto Water	i. Isolate storm-related flooding call ii. Remove duplicate of calls. iii. Calculate point density. iv. Reclassify using Decatiles
B	Riverine Flood Vulnerable Area *(Polygon)*	Toronto & Region Conservation Authority	Euclidean Distance: 10: Within polygon 9 : <100m 8 : 101m to 250m 6 : 251m to 500m 3 : 501m to 1000m 1 : >1000m
		GIS Function	
	Priority Scoring:	Weighted Overlay	Calculate average of both flood scores.

Breakdown #6: Overall Priority (ALL)

For the overall priority map, the mean of all 5 themes is calculated for each $10m^2$ raster cell.

[*All maps are visible at end of document*]

Constraints/Limitations of current GIS model

1. This model is purely based on historical data and fail to capture risks that may arise with climate change.
2. Aged map for extreme heat – the current map was a single flyover from 2007.
3. Other data gaps identified:
   - Sink basin analysis raster (for flooding)
   - Ecological connectivity
   - Contaminated soil map (in progress)
   - Boulevard width
   - Other resiliency factors
4. There is a desire to incorporate geotechnical & site feasibility to this analysis; however geotechnical data is a highly localized factor and current data fails to meet desired resolution. As of now, site feasibility is attached as preliminary reference before geotechnical data is available.

Green Streets will update the datasets as new data arise. Green Streets will periodically revaluate the priority map to update datasets and realign objectives of the maps with those of the project.

C. Desktop Analysis

After the shortlisted project candidates are produced, a holistic scan is done on each sites through Google Street View, City of Toronto's INView, T.W.A.G, and other internal resources available to staff – thus the name of desktop analysis. Common screening aspects are boulevard space, soil feasibility, support and partnering opportunities are flagged. Other factors that are not automated via GIS is considered at this stage as well.

Screened Aspects	Information Source
Boulevard Space	1) Google Street View
Concurrent projects (conflicts/partnership)	2) TO INView, staff knowledge
Sewer/Hydrological Information	3) T.W.A.G (Toronto Water Asset Geodatabase)
Soil Feasibility (Mapped in GIS)	4) Soil Permeability (Ontario Geological Survey) 5) Depth to Bedrock (Ontario Geological Survey) 6) Depth to Water Table (Toronto & Region Conservation Authority) 7) Gradient (Slope) (City of Toronto Database)
Counsellor/BIA/NEI/ Community Support	8) Staff knowledge & coordination.
Existing Green Infrastructure (to ensure equitable distribution city-wide)	9) Staff knowledge & GI database (currently being built)

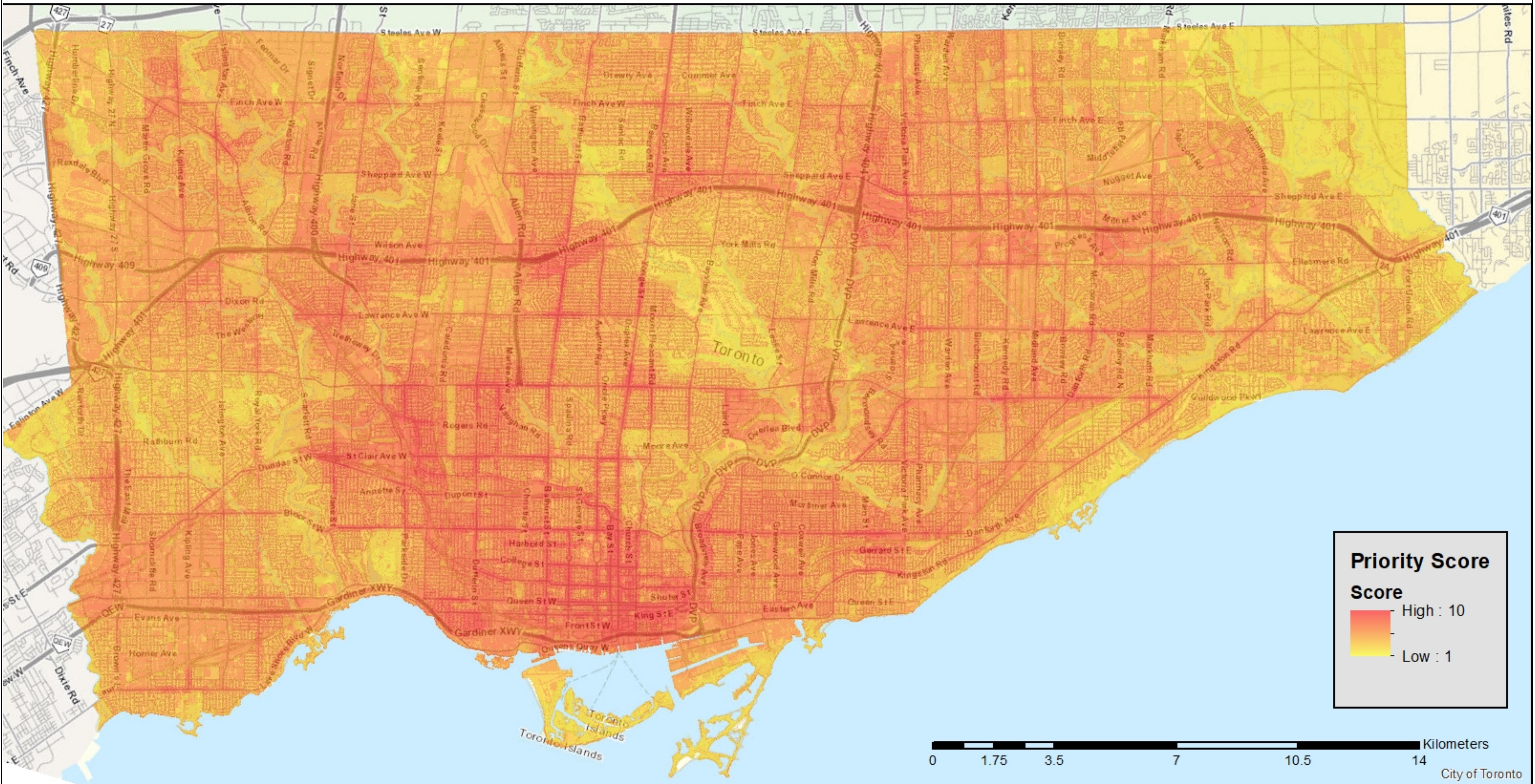
D. Stakeholder Coordination

At the final stage, the shortlist will be reviewed by City of Toronto staff, including members from the Green Streets Implementation Working Group (GSIWG), project managers, coordination staff, and budgeting personnel. If required, community outreach will be performed as well. Once delivery is locked in, the city will coordinate field verification studies (e.g. survey, geotech, SUE investigation, etc.) and based on the findings, propose the appropriate GI technology on site.

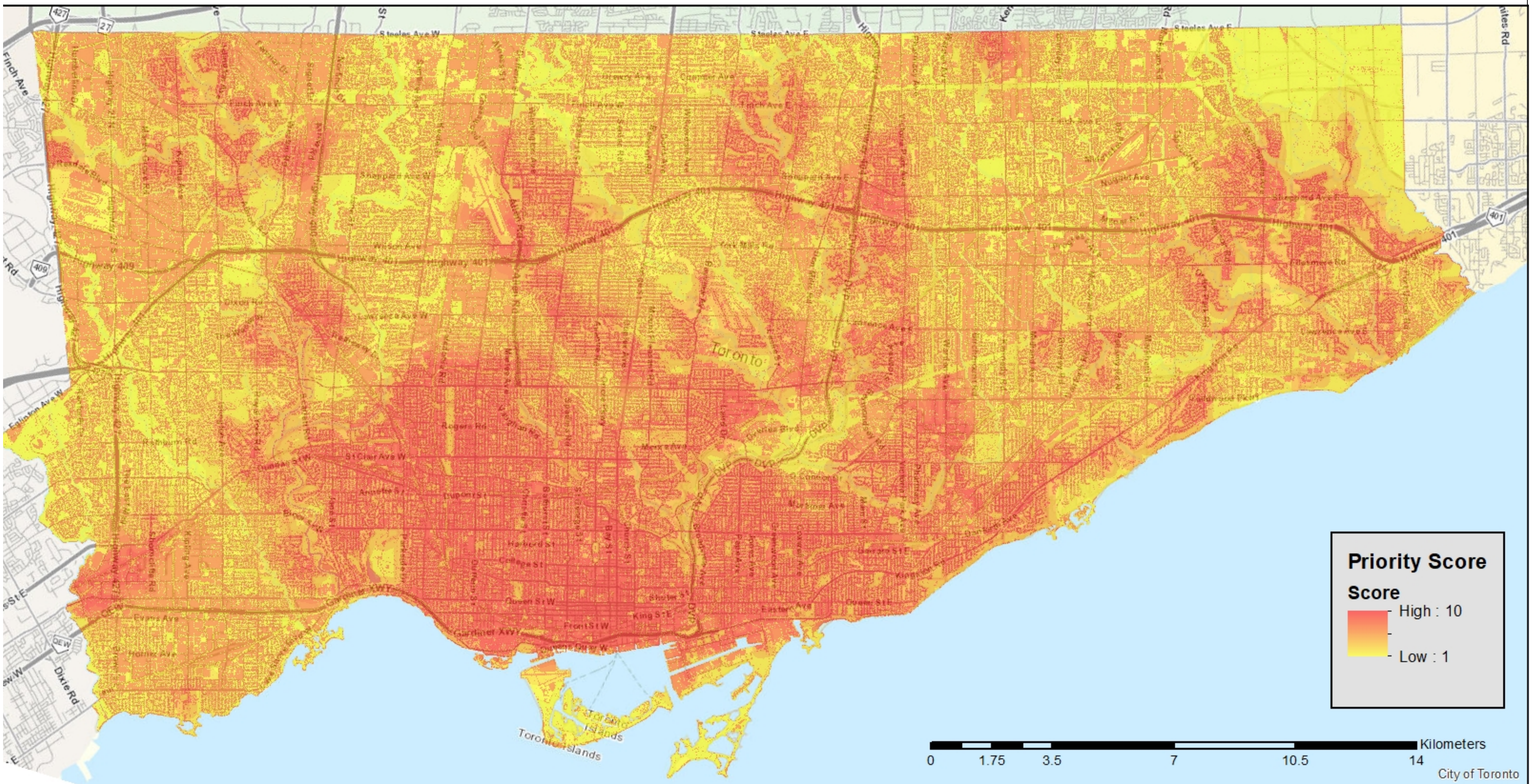
E. Conclusion

The main motive of the Project Selection Process is to use a data-driven decision making process to build low-cost, high-benefit projects for Green Streets. Through multi-divisional collaboration and consultation, the Green Streets group have built a selection model that is aligned with the city's larger motives, yet remains straightforward to use. As we have received many interest in the GIS tool, our next step is to explore options to bring it online. As with all new projects, Green Streets is dynamic and evolving. Periodical review of this process will be necessary as Green Streets ramps up. For the most up to date information – visit the Green Streets webpage on www.toronto.ca.

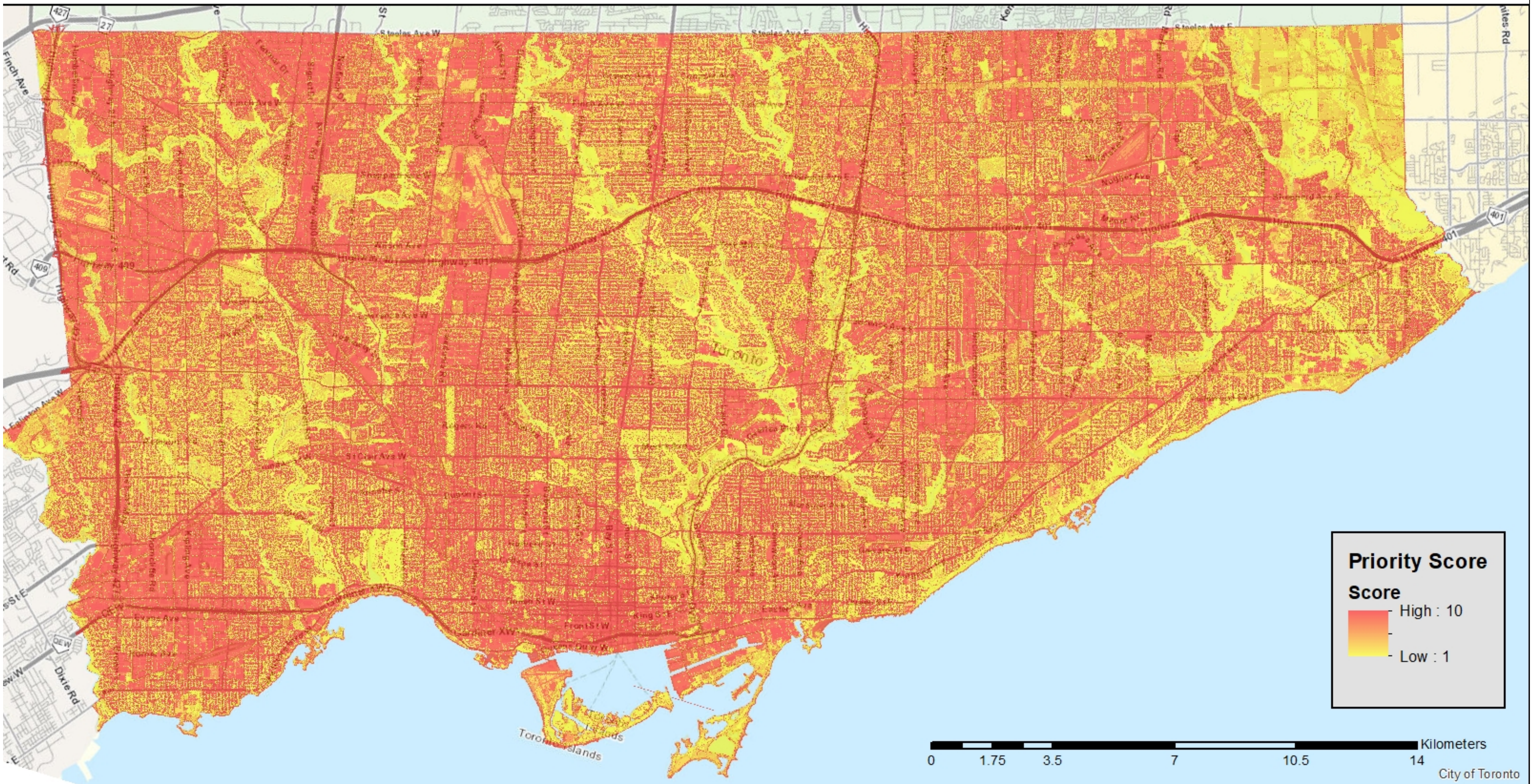
Green Streets Priority Map: Overall Average



Green Streets Priority Map: Stormwater Management

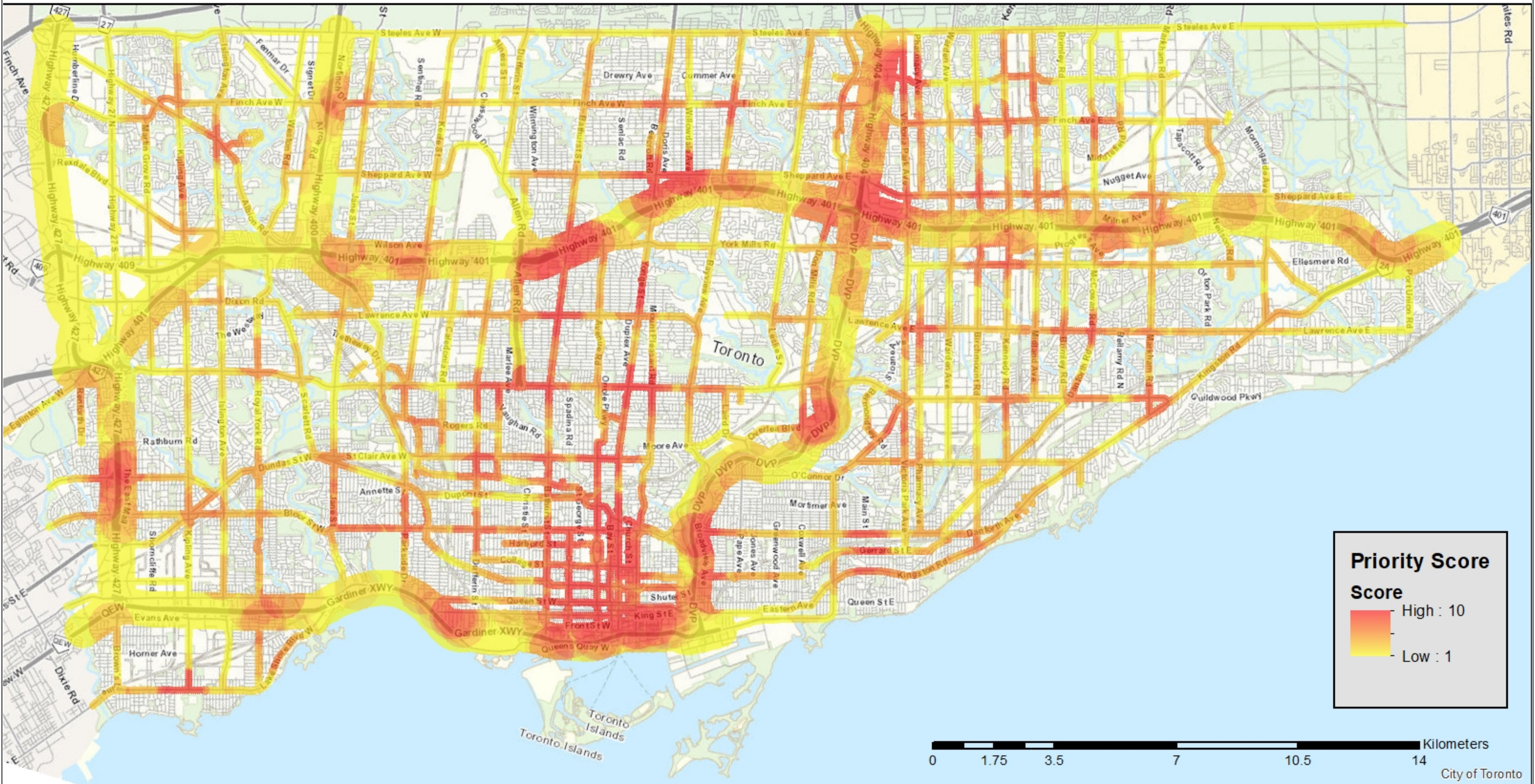


Green Streets Priority Map: Tree Canopy Cover

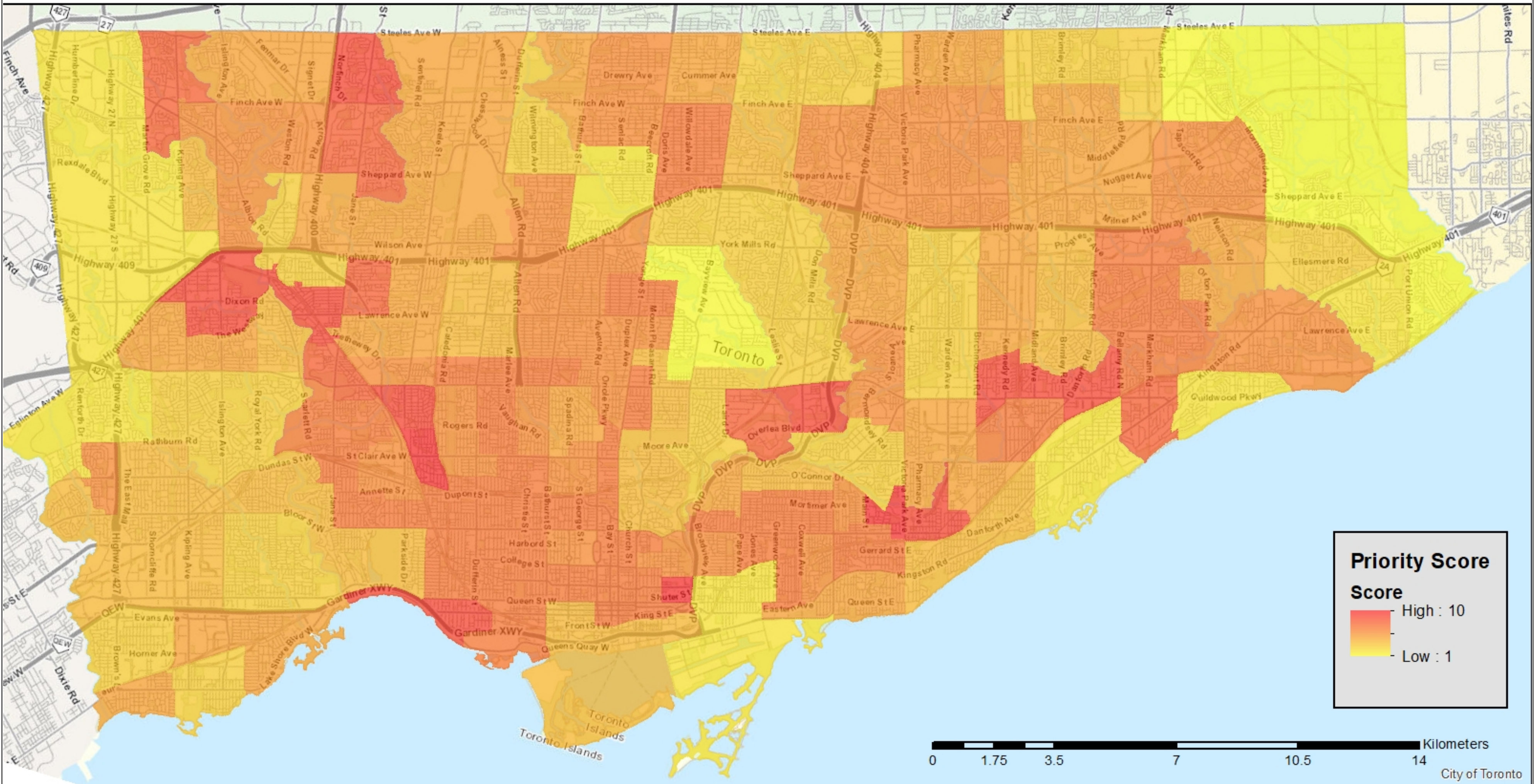


Opt in

Green Streets Priority Map: Traffic-Related Air Quality



Green Streets Priority Map: Social Wellness (Old Neighbourhood Map)



Green Streets Priority Map: Climate Resilience