GREATER LAKES

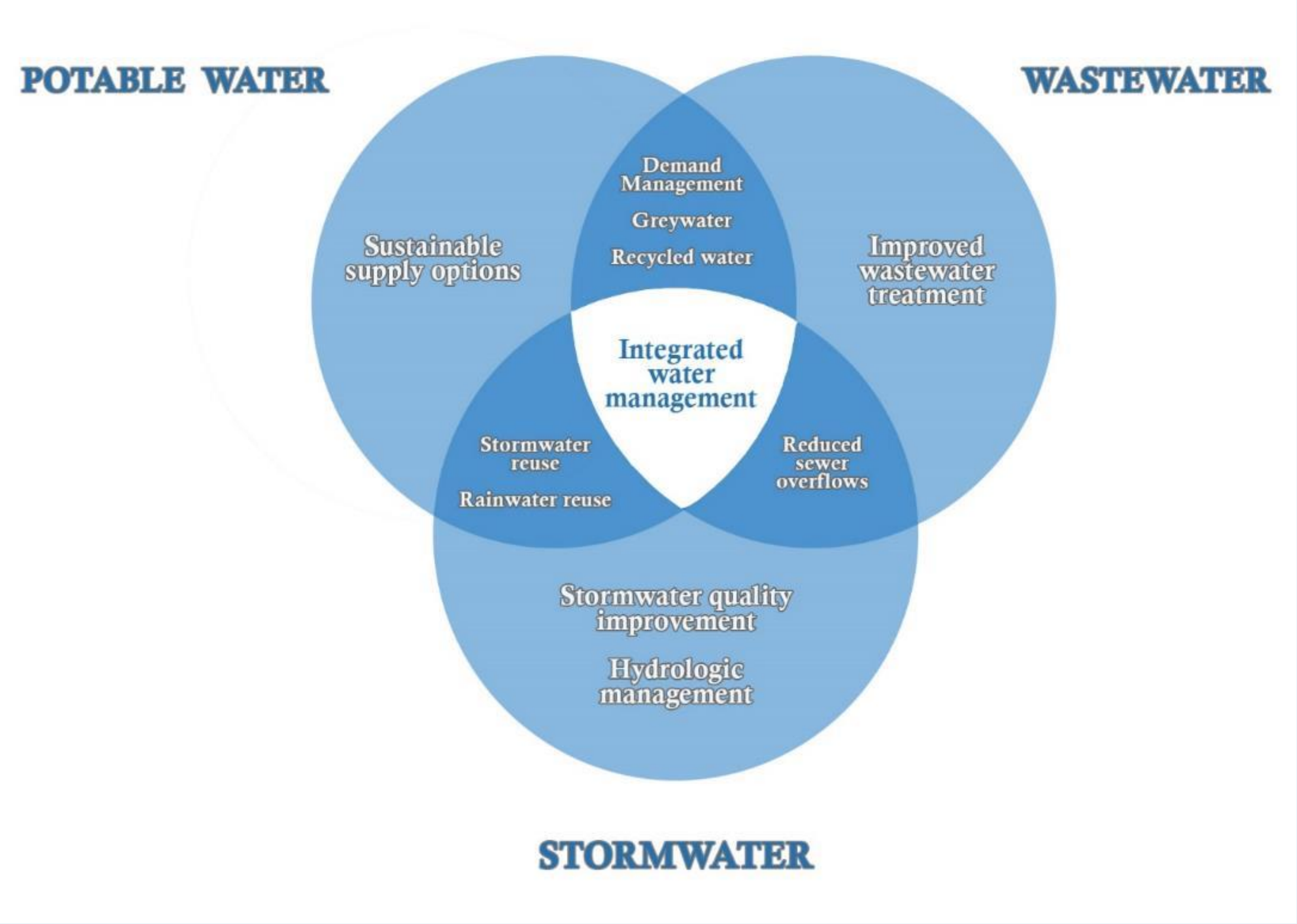
Reconnecting the Great Lakes Water Cycle

Selecting Least Cost Green Infrastructure

James W. Ridgway, PE

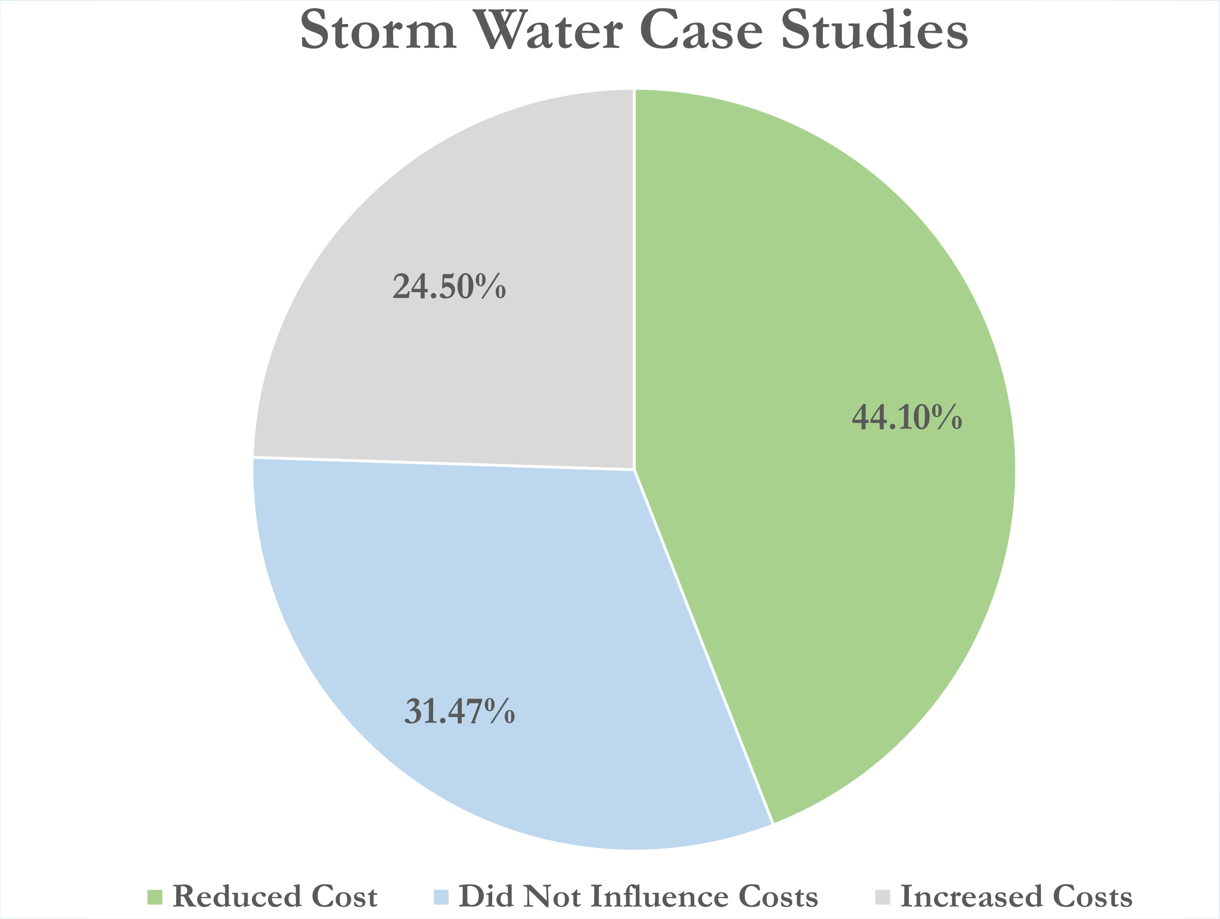
October 14, 2015

Integrated Water Management??



IS GREEN INFRASTRUCTURE LESS COSTLY THEN GRAY INFRASTRUCTURE?

Cost of Green Infrastructure vs. Gray Infrastructure



479 case studies collect by American Society of Landscape Architects at the request of USEPA - www.asla.org/stormwateroverview.aspx

Evaluating Green Infrastructure?

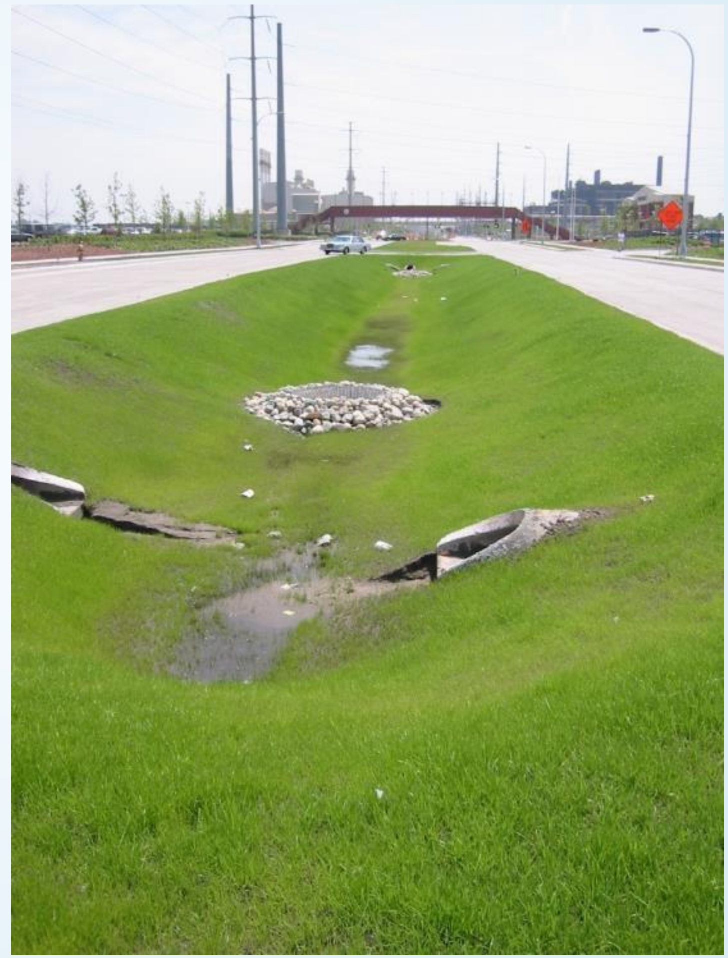
Not All green Infrastructure is Created Equally

- Volume Control
  - Infiltration – Is it possible?
  - Reduce peak offsite runoff rates – Is it necessary?
  - Divert flows from sewers – of course!
- Define Capture Requirement
- Define Release Rate
- Identify Available Area

Increase Infiltration

Green Infrastructure
Public/Private Places

Store Water - Above and Below Grade **(to Encourage Infiltration)**



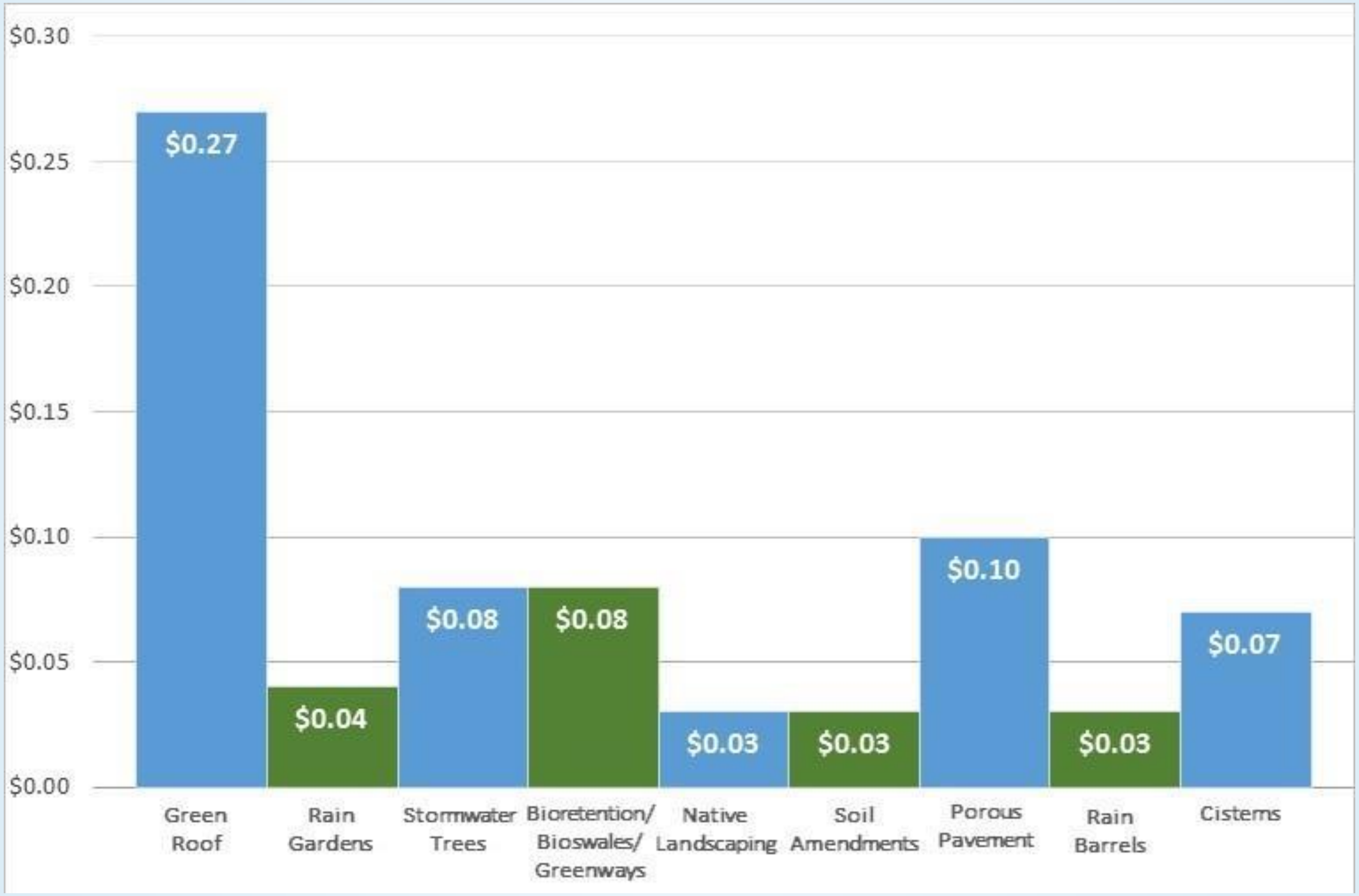
Store Water - Above and Below Grade **(to Encourage Reuse)**



IS VOLUME THE DRIVING FORCE?

Incremental Cost per Annual Gallon Captured

(Milwaukee Metropolitan Sewerage District, 2013)

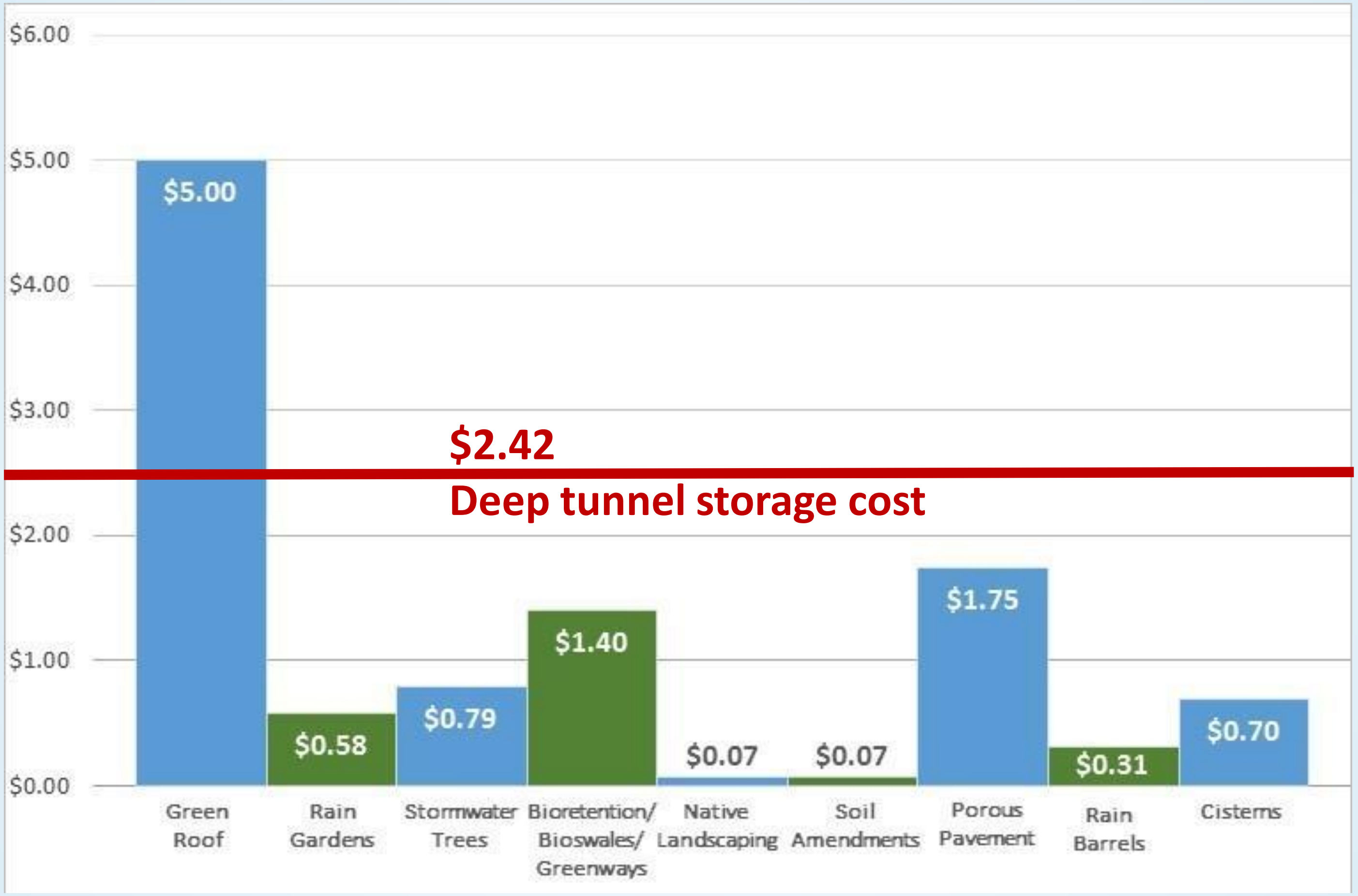




IS AREA THE DRIVING FORCE?

Incremental Cost per Square Foot Managed

(Milwaukee Metropolitan Sewerage District, 2013)



Note: The green infrastructure strategies supporting green alleys, streets, and parking lots are included in other strategies. The wetlands Green Infrastructure Strategy is encouraged but not quantified in the plan.

Stand-alone Costs (per green infrastructure SF and per SF managed) and the Relationship to Incremental Costs

(Milwaukee Metropolitan Sewerage District, 2013)

Green Infrastructure Strategy	Stand-alone Cost ($/SF)	Loading Ratio (Ratio of Area Managed to Area of GI)	Stand-alone Cost ($/SF Managed)	Incremental GI Cost Compared to Stand-alone Cost	Description of Cost Assumption
Green Roofs[1]	$11.50	1.0	$11.50	43%	Median PWD cost ($11.50/SF)
Rain Gardens	$10.00	12.0	$0.83	70%	Middle of FCGS range rounded up to $10/SF
Stormwater Trees[2]	$0.80	0.5	$1.58	50%	FCGS cost
Bioretention/ Bioswale	$24.00	12.0	$2.00	70%	Average between PWD[3] and SUSTAIN[4] demonstration project
Native Landscaping/Soil Amendments	$0.11	1.0	$0.11	60%	Middle of FCGS[5] range, rounded up to nearest $1,000
Porous Pavement	$10.00	4.0	$2.50	70%	$10/SF, approximately 90 percent of median PWD costs
44-gallon Rain Barrels[6]	$120 (each)	N/A	$0.34	90%	Middle of FCGS range rounded up to nearest $10
1,000-gallon Cisterns[7]	$5,000 (each)	N/A	$0.78	90%	$5/gal., middle of FCGS range for 1,000-gal cistern

[1]Incremental cost of green roofs set to 43 percent to match MMSD's $5/SF ($217,800/acre) green roof incentive program.

[2]Trees are assumed to have an average 10-ft canopy radius (314 SF), with 50 percent assumed to be overhanging impervious area.

[3]PWD is Philadelphia Water Department.

[4]SUSTAIN is from (MMSD 2011) Determining the Potential of Green Infrastructure to Reduce Overflows in Milwaukee.

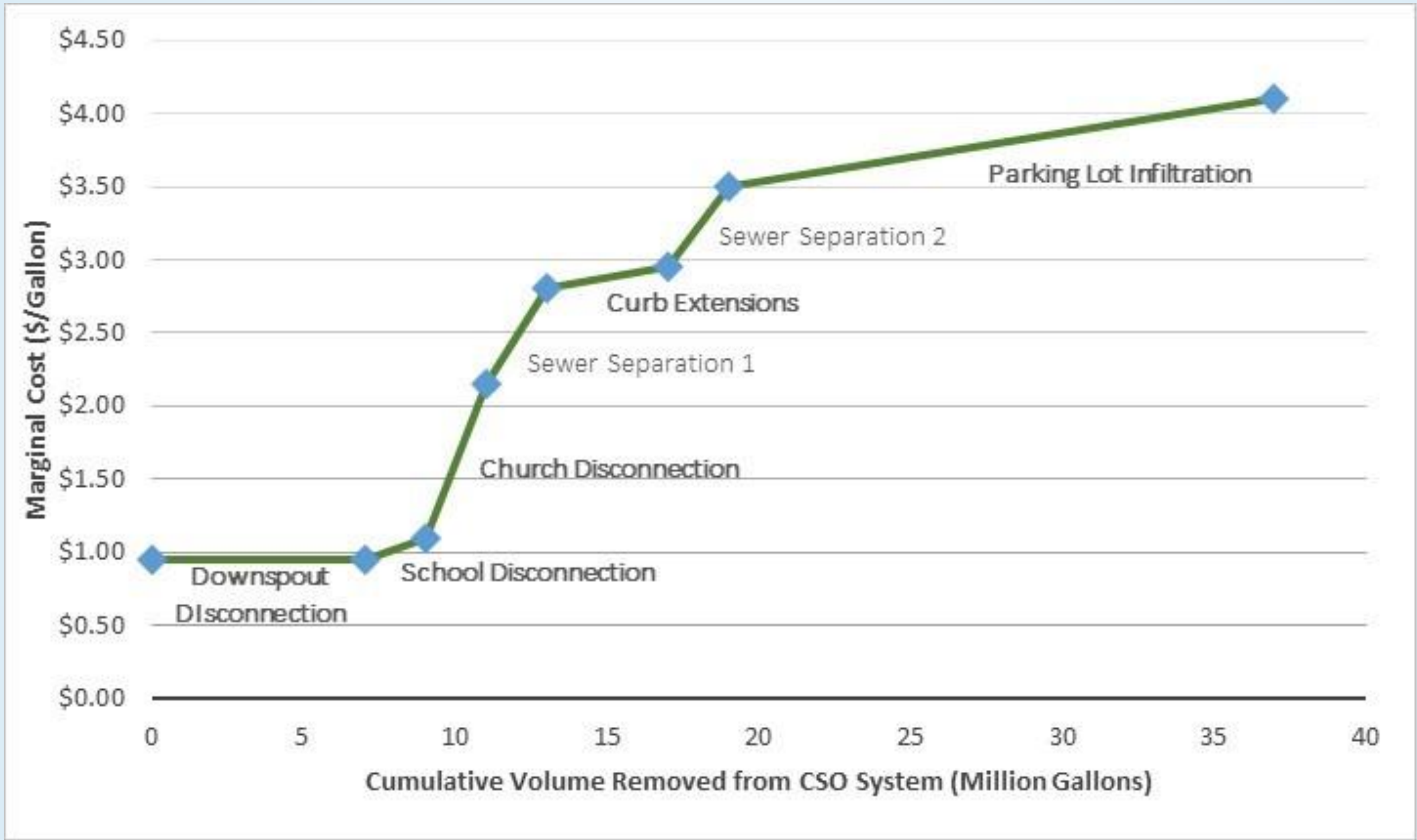
[5]FCGS is "Fresh Coast Green Solutions" (MMSD 2009).

[6]Each rain barrel is assumed to manage 350 SF of rooftop; therefore, 124.5 barrels are required for 1 acre of roof.

[7]Each 1,000-gallon cistern is assumed to manage 6,500 SF of impervious area; therefore, 6.7 cisterns are required for 1 acre.

Costs and Cumulative Volume of Stormwater Removed from the CSO System through Various Gray and Green Strategies (Green in Bold)

(Odefey, 2012)





WHAT ARE THE TECHNICAL DRIVERS?

Public Works Priorities

(a.k.a. The Technical Drivers)

- Volume Management
  - No Flooding
  - Reduce Flashy Flows
  - Limit Erosion
- Pollutant Removal
  - Bacteria
  - Oxygen Demanding Materials
  - Phosphorous/Nitrogen
  - Other Pollutants
- Green Space
- Quality of Life



WATER RESOURCES IMPACT ASSESSMENT TOOL

Water Resources
Impact Assessment Tool

- Prioritize the challenges
- Select Design Drivers
- Identify Funding Requirements/Opportunities
- Minimize Cost
- Maximize Benefit
- Aggregate Solutions
- Finance Large Scale Implementation

Greater Lakes Stormwater Management Calculator

Welcome to the Greater Lakes Stormwater Management Calculator—an MSExcel based tool that utilizes the TR-55 Method to estimate the effect of Green Infrastructure BMPs on reducing the amount of stormwater runoff on a site basis. The calculator automatically assists the user with determining the values needed to use this tool based on the site specific data that is provided by the user. Cells with a small triangle in the upper righthand corner indicates that additional guidance is available for the information requested which can be viewed by hovering over the cell. Cells in blue require data input by the user.

Great Lakes Commission des Grands Lacs

ECT Environmental Consulting & Technology, Inc.

Great Lakes Protection Fund

Step 1: Calculating Runoff

Establish the Rainfall Event

Click here for directions

Tip

Rain Event:

1.5 ▾ ·hes

0.5
1
1.5
2
2.5
3
3.5
4

·er Data here

Enter Land Cover Areas

Click here for directions

Tip

Land Cover Key

·ject Totals

Site Area (ac)	5.60	acres
Impervious Area (ac)	3.37	acres
Runoff Volume (ft^3)	18,404	cubic feet

Enter Data Here

	Land Cover	Condition	Hydrologic Soil Type	Area (sf)	Area (ac)	CN (TR-55)	S	Runoff, Q (in)	Runoff Volume (ft^3)
1	Existing Building	N/A	N/A	60,000	1.377	98	0.2	1.28	6,400.71
2	Proposed Building	N/A	N/A	30,000	0.689	98	0.2	1.28	3,200.36
3	Existing Paved Parking Area	N/A	N/A	10,000	0.230	98	0.2	1.28	1,066.79
4	Proposed Paved Parking Area	N/A	N/A	10,000	0.230	98	0.2	1.28	1,066.79
5	Existing Paved Walkway	N/A	N/A	1,500	0.034	98	0.2	1.28	160.02
6	Proposed Paved Walkway	N/A	N/A	500	0.011	98	0.2	1.28	53.34
7	Existing Roadway	N/A	N/A	25,000	0.574	98	0.2	1.28	2,666.96
8	Proposed Roadway	N/A	N/A	10,000	0.230	98	0.2	1.28	1,066.79
9	Open Space	Poor	C	5,000	0.115	86	1.6	0.49	205.08
10	Pasture	Fair	B	2,500	0.057	69	4.5	0.07	14.79
11	Meadow	N/A	C	1,500	0.034	71	4.1	0.10	12.23
12	Brush	Poor	D	3,000	0.069	83	2.0	0.38	94.70
13	Woodland/Grassland	Good	C	10,000	0.230	72	3.9	0.11	94.27
14	Woods	Good	C	50,000	1.148	70	4.3	0.08	349.38
15	Bare Soil	N/A	D	25,000	0.574	94	0.6	0.94	1,951.41

Step 2: Green Infrastructure Planning

Select BMPs

Click here for directions

Assumptions

Note:

Percent volumes greater that 100% indicate that there is a surplus of storage.

Negative volumes indicate the total surplus of storage.

1 Existing Building

BMP	Surface Area (sf)	Ponding Depth (in)	Planting Media Depth (in)	Stone Base Depth (in)	Storage Volume (ft^3)	Remaining Unstored Volume (ft^3)	Percent Volume Stored
Green Roof	500	4	6	0	217	6,184	3.4%
Blue Roof	100	4	0	0	33	6,151	0.5%
Green Roof	250	4	6	0	108	6,042	1.7%

Total Runoff without GI:	6,401
Total Storage from GI:	358
Total Remaining Volume:	6,042

2 Proposed Building

BMP	Surface Area (sf)	Ponding Depth (in)	Planting Media Depth (in)	Stone Base Depth (in)	Storage Volume (ft^3)	Remaining Unstored Volume (ft^3)	Percent Volume Stored
Blue Roof	1,000	4	0	0	333	2,867	10.4%
Green Roof	500	4	6	0	217	2,650	6.8%
Blue Roof	0	0	0	0	0	2,650	0.0%

Total Runoff without GI:	3,200
Total Storage from GI:	550
Total Remaining Volume:	2,650

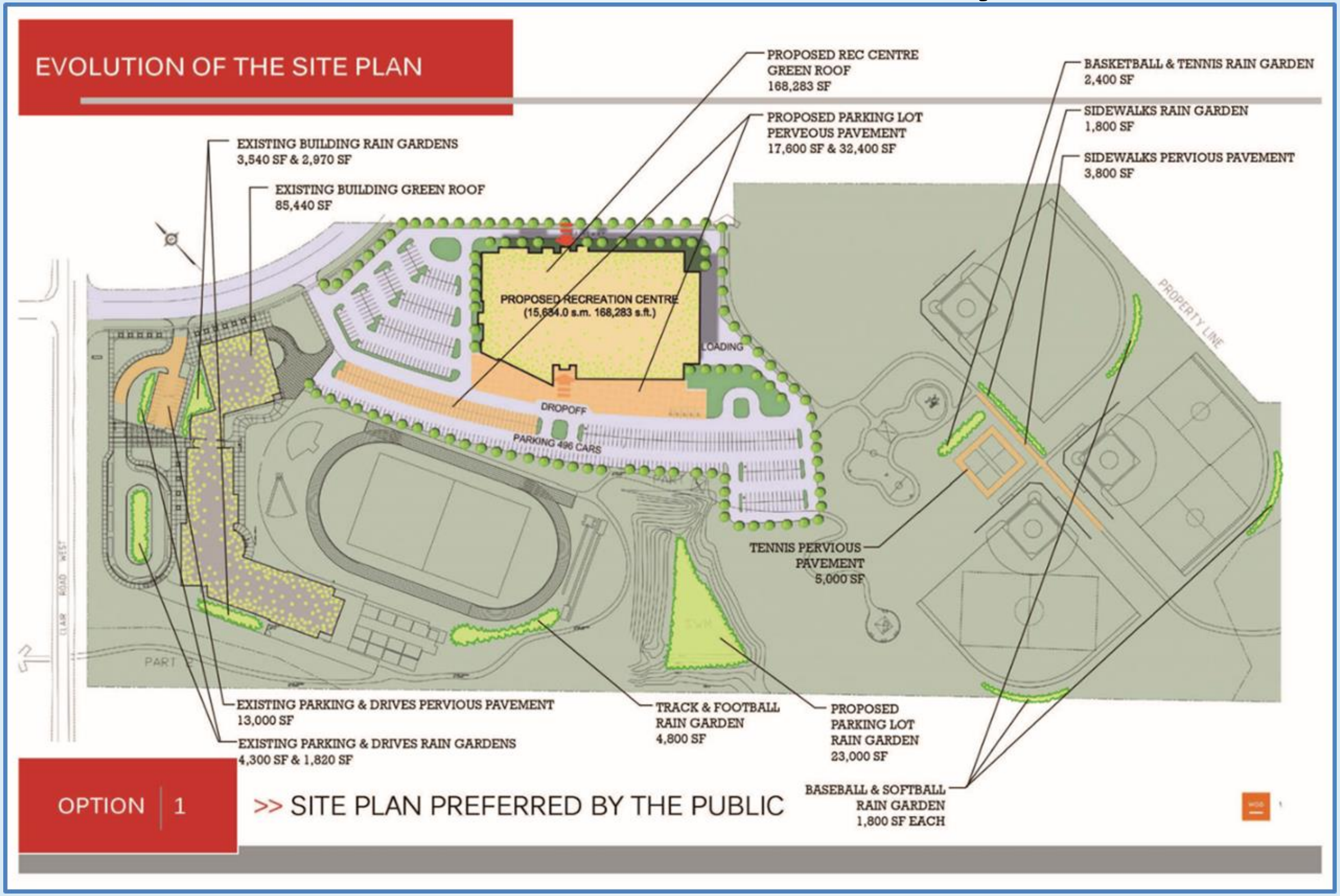
Scroll down for additional BMPs



GUELPH, ONTARIO
(AN EXAMPLE)


GREEN INFRASTRUCTURE CONCEPTUAL DESIGN
STEVENSON STREET CORRIDOR
SOUTH END COMMUNITY PARK
GUELPH, ONTARIO
CANADA
ECT Environmental Consulting & Technology, Inc.

South End Community Park



Comparing Volume Captured to Area Required

Volume (CF) Stored per 100 SF of BMP
88
33
30
7

BMP	Ponding Depth (inches)	Planting Material Depth (inches)	Stone Base Depth (inches)	Volume (CF) Stored per 100 SF of BMP
Rain Garden	6	12	6	**88**
Blue Roof	4	0	0	**33**
Intensive Green Roof	0	18	0	**30**
Extensive Green Roof	0	4	0	**7**

South End Community Park

Calculating Site-wide Runoff

Rainfall = 1 inch

Rainfall = 1 inches

	Cover Type	Soil Type	Area (sf)	Area (ac)	CN (TR-55)	S	Runoff, Q (in)	Runoff Volume, V (ft3)	Total Runoff Volume (ft3)
Ex. Building	Impervious	D	85,437	1.961	98	0.2	0.8	5,631.06	5,631.06
	Urban Compact	D	-	0.000	84	1.9	0.0	-	
Ex. Parking & Drives	Impervious	D	76,037	1.746	98	0.2	0.8	5,011.48	5,326.83
	Urban Compact	D	24,922	0.572	84	1.9	0.2	315.35	
Track & Football	Impervious	D	40,643	0.933	98	0.2	0.79	2,678.73	4,180.37
	Urban Compact	D	118,674	2.724	84	1.9	0.15	1,501.64	
Basketball, Tennis & Splash Pad	Impervious	D	31,041	0.713	98	0.2	0.79	2,045.88	2,045.88
	Urban Compact	D	-	0.000	84	1.9	0.00	-	
[illegible]	pervious	D	23,482	0.539	98	0.2	0.79	1,547.67	1,547.67
	ban Compact	D	-	0.000	84	1.9	0.00	-	
[illegible]	pervious	D	-	0.000	98	0.2	0.00	-	1,516.37
	ban Compact	D	119,838	2.751	84	1.9	0.15	1,516.37	
[illegible]	pervious	D	-	0.000	98	0.2	0.00	-	1,508.04
	rban Compact	D	119,180	2.736	84	1.9	0.15	1,508.04	
Softball #2	Impervious	D	-	0.000	98	0.2	0.00	-	1,506.70
	Urban Compact	D	119,074	2.734	84	1.9	0.15	1,506.70	
Proposed Rec Centre	Impervious	D	168,283	3.863	98	0.2	0.79	11,091.33	11,091.33
	Urban Compact	D	-	0.000	84	1.9	0.00	-	
Proposed Parking	Impervious	D	292,391	6.712	98	0.2	0.79	19,2[illegible]1.15	19,474.92
	Urban Compact	D	16,104	0.370	84	1.9	0.15	203.77	

Proposed Rec Centre	
	Impervious
	Urban Compact

11,091.33

South End Community Park

Identifying Least Cost BMPs

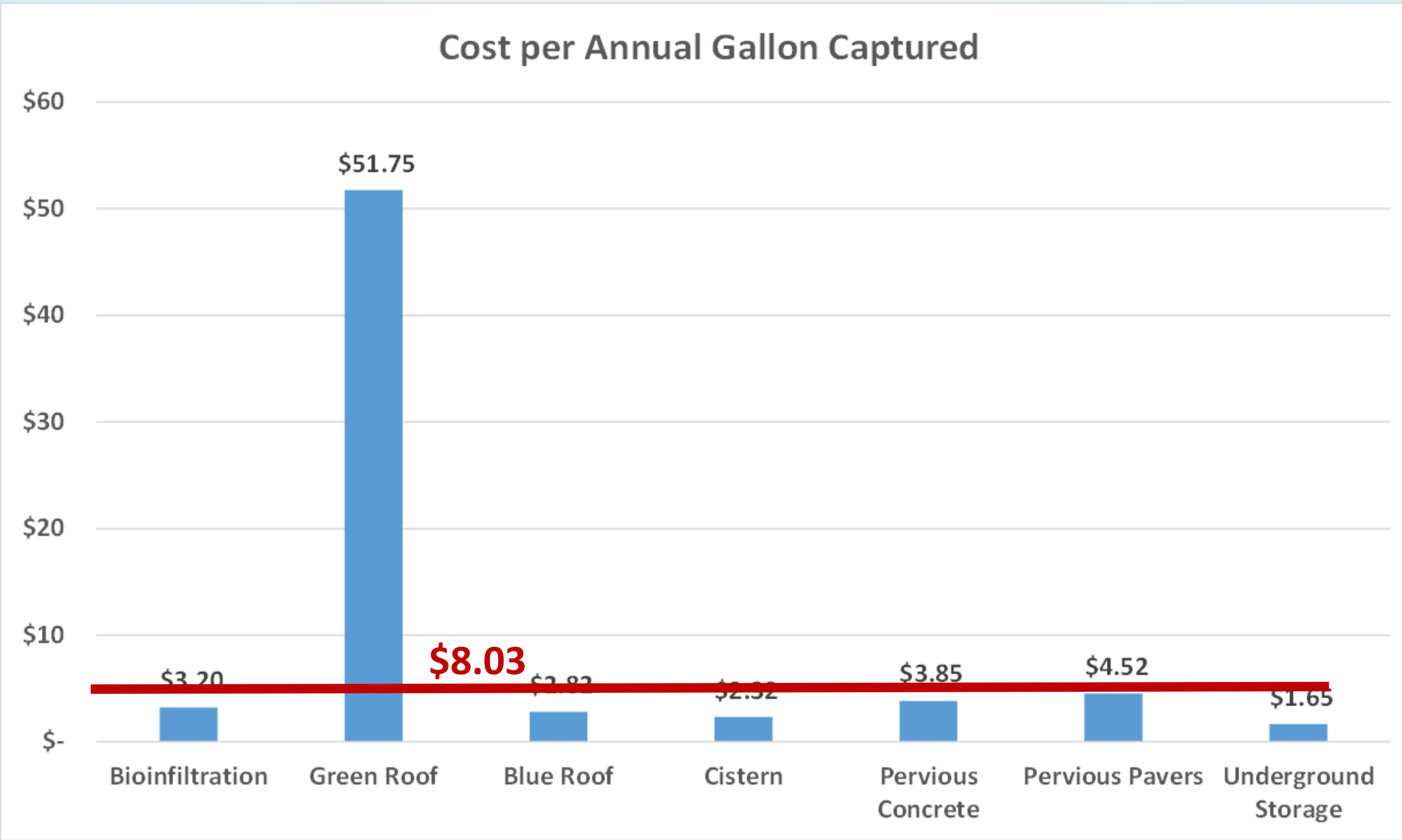
IMPLEMENTATION COSTS - South End Community Park

	Location	BMP	Size	Unit	Unit Price	Construction Cost	Annual Maintenance Cost	Lowest Year 1 Cost
1	Existing Building	Bioinfiltration	6,500	SF	$ 12.00	$ 78,000.00	$ 3,250.00	$ 58,416.75
		Green Roof	85,437	SF	$ 15.00	$ 1,281,556.50	$ 35,200.09	
		Blue Roof	85,437	SF	$ 4.00	$ 341,748.40	$ 17,087.42	
		Cistern	5631.0584	CF	$ 10.00	$ 56,310.58	$ 2,106.16	
2	Existing Drives & Parking	Bioinfiltration	6100	SF	$ 12.00	$ 73,200.00	$ 3,050.00	$ 39,280.16
		Pervious Concrete	13000	SF	$ 7.00	$ 91,000.00	$ 2,080.00	
		Pervious Pavers	13000	SF	$ 9.00	$ 117,000.00	$ 468.00	
		Underground Storage	5326.8262	CF	$ 7.00	$ 37,287.78	$ 1,992.37	
3	Track & Football	Bioinfiltration	4800	SF	$ 12.00	$ 57,600.00	$ 2,400.00	$ 60,000.00
4	Basketball, Splash Pad, Tennis	Bioinfiltration	[illegible]	[illegible]	[illegible]	$ 28,[illegible]	[illegible]	[illegible]
		Pervious Concrete	[illegible]	[illegible]	[illegible]	$ 35,[illegible]	[illegible]	
10	Rec Parking	Bioinfiltration	23000	SF	$ 12.00	$ 276,000.00	$ 11,500.00	$ 143,608.55
		Pervious Concrete	50000	SF	$ 7.00	$ 350,000.00	$ 8,000.00	
		Pervious Pavers	50000	SF	$ 9.00	$ 450,000.00	$ 1,800.00	
		Underground Storage	19474.917	CF	$ 7.00	$ 136,324.42	$ 7,284.13	

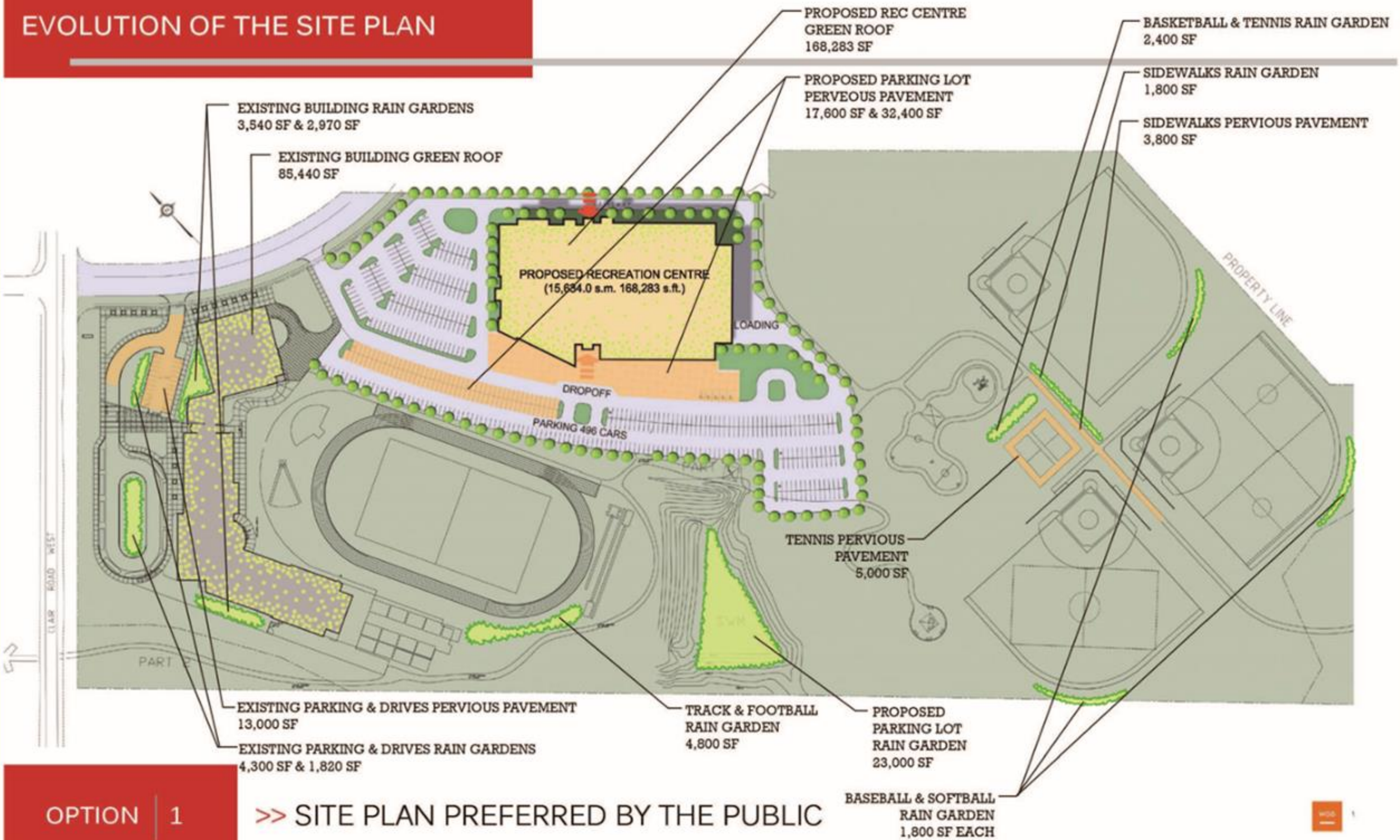
Lowest Cost Total **$ 536,367.23**

Existing Drives & Parking	Size	Construction Cost
Bioinfiltration	6,100	$73,200
Pervious Concrete	13,000	$91,000
Pervious Pavers	13,000	$117,000
Underground Storage	5,326	$37,287

South End Community Park



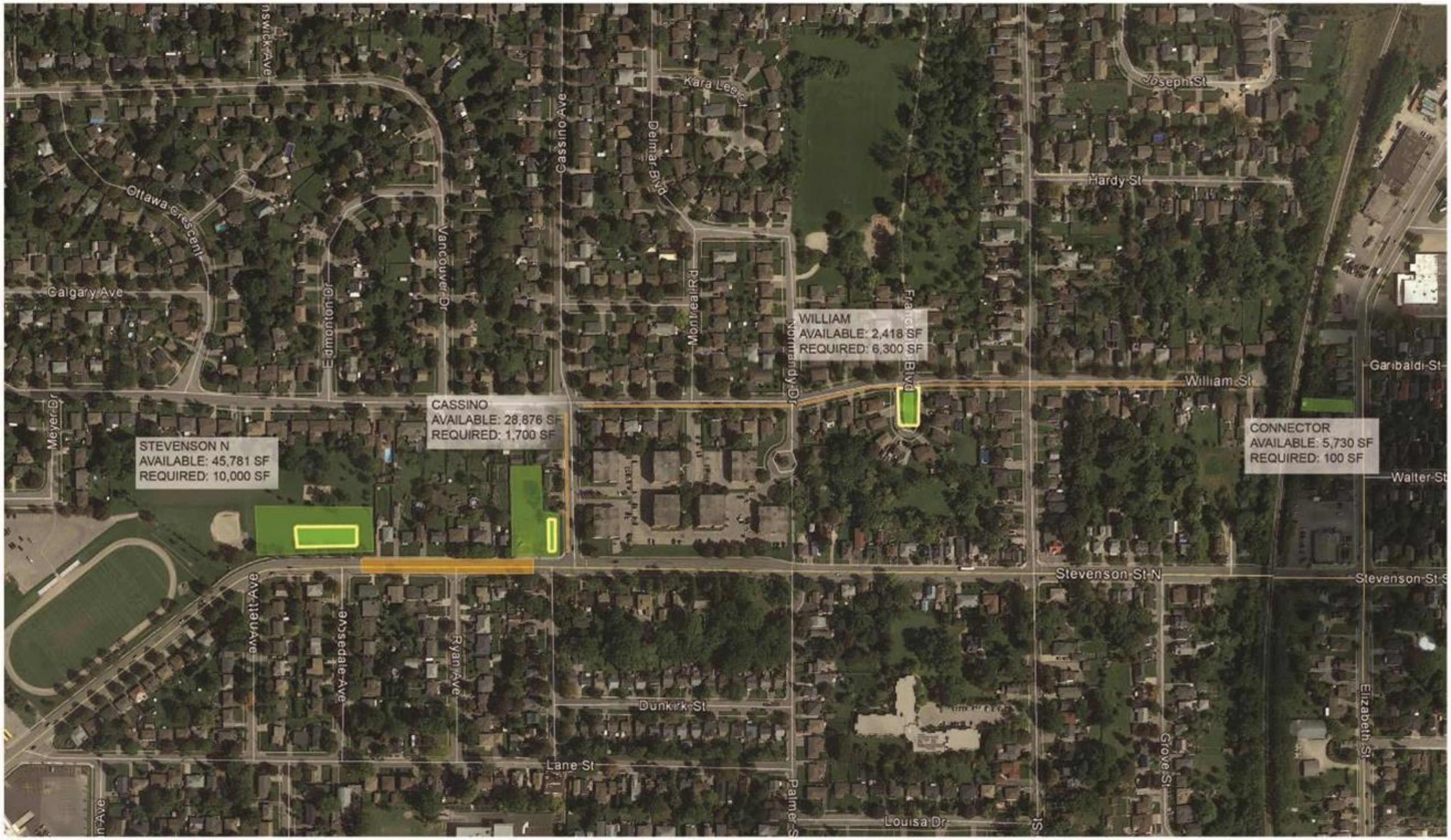
EVOLUTION OF THE SITE PLAN



OPTION | 1

>> SITE PLAN PREFERRED BY THE PUBLIC

Stevenson Street



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STEVENSON STREET GREEN INFRASTRUCTURE PLAN

Bioinfiltration Areas | **Pervious Pavement Areas**

June 4, 2015

Identifying Least Cost BMPs

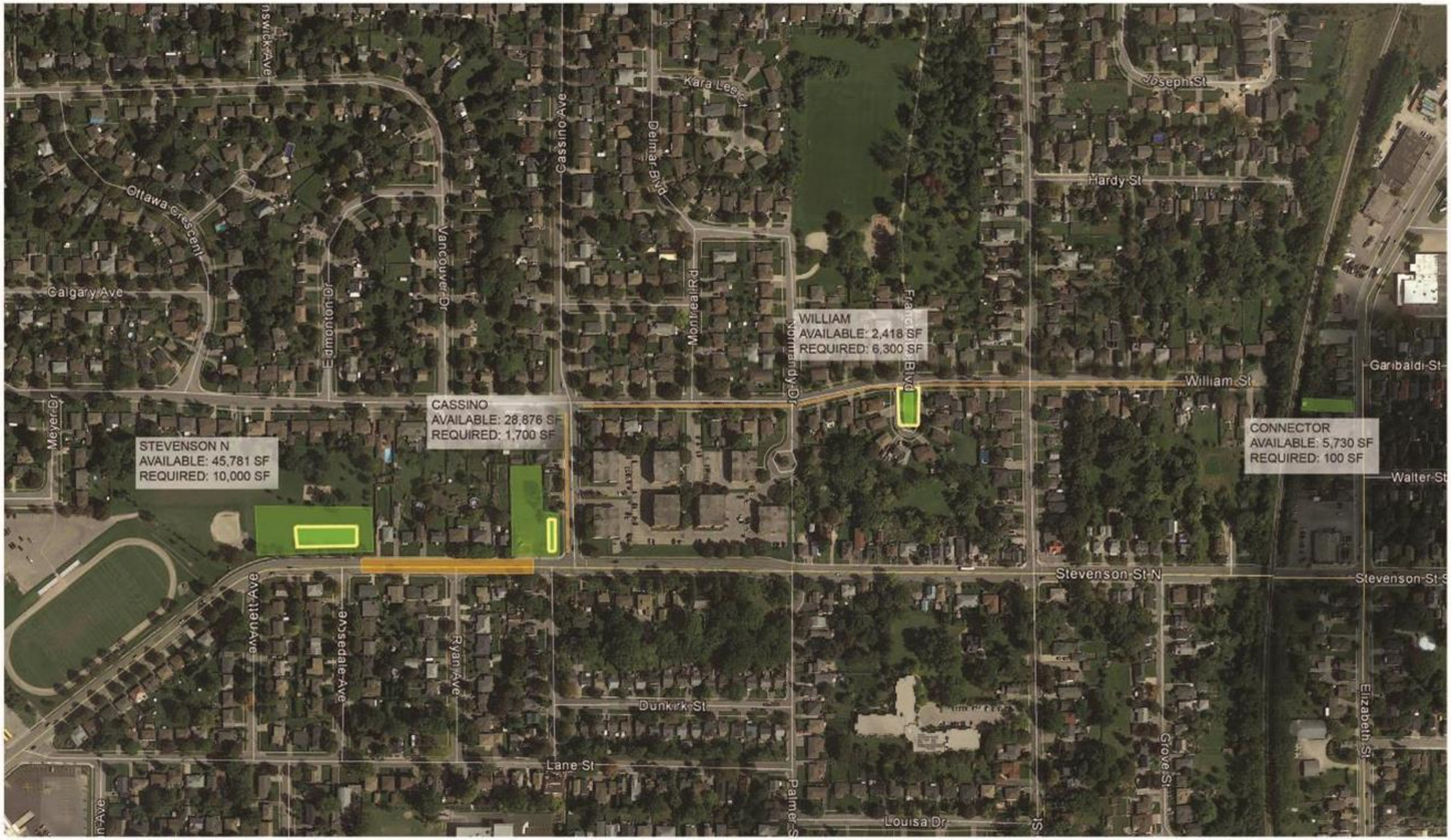
IMPLEMENTATION COSTS - Stevenson Street GI Plan

Location	BMP	Size	Unit	Feasibility	Unit Price	Construction Cost	Annual Maintenance Cost	Lowest Year 1 Cost
Stevenson N	Bioinfiltration	10,000	SF	1	$ 12.00	$ 120,000.00	$ 3,400.00	$ 89,915.08
	Pervious Concrete	21,000	SF	1	$ 7.00	$ 147,000.00	$ 3,360.00	
	Pervious Pavers	21,000	SF	1	$ 9.00	$ 189,000.00	$ 756.00	
	Underground Storage	8,667	CF	1	$ 10.00	$ 86,673.39	$ 3,241.68	
	Bioinfiltration	1,700	S		2.00			$ 10,410.49
	Pervious Concrete	3,400	S		7.00			
		00	S		9.00			
		12	C		7.00			
		00	S		2.00			$ 40,351.23
		00	S		7.00			
		00	S		9.00			
		72	C		7.00			
		00	S		2.00			$ 593.26
		80	S		7.00			

Lowest Cost Total	$ 141,270.05

Stevenson N		Size	Construction Cost
	Bioinfiltration	10,000	$120,000
	Pervious Concrete	21,000	$147,000
	Pervious Pavers	21,000	$189,000
	Underground Storage	8,667	$86,673

Sized to Capture 1" of Rain



ECT Environmental Consulting & Technology, Inc.

STEVENSON STREET GREEN INFRASTRUCTURE PLAN

Bioinfiltration Areas **Pervious Pavement Areas**

June 4, 2015

9Ways planners are making green infrastructure work in their communities.

1
Code it
Incorporating green infrastructure into codes & practices

Ventura County, CA
& New York, NY

2
Retrofit it
Providing incentives for owners to retrofit existing buildings

Chicago, IL
& Cincinnati, OH

3
Scale it
Bringing green infrastructure to scale

Los Angeles, CA

4
Incentivize it
Implementing stormwater fees and incentives

Minneapolis, MN
& Cleveland, OH

5
Market it
Establishing mitigation bank & ecosystem services markets

Charlotte, NC

6
Flip it
Avoiding costs by substituting green infrastructure for gray

Portland, OR
& Los Angeles, CA

7
Coordinate it
Coordinating powers and responsibilities

Milwaukee, WI
& Richmond, VA

8
Expand it
Expanding the territory

Albany, NY

9
Teach it
Encouraging innovation

Chicago, IL
& Syracuse, NY

http://www.rpa.org/article/9-ways-to-make-green-infrastructure-work-in-cities-towns

QUESTIONS?