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MEMORANDUM

To:	Mike Lunn, Carrie Rivette
Cc:	Pete Daukss
From:	Dan Christian, Valerie Novaes, Anne Thomas (Tetra Tech)
Date:	September 3, 2015
Subject:	Large Scale Public Green Infrastructure Opportunities

The City of Grand Rapids is evaluating opportunities throughout the city to cost-effectively incorporate green infrastructure on publicly-owned property to help manage stormwater. Two main publicly-owned property types being evaluated are road right-of-way and parks. This memorandum focuses on green infrastructure opportunities within parks. In support of this endeavor, city parks were prioritized by city staff for incorporation of green infrastructure. The primary considerations for prioritization were potential drainage area to a green infrastructure practice, soil type, and available open space within the park. Green infrastructure concepts were then evaluated for the top ten priority parks.

For each of the ten parks, green infrastructure practices were sized and sited to capture and detain runoff from the 2-year 24-hour channel protection storm event (2.56 inches per NOAA Atlas 14). The green infrastructure evaluation considered two drainage area scenarios. The first scenario included delineating a drainage area that can discharge to surface green infrastructure practices (i.e. bioretention) via overland flow. The second scenario included delineating a drainage area that can be piped to a subsurface practice (i.e. subsurface arch storage). The pipe could be proposed pipe or interception of existing pipe. Not every park was conducive to both scenarios.

At this conceptual level, a typical cross-section was assumed for the surface and subsurface practices to develop conceptual costs and stormwater storage capacity per square foot of practice area. Maintenance and rehabilitation costs were also assumed over a 50-year life cycle to calculate a net present value over 50 years. Additional stormwater management infrastructure required to manage large storm events (i.e. 10-year, 25-year, and 100-year recurrence intervals) were not considered in this analysis.

The runoff curve number approach was used to generate runoff over the drainage area for the 2-year 24-hour storm event. The hydrologic soil group representative of each park was used to calculate runoff and volume retention within the green infrastructure practice. Over 50 years of daily rainfall totals in Grand Rapids were used to estimate the average annual volume of runoff retained on each site using the proposed green infrastructure.

A summary of the runoff, green infrastructure practices, cost, and benefit information is provided for each site in **Attachment 1** along with a concept map for the surface practice scenario and the subsurface practice scenario, as applicable.

The following provides a brief review of the assumptions and results for each of the prioritized parks.

1. LINCOLN PARK (1120 BRIDGE STREET NW, GRAND RAPIDS, MI)

i. Subsurface Feature

Lincoln Park is a recreational space adjacent to Bridge Avenue between Marion Street and Garfield Street. Because it is located downstream from a large catchment area, it is possible to redirect fairly shallow storm pipe (Approx. 7 feet deep) that runs diagonally through the park to a subsurface storage practice beneath its southwestern side. The storage practice could feasibly retain close to the 1-year 24-hour storm event from the 212-acre drainage area.

Table 1 Lincoln Park Green Infrastructure Results (Subsurface)

Green Infrastructure Practice	63,500 sf of Underground Arch Storage
Green Infrastructure Capital Cost	$3,974,000
50-Year Net Present Value	$4,686,000
Performance (capital costs/storage volume)	$3/gallon
Avg. Annual Runoff Volume Retained On-Site	14.40 Mgal (75% of total runoff retained)

ii. Surface Feature

Linear Bioretention could be incorporated on the West, South and East ends of the park to capture and retain surface flow from adjacent drainage areas. There is enough open space to retain runoff for the 2-year 24-hour storm event from the nearly 2-acre drainage area.

Table 2 Lincoln Park Green Infrastructure Results (Surface)

Green Infrastructure Practice	6,000 sf of Linear Bioretention
Green Infrastructure Capital Cost	$931,000
50-Year Net Present Value	$815,000
Performance (capital costs/storage volume)	$17/gallon
Avg. Annual Runoff Volume Retained On-Site	0.26 Mgal (95% of total runoff retained)

2. NORTH PARK (337 CHENEY AVE NE, GRAND RAPIDS, MI)

i. Subsurface Feature

North Park is a recreational space on the west side of the North Park Montessori Academy. It is located between Cheney and Eastern and Elmdale and North Park streets. Wells Drain runs just west of North Park along Eastern. The 15-inch gravity can be intercepted just south of Hubbard and directed into subsurface storage within North Park. The locations of the collector pipes make it possible to capture and retain nearly 80 percent of the surface runoff from the drainage area by redirecting the flow through shallow storm pipe (Approx. 7 feet deep) to an underground storage tank on the park's southwest side. This practice would be able to retain the 2-year 24-hour storm event from a 3- acre drainage area.

Table 3 North Park Green Infrastructure Results (Subsurface)

Green Infrastructure Practice	6,900 sf of Underground Arch Storage
Green Infrastructure Capital Cost	$720,000
50-Year Net Present Value	$510,000
Performance (capital costs/storage volume)	$4/gallon
Avg. Annual Runoff Volume Retained On-Site	0.47 Mgal (80% of total runoff retained)

ii. Surface Feature

Linear Bioretention could be installed along the park's west edge, with smaller sections installed on the southwestern and northwestern edges. These installations could retain the 2-year 24-hour storm event from the adjacent 1-acre drainage area.

Table 4 North Park Green Infrastructure Results (Surface)

Green Infrastructure Practice	3,200 sf of Linear Bioretention
Green Infrastructure Capital Cost	$497,000
50-Year Net Present Value	$435,000
Performance (capital costs/storage volume)	$17/gallon
Avg. Annual Runoff Volume Retained On-Site	0.14 Mgal (95% of total runoff retained)

3. SOUTHERN LITTLE LEAGUE PARK (2531 KALAMAZOO AVE. SE, GRAND RAPIDS, MI) [MACKAY-JAYCEE PARK]

i. Subsurface Feature

Southern Little League Park or MacKay-Jaycee Park is a large recreational space with multiple baseball/softball fields and additional field space adjacent to 28th Street. By redirecting stormwater flow with a shallow storm pipe (Approx. 7 feet deep), runoff from the 2-year 24-hour storm event can be captured and retained in an underground storage tank in the southwestern quadrant of the park. It would collect runoff from a 4.5-acre drainage area that includes a portion of 28th Street adjacent to the park.

Table 5 Southern Little League Park Green Infrastructure Results (Subsurface)

Green Infrastructure Practice	5,100 sf of Underground Arch Storage
Green Infrastructure Capital Cost	$525,000
50-Year Net Present Value	$377,000
Performance (capital costs/storage volume)	$4/gallon
Avg. Annual Runoff Volume Retained On-Site	1.07 Mgal (94% of total runoff retained)

ii. Surface Feature

Linear Bioretention could be installed along the southern edge of the park adjacent to 28th Street to capture and retain the 2-year 24-hour storm event from the 9-acre drainage area consisting of overland flow from the park as well as road runoff from 28th Street.

Table 6 Southern Little League Park Green Infrastructure Results (Surface)

Green Infrastructure Practice	5,500 sf of Linear Bioretention
Green Infrastructure Capital Cost	$854,000
50-Year Net Present Value	$747,000
Performance (capital costs/storage volume)	$17/gallon
Avg. Annual Runoff Volume Retained On-Site	0.14 Mgal (64% of total runoff retained)

4. HUFF PARK (2286 BALL AVENUE NE, GRAND RAPIDS, MI)

i. Subsurface Feature

Huff Park is a recreational and natural reserve area with multiple baseball diamonds and approximately 67 acres of natural cover. Richard Fairplains Drain crosses the park and traverses single-family residential neighborhoods. Separated storm sewers discharge to the drain in this area. There is an opportunity to improve water quality and provide quantity control of runoff using green infrastructure by intercepting the collector pipes near the storm sewer outfalls. Underground storage would allow detention of the 2-year 24-hour storm event, both enhancing water quality through pre-treatment devices and alleviating the erosion potential of the drain.

Table 7 Huff Park Green Infrastructure Results (Subsurface)

Green Infrastructure Practice	26,000 sf of Underground Storage
Green Infrastructure Capital Cost	$2,686,000
50-Year Net Present Value	$1,920,000
Performance (capital costs/storage volume)	$4/gallon
Avg. Annual Runoff Volume Retained On-Site	1.54 Mgal (77% of total runoff retained)

ii. Surface Feature

There is an opportunity for Linear Bioretention along the northern and eastern sides of Huff Park. As a water quality control, this practice can be constructed along the roadsides to accommodate storm runoff for the 2-year 24-hour storm event. Steep grades prevent other locations from serving as effective areas for green infrastructure practices.

Table 8 Huff Park Green Infrastructure Results (Surface)

Green Infrastructure Practice	9,100 sf of Linear Bioretention
Green Infrastructure Capital Cost	$1,412,000
50-Year Net Present Value	$1,236,000
Performance (capital costs/storage volume)	$17/gallon
Avg. Annual Runoff Volume Retained On-Site	0.91 Mgal (99% of total runoff retained)

5. RICHMOND PARK (1101 RICHMOND AVENUE NW, GRAND RAPIDS, MI)

i. Surface Feature

Richmond Park has opportunities along Tamarack Street to incorporate Bioretention to capture and treat 1.5 acres of road runoff from the 2-year 24-hour storm event. An existing pond lies in the southern end of the park to detain stormwater; therefore, subsurface storage was not included in the analysis.

Table 9 Richmond Park Green Infrastructure Results (Surface)

Green Infrastructure Practice	3,900 sf of Bioretention
Green Infrastructure Capital Cost	$248,000
50-Year Net Present Value	$264,000
Performance (capital costs/storage volume)	$6/gallon
Avg. Annual Runoff Volume Retained On-Site	0.34 Mgal (90% of total runoff retained)

6. SHAWMUT HILLS PARK (2550 BURRITT ST NW, GRAND RAPIDS, MI)

i. Subsurface Feature

Shawmut Hills Park includes a baseball field and is adjacent to Shawmut Hills School which lies to the north. An open area extends from the school north to 7th Street NW. The area is adjacent to Burritt Avenue between Fairfield Avenue NW and Oakleigh Avenue NW. The drainage area north of 7th Street NW provides an opportunity to intercept a storm sewer and direct it to subsurface storage within the north side of the open space. This would allow for the capture of runoff from a 20-acre drainage area for the 2–year 24-hour storm event. The park is elevated above Lake Michigan Drive NW on the south making capture of runoff from the road infeasible.

Table 10 Shawmut Hills Park Green Infrastructure Results (Subsurface)

Green Infrastructure Practice	12,100 sf of Underground Arch Storage
Green Infrastructure Capital Cost	$1,218,000
50-Year Net Present Value	$894,000
Performance (capital costs/storage volume)	$3/gallon
Avg. Annual Runoff Volume Retained On-Site	1.22 Mgal (89% of total runoff retained)

ii. Surface Feature

The parking lot at Shawmut Hills School could be retrofit with Permeable Pavement. There is no nearby storm sewer to connect an underdrain to, but HSG B soil will likely drain well enough. There is also an opportunity on the north side to direct road runoff to Linear Bioretention behind the curb. These installations would allow the capture and retention of runoff from 1.5 acres for the 2-year 24-hour storm event.

Table 11 Shawmut Hills Park Green Infrastructure Results (Surface)

Green Infrastructure Practice	11,100 sf of Permeable Parking 900 sf of Linear Bioretention
Green Infrastructure Capital Cost	$589,000
50-Year Net Present Value	$482,000
Performance (capital costs/storage volume)	$7/gallon
Avg. Annual Runoff Volume Retained On-Site	0.88 Mgal (98% of total runoff retained)

7. 6TH STREET BRIDGE PARK (647 MONROE AVE NW, GRAND RAPIDS, MI)

i. Subsurface Feature

Sixth Street Bridge Park runs adjacent to the Grand River on its east side. There is an opportunity within the park to divert flow from two adjacent storm sewers to a subsurface storage practice within the park. This would allow for the capture of runoff from 37 acres for the 2-year 24-hour storm event.

Table 12 Sixth Street Bridge Park Green Infrastructure Results (Subsurface)

Green Infrastructure Practice	35,562
Green Infrastructure Capital Cost	$3,590,000
50-Year Net Present Value	$2,626,000
Performance (capital costs/storage volume)	$3/gallon
Avg. Annual Runoff Volume Retained On-Site	8.53 Mgal (85% of total runoff retained)

ii. Surface Feature

There is an opportunity within the park to capture road and parking lot runoff into both Linear (central) and Pocket (west edge) Bioretention areas. The inlets to the proposed Linear Bioretention along Monroe Avenue NW would need to pass beneath the sidewalk. These practices would allow for the capture and retention of runoff from 1.5 acres for the 2-year 24-hour storm event.

Table 13 Sixth Street Bridge Park Green Infrastructure Results (Surface)

Green Infrastructure Practice	4,317 sf of Linear Bioretention 3,500 sf of Pocket Bioretention
Green Infrastructure Capital Cost	$892,000
50-Year Net Present Value	$823,000
Performance (capital costs/storage volume)	$12/gallon
Avg. Annual Runoff Volume Retained On-Site	0.63 Mgal (98% of total runoff retained)

8. GRAHAM HORTICULTURE STATION (3121 LAKE MICHIGAN DRIVE NW, GRAND RAPIDS, MI)

i. Surface Feature

Graham Horticultural Station is located northeast of the intersection of Maynard Avenue NW and Lake Michigan Drive NW. Lincoln Square retirement community is located within the designated horticulture land. There is an opportunity to capture and treat runoff for a 2-year 24-hour storm event with Linear Bioretention from Lake Michigan Drive NW and the circular drive accessing the retirement community.

Table 14 Graham Horticulture Station Green Infrastructure Results (Surface)

Green Infrastructure Practice	5,300 sf of Linear Bioretention
Green Infrastructure Capital Cost	$823,000
50-Year Net Present Value	$720,000
Performance (capital costs/storage volume)	$17/gallon
Avg. Annual Runoff Volume Retained On-Site	0.53 Mgal (97% of total runoff retained)

9. OXFORD PLACE (EAST CASTLE DR SE (44TH & BRETON), GRAND RAPIDS, MI)

i. Surface Feature

Oxford Place is a natural city park near a single-family and multi-family residential neighborhood. The park slopes toward East Castle Street making storage within the park infeasible. There is however space available within the right-of-way along East Castle to capture road runoff. Linear Bioretention installed along East Castle could capture runoff from 7 acres for just under the 2-year 24-hour storm event.

Table 15 Oxford Place Green Infrastructure Results (Surface)

Green Infrastructure Practice	10,581 sf of Linear Bioretention
Green Infrastructure Capital Cost	$1,642,000
50-Year Net Present Value	$1,437,000
Performance (capital costs/storage volume)	$17/gallon
Avg. Annual Runoff Volume Retained On-Site	0.51 Mgal (79% of total runoff retained)

PROJECT SUMMARY

This summarizes conceptual green infrastructure projects within City of Grand Rapids parks having predominately HSG A soils.

Design Standard or Objective

Description	ENR Cost Index	ENR Geographic Index
Enter a description of how the sites were assessed, i.e. Sites designed to retain the 2-year storm event	9972	0.92

Climatology Data

	Water Quality Treatment Volume	Channel Protection	Collection (Pipe) System	Site and Roadway Flooding
Recurrence Interval	90%	2-year	10-year	100-year
Duration (hr)	24-hr	24-hr	24-hr	24-hr
Precipitation (in)	0.99	2.56	3.77	6.27

Soil Infiltration

Texture Class	Min Infil Rate (in/hr)	Hydrologic Soil Group	Allowable Duration for Infiltration (days)
Loamy sand	2.41	A	3

SITE SUMMARY

No.	Location	Green Infrastructure Area (sf)	GI Capital Cost	50-year NPV	Performance (cost per gallon)	Annual Retention (Mgal and percent of annual runoff)
1	Lincoln Park - Subsurface (112	63,456	$6,359,000	$4,686,000	$3 per gallon	14.40 Mgal (75%)
2	Lincoln Park - Surface (1120 Br	6,000	$931,000	$815,000	$17 per gallon	0.26 Mgal (95%)
3	North Park - Subsurface	6,900	$720,000	$510,000	$4 per gallon	0.47 Mgal (80%)
4	North Park - Surface	3,200	$497,000	$435,000	$17 per gallon	0.14 Mgal (95%)
5	Southern Little League Park - S	5,100	$525,000	$377,000	$4 per gallon	1.07 Mgal (94%)
6	Southern Little League Park - S	5,500	$854,000	$747,000	$17 per gallon	0.14 Mgal (64%)
7						
8						
9						
10						

NOTES

Cost information represents Engineers Opinion of Probable Cost based on Conceptual Level Design
Retained refers to water that is infiltrated onsite within 72 hours; Detained refers to water that is slowed down and released.

Lincoln Park - Subsurface (1120 Bridge St NW, Grand Rapids, MI)

Lincoln Park is located downstream of a large catchment area (~200 acres). A 102-inch storm pipe crosses the park providing an opportunity to intercept that flow in an off-line subsurface storage configuration.

LAND COVER

RUNOFF (thousand gallons)

Description	Area (sf)	90%	2-yr	10-yr	100-yr	Avg Annual
Urban | Commercial and Business (est. 85% imperv.)	1,008,290	197.9	922.9	1,585.9	3,050.6	5,530.9
Streets & Roads | Paved; open ditches (incl. ROW)	113,154	12.8	75.2	138.8	288.5	363.8
Streets & Roads | Paved; curbs and storm sewers (incl. ROW)	403,752	45.7	268.2	495.3	1,029.4	1,298.2
Urban | Residential | 1/8 acre lot (town houses) (est. 65% imperv.)	6,131,216	401.6	2,950.4	5,814.7	12,991.6	11,980.8
Urban | Open Space (lawns, parks, golf, cemeteries) | Good (grass cover >75%	1,461,220	10.0	27.5	130.9	556.6	51.4
Natural | Woods | Good | Protected from Grazing, litter/brush cover soi	139,683	4.1	0.0	2.8	23.2	0.6
Total	9,257,315	672	4,244	8,168	17,940	19,226
	Runoff (in) ->	*0.12*	*0.74*	*1.42*	*3.11*	*3.33*

PROPOSED IMPROVEMENTS

Green Infrastructure

SCM Practice Selection	Surface Area (sf)	Volume Retain (Tgal)	Volume Detain (Tgal)	Volume Total (Tgal)	Unit Cost ($/sf)	Capital Cost
Underground Arch Storage	63,456	1,893.2	0.0	1,893.2	$63	$3,973,884
Subtotal	63,456	1,893	0	1,893		$3,973,884
	Runoff (in) ->	*0.33*	*0.00*	*0.33*		

Linear Conveyance

Conveyance Practice Selection	Length (ft)	Unit Cost	Capital Cost
Subtotal			$0

OPINION OF PROBABLE COST

Capital Cost		$3,973,884	Average Annual NPV O&M	$300
Contingencies (as a percentage of construction cost)	30%	$1,192,165		
Engineering, Inspection, Testing, Legal, Administration, and Financing	30%	$1,192,165	50-yr Net Present Value	$4,686,000
TOTAL Capital		$6,359,000		
Unitized Capital Cost	$30,000 per acre		$3 per gallon	

BENEFITS

Targeted Practices and Locations

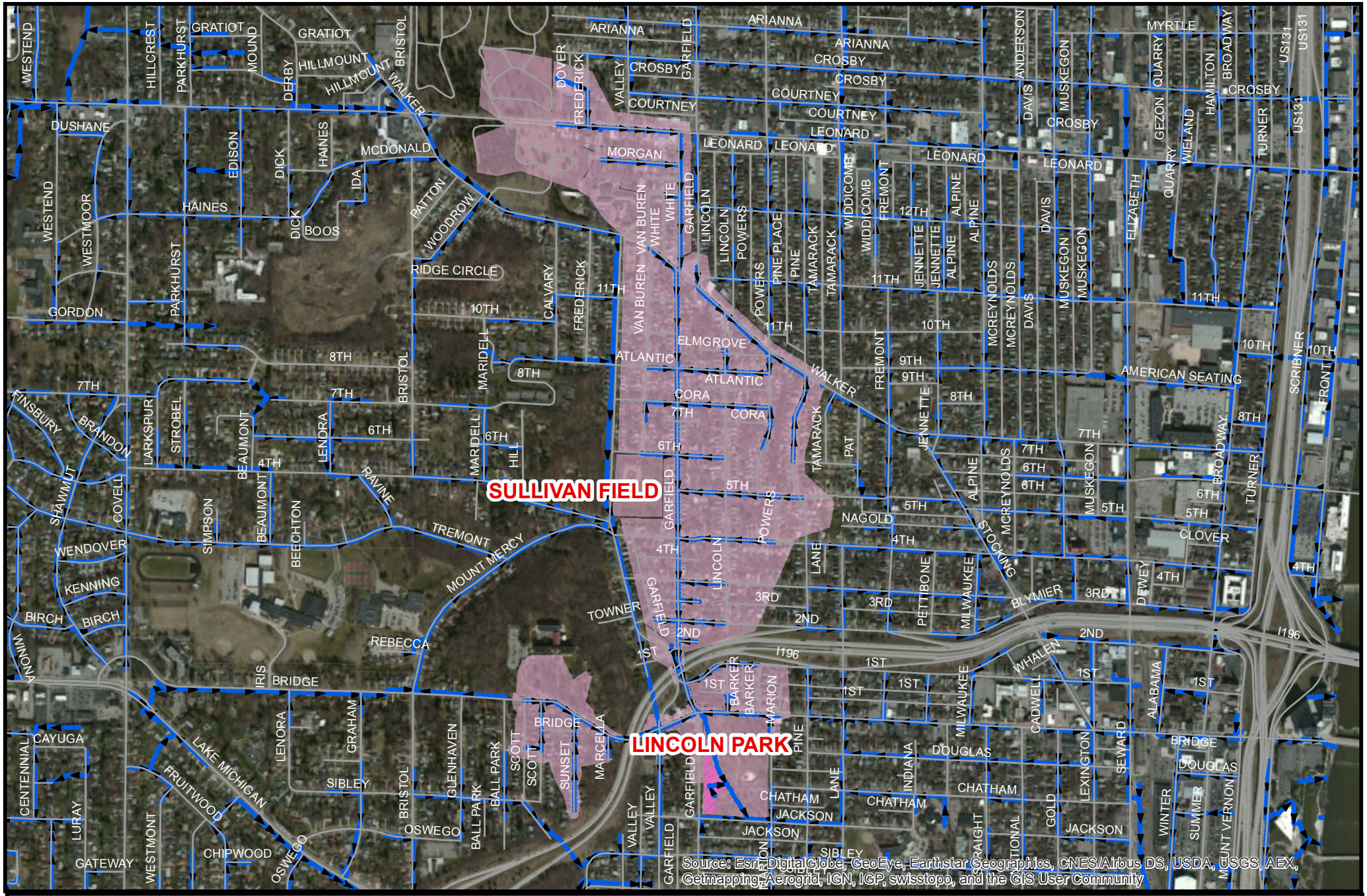
Drainage area (DA) | Area green infrastructure (GI) | Ratio DA:GI | Ratio Imp:G	212.52 acres	1.46 acres	145.9:1	82.4:1

Environmental Benefits

Water quality treatment volume (90%) managed and retained	Volume Managed: Yes	Volume Retained: Yes
Average annual runoff volume retained on-site	14.40 Mgal	75% percent of total runoff retained

NOTES

Cost information represents Engineers Opinion of Probable Cost based on Conceptual Level Design
Retained refers to water that is infiltrated onsite within 72 hours; Detained refers to water that is slowed down and released
Tgal are units of thousands of gallons



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Underground Storage

DCollector

Drainage Area

City Parks
Green Infrastructure
Lincoln Park Opportunity Map
Suburface Storage Alternative

Lincoln Park - Surface (1120 Bridge St NW, Grand Rapids, MI)

Road runoff from the perimeter of Lincoln Park can be directed through curb cuts to a bioswale practice within the area between the curb and sidewalk. Areas around trees could be gently graded to accept stormwater flow without harming the tree.

LAND COVER

Description	Area (sf)	90%	2-yr	10-yr	100-yr	Avg Annual
			RUNOFF (thousand gallons)			
Streets & Roads | Paved; curbs and storm sewers (incl. ROW)	83,951	9.5	55.8	103.0	214.0	269.9
Total	83,951	9	56	103	214	270
	Runoff (in) ->	*0.18*	*1.07*	*1.97*	*4.09*	*5.16*

PROPOSED IMPROVEMENTS

Green Infrastructure

SCM Practice Selection	Surface Area (sf)	Volume Retain (Tgal)	Volume Detain (Tgal)	Volume Total (Tgal)	Unit Cost ($/sf)	Capital Cost
Bioswale	6,000	56.1	0.0	56.1	$97	$581,820
Subtotal	6,000	56	0	56		$581,820
	Runoff (in) ->	*1.07*	*0.00*	*1.07*		

Linear Conveyance

Conveyance Practice Selection	Length (ft)	Unit Cost	Capital Cost
Subtotal			$0

OPINION OF PROBABLE COST

Capital Cost		$581,820	Average Annual NPV O&M	$3,300
Contingencies (as a percentage of construction cost)	30%	$174,546		
Engineering, Inspection, Testing, Legal, Administration, and Financing	30%	$174,546	50-yr Net Present Value	$815,000
TOTAL Capital		$931,000		
Unitized Capital Cost	$483,000 per acre		$17 per gallon	

BENEFITS

Targeted Practices and Locations

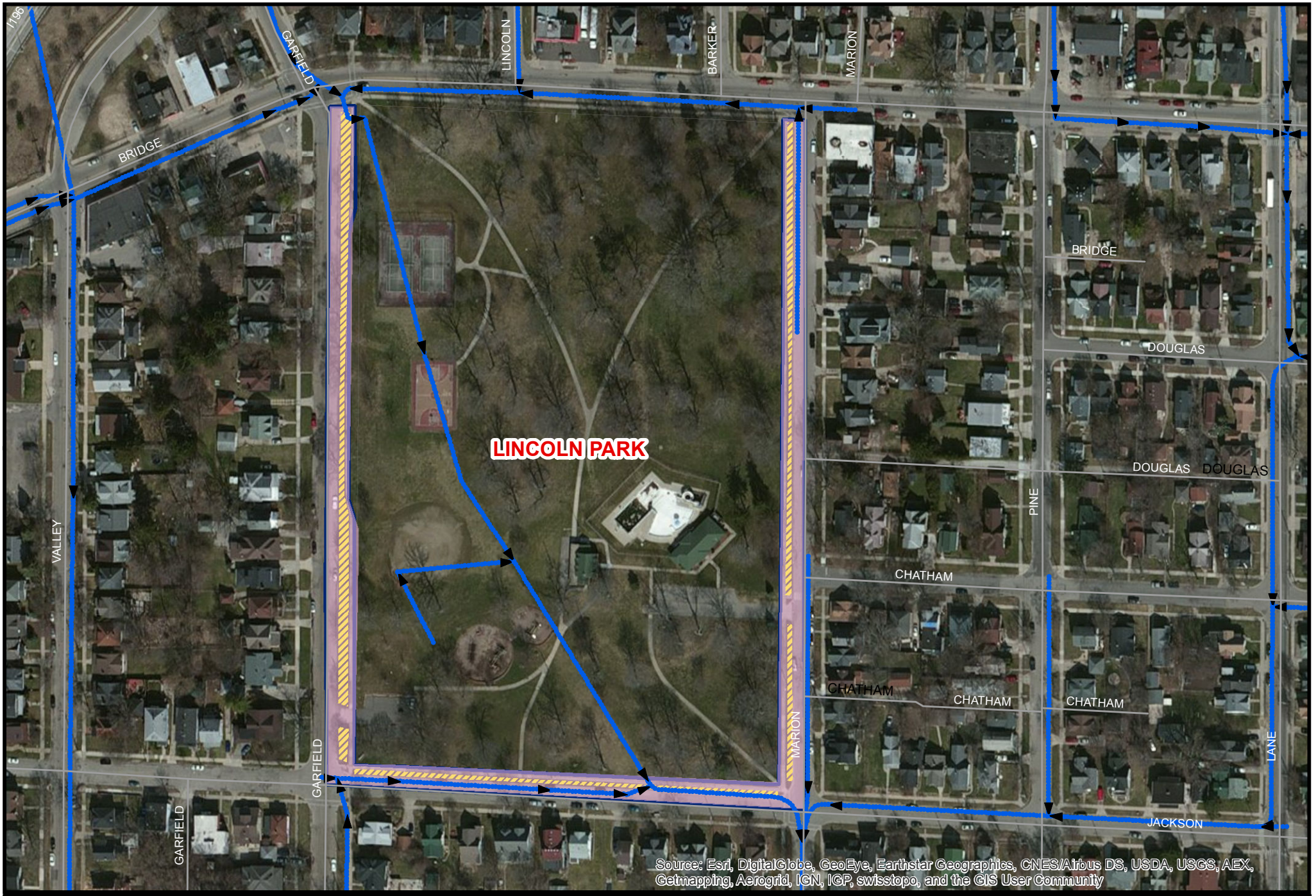
Drainage area (DA) | Area green infrastructure (GI) | Ratio DA:GI | Ratio Imp:G	1.93 acres	0.14 acres	14:1	10.5:1

Environmental Benefits

Water quality treatment volume (90%) managed and retained	Volume Managed: Yes	Volume Retained: Yes
Average annual runoff volume retained on-site	0.26 Mgal	95% percent of total runoff retained

NOTES

Cost information represents Engineers Opinion of Probable Cost based on Conceptual Level Design
Retained refers to water that is infiltrated onsite within 72 hours; Detained refers to water that is slowed down and released
Tgal are units of thousands of gallons



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Linear Bioretention

Drainage Area

City Parks
Green Infrastructure
Lincoln Park Opportunity Map
Surface Storage Alternative

North Park - Subsurface

Wells Drain runs just west of North Park along Eastern. The 15-inch gravity can be intercepted just south of Hubbard and directed into subsurface storage within Nort h Park.

LAND COVER

RUNOFF (thousand gallons)

Description	Area (sf)	90%	2-yr	10-yr	100-yr	Avg Annual
Urban | Residential | 1/4 acre lot (est. 38% imperv.)	772,444	7.6	145.3	343.2	926.1	385.7
Natural | Woods | Fair | Grazed but not Burned, some forest liter	127,049	1.5	1.2	7.8	38.4	2.6
Urban | Residential | 1/3acre lot (est. 30% imperv.)	37,910	0.2	5.4	13.5	38.5	12.9
Urban | Open Space (lawns, parks, golf, cemeteries) | Fair (grass cover 50% to	330,303	0.0	24.1	71.2	230.5	47.5
Streets & Roads | Paved; curbs and storm sewers (incl. ROW)	44,367	5.0	29.5	54.4	113.1	142.7
Total	1,312,073	14	205	490	1,347	591
Runoff (in) ->		*0.02*	*0.25*	*0.60*	*1.65*	*0.72*

PROPOSED IMPROVEMENTS

Green Infrastructure

SCM Practice Selection	Surface Area (sf)	Volume Retain (Tgal)	Volume Detain (Tgal)	Volume Total (Tgal)	Unit Cost ($/sf)	Capital Cost
Underground Arch Storage	6,900	205.9	0.0	205.9	$63	$432,107
Subtotal	6,900	206	0	206		$432,107
Runoff (in) ->		*0.25*	*0.00*	*0.25*		

Linear Conveyance

Conveyance Practice Selection	Length (ft)	Unit Cost	Capital Cost
15" RCP, Medium, Under Pavement	179	$97	$17,408
Subtotal			$17,408

OPINION OF PROBABLE COST

Capital Cost		$449,515	Average Annual NPV	$100
Contingencies (as a percentage of construction cost)	30%	$134,855		
Engineering, Inspection, Testing, Legal, Administration, and Financing	30%	$134,855	50-yr Net Present Value	$510,000
TOTAL Capital		$720,000		
Unitized Capital Cost	$24,000 per acre		$4 per gallon	

BENEFITS

Targeted Practices and Locations

Drainage area (DA) | Area green infrastructure (GI) | Ratio DA:GI | Ratio Imp:GI	30.12 acres	0.16 acres	190.2:1	49:1

Environmental Benefits

Water quality treatment volume (90%) managed and retained	Volume Managed: Yes	Volume Retained: Yes
Average annual runoff volume retained on-site	0.47 Mgal	80% percent of total runoff retained

NOTES

Cost information represents Engineers Opinion of Probable Cost based on Conceptual Level Design

Retained refers to water that is infiltrated onsite within 72 hours; Detained refers to water that is slowed down and released.

Tgal are units of thousands of gallons


PARKWAY
PARKWAY
ELMDALE
Flow Split
WATERFORD
ELMDALE
COIT
WELLS
TOWNSEND
NORTH PARK
HUBBARD
CHENEY
TOWNSEND
ESSEX
EASTERN
NORTH PARK
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
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Underground Storage
Drainage Area
Sewer
DCollector
City Parks
Green Infrastructure
North Park Opportunity Map
Subsurface Storage Alternative

North Park - Surface

Road runoff can be captured and treated within bioswales or bioretention around the perimeter of North Park. The south and west side of the park does not have curb allowing for sheet flow from the road. The north side has a parkway wide enough to accommodate a bioswale.

LAND COVER

RUNOFF (thousand gallons)

Description	Area (sf)	90%	2-yr	10-yr	100-yr	Avg Annual
Streets & Roads | Paved; curbs and storm sewers (incl. ROW)	45,210	5.1	30.0	55.5	115.3	145.4
Total	45,210	5	30	55	115	145
	Runoff (in) ->	*0.18*	*1.07*	*1.97*	*4.09*	*5.16*

PROPOSED IMPROVEMENTS

Green Infrastructure

SCM Practice Selection	Surface Area (sf)	Volume Retain (Tgal)	Volume Detain (Tgal)	Volume Total (Tgal)	Unit Cost ($/sf)	Capital Cost
Bioswale	3,200	29.9	0.0	29.9	$97	$310,304
Subtotal	3,200	30	0	30		$310,304
		1.06	*0.00*	*1.06*		

Linear Conveyance

Conveyance Practice Selection	Length (ft)	Unit Cost	Capital Cost
Subtotal			$0

OPINION OF PROBABLE COST

Capital Cost		$310,304	Average Annual NPV	$1,800
Contingencies (as a percentage of construction cost)	30%	$93,091		
Engineering, Inspection, Testing, Legal, Administration, and Financing	30%	$93,091	50-yr Net Present Value	$435,000
TOTAL Capital		$497,000		
Unitized Capital Cost	$479,000	per acre	$17	per gallon

BENEFITS

Targeted Practices and Locations

Drainage area (DA) | Area green infrastructure (GI) | Ratio DA:GI | Ratio Imp:GI	1.04	acres	0.07 acres	14.1:1	10.6:1

Environmental Benefits

Water quality treatment volume (90%) managed and retained	Volume Managed: Yes	Volume Retained: Yes
Average annual runoff volume retained on-site	0.14 Mgal	95% percent of total runoff retained

NOTES

Cost information represents Engineers Opinion of Probable Cost based on Conceptual Level Design

Retained refers to water that is infiltrated onsite within 72 hours; Detained refers to water that is slowed down and released.

Tgal are units of thousands of gallons

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Drainage Area

Linear Bioretention

DCollector

City Parks
Green Infrastructure
North Park Opportunity Map
Surface Storage Alternative

Southern Little League Park - Subsurface

Southern Little League Park or MacKay-Jaycee Park is a large recreational space with multiple baseball/softball fields It is possible to redirect fairly shallow storm pipe (~7 feet deep) to a subsurface storage basin in the southwest portion of the park. The potential drainage area is 4.5

LAND COVER

RUNOFF (thousand gallons)

Description	Area (sf)	90%	2-yr	10-yr	100-yr	Avg Annual
Streets & Roads | Paved; curbs and storm sewers (incl. ROW)	130,465	14.8	86.7	160.1	332.6	419.5
Urban | Paved Parking, Roofs, Driveways (excl. ROW) | 100% impervious	45,148	22.6	66.2	100.1	170.3	717.0
Urban | Open Space (lawns, parks, golf, cemeteries) | Good (grass cover >75%)	19,592	0.1	0.4	1.8	7.5	0.7
Total	195,205	38	153	262	510	1,137
Runoff (in) ->		*0.31*	*1.26*	*2.15*	*4.19*	*9.35*

PROPOSED IMPROVEMENTS

Green Infrastructure

SCM Practice Selection	Surface Area (sf)	Volume Retain (Tgal)	Volume Detain (Tgal)	Volume Total (Tgal)	Unit Cost ($/sf)	Capital Cost
Underground Arch Storage	5,100	152.2	0.0	152.2	$63	$319,384
Subtotal	5,100	152	0	152		$319,384
Runoff (in) ->		*1.25*	*0.00*	*1.25*		

Linear Conveyance

Conveyance Practice Selection	Length (ft)	Unit Cost	Capital Cost
21" RCP, Shallow, Under Pavement	79	$104	$8,190
Subtotal			$8,190

OPINION OF PROBABLE COST

Capital Cost		$327,574	Average Annual NPV	$100
Contingencies (as a percentage of construction cost)	30%	$98,272		
Engineering, Inspection, Testing, Legal, Administration, and Financing	30%	$98,272	50-yr Net Present Value	$377,000
TOTAL Capital		$525,000		
Unitized Capital Cost	$117,000	per acre	$4	per gallon

BENEFITS

Targeted Practices and Locations

Drainage area (DA) | Area green infrastructure (GI) | Ratio DA:GI | Ratio Imp:GI	4.48	acres	0.12 acres	38.3:1	28:1

Environmental Benefits

Water quality treatment volume (90%) managed and retained	Volume Managed: Yes	Volume Retained: Yes
Average annual runoff volume retained on-site	1.07 Mgal	94% percent of total runoff retained

NOTES

Cost information represents Engineers Opinion of Probable Cost based on Conceptual Level Design

Retained refers to water that is infiltrated onsite within 72 hours; Detained refers to water that is slowed down and released.

Tgal are units of thousands of gallons

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Sewer
Drainage Area
Underground Storage

DCollector
DCulvert

DOpenChannel
DUnderdrain

City Parks
Green Infrastructure
Southern Little League Park Opportunity Map
Subsurface Storage Alternative

Southern Little League Park - Surface

Southern Little League Park or MacKay-Jaycee Park is a large recreational space with multiple baseball/softball fields Linear bioretention can be used along the southern edge of the park to capture road runoff and overland flow from the park. Drainage area is about 9 acres.

LAND COVER / RUNOFF (thousand gallons)

Description	Area (sf)	90%	2-yr	10-yr	100-yr	Avg Annual
Streets & Roads | Paved; curbs and storm sewers (incl. ROW)	67,670	7.7	45.0	83.0	172.5	217.6
Natural | Woods | Good | Protected from Grazing, litter/brush cover soil	72,561	2.1	0.0	1.5	12.1	0.3
Urban | Open Space (lawns, parks, golf, cemeteries) | Good (grass cover >75%)	253,519	1.7	4.8	22.7	96.6	8.9
Total	393,750	11	50	107	281	227
	Runoff (in) ->	*0.05*	*0.20*	*0.44*	*1.15*	*0.92*

PROPOSED IMPROVEMENTS

Green Infrastructure

SCM Practice Selection	Surface Area (sf)	Volume Retain (Tgal)	Volume Detain (Tgal)	Volume Total (Tgal)	Unit Cost ($/sf)	Capital Cost
Bioswale	5,500	51.4	0.0	51.4	$97	$533,335
Subtotal	5,500	51	0	51		$533,335
	Runoff (in) ->	*0.21*	*0.00*	*0.21*		

Linear Conveyance

Conveyance Practice Selection	Length (ft)	Unit Cost	Capital Cost
Subtotal			$0

OPINION OF PROBABLE COST

Capital Cost		$533,335	Average Annual NPV	$3,000
Contingencies (as a percentage of construction cost)	30%	$160,001		
Engineering, Inspection, Testing, Legal, Administration, and Financing	30%	$160,001	50-yr Net Present Value	$747,000
TOTAL Capital		$854,000		
Unitized Capital Cost		$94,000 per acre		$17 per gallon

BENEFITS

Targeted Practices and Locations

Drainage area (DA) | Area green infrastructure (GI) | Ratio DA:GI | Ratio Imp:GI	9.04 acres	0.13 acres	71.6:1	9.2:1

Environmental Benefits

Water quality treatment volume (90%) managed and retained	Volume Managed: Yes	Volume Retained: Yes
Average annual runoff volume retained on-site	0.14 Mgal	64% percent of total runoff retained

NOTES

Cost information represents Engineers Opinion of Probable Cost based on Conceptual Level Design
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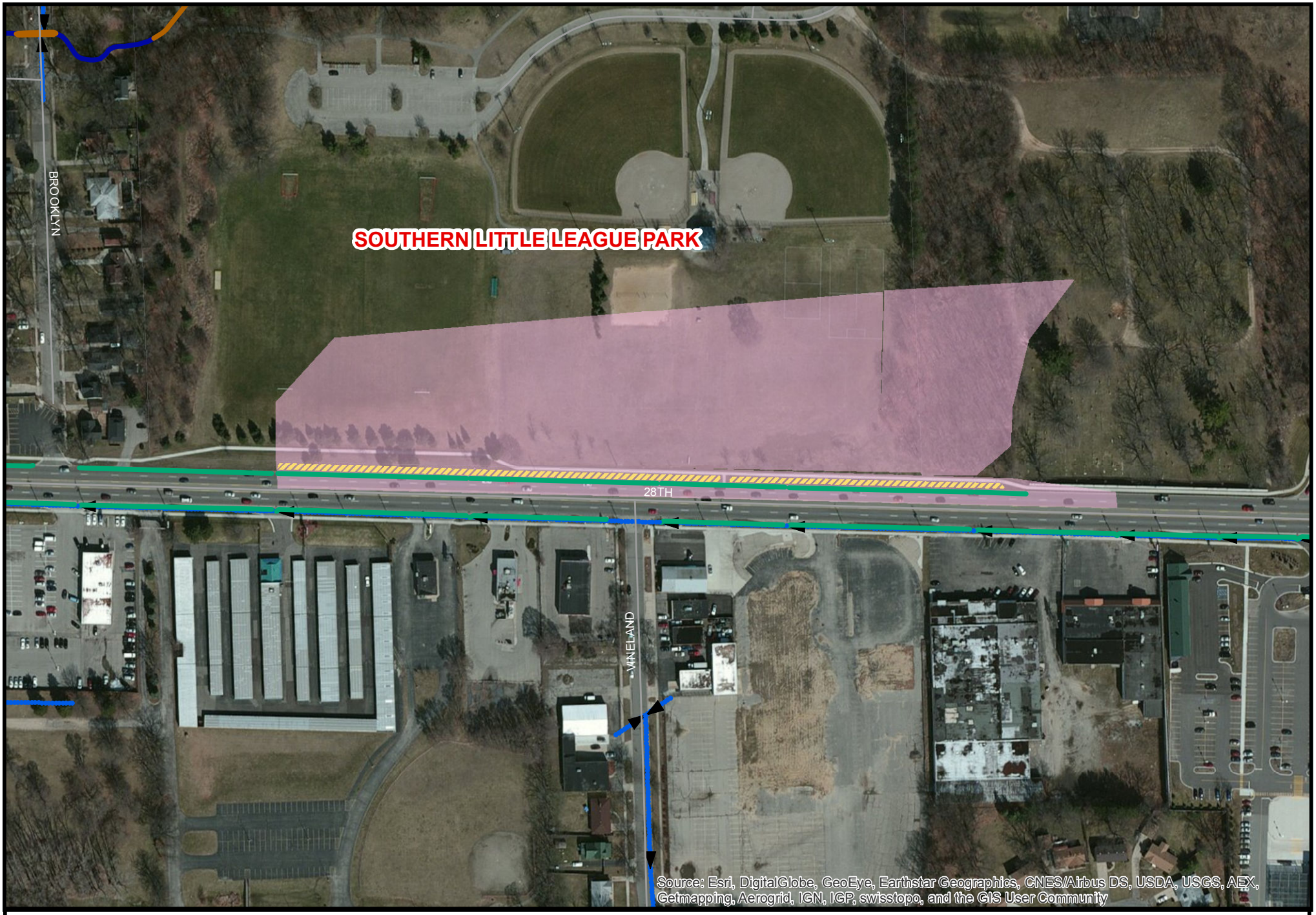
Tgal are units of thousands of gallons



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Linear Bioretention
Drainage Area
DCollector
DCulvert
DOpenChannel
DUnderdrain

City Parks
Green Infrastructure
Southern Little League Park Opportunity Map
Surface Storage Alternative

Huff Park - Subsurface

Huff Park is a recreational and natural reserve area with multiple baseball diamonds. There are several opportunities to intercept piped stormwater and detain in a subsurface storage practice wihtin the park. The drainage area is approximately 149 acres.

LAND COVER

RUNOFF (thousand gallons)

Description	Area (sf)	90%	2-yr	10-yr	100-yr	Avg Annual
Natural | Woods | Good | Protected from Grazing, litter/brush cover soil	2,192,265	63.6	0.1	43.9	364.7	9.1
Urban | Residential | 1/4 acre lot (est. 38% imperv.)	3,889,049	38.1	731.6	1,727.9	4,662.8	1,942.0
Urban | Open Space (lawns, parks, golf, cemeteries) | Fair (grass cover 50% to	405,555	0.0	29.6	87.4	283.0	58.3
Total	6,486,869	102	761	1,859	5,310	2,009
	Runoff (in) ->	*0.03*	*0.19*	*0.46*	*1.31*	*0.50*

PROPOSED IMPROVEMENTS

Green Infrastructure

SCM Practice Selection	Surface Area (sf)	Volume Retain (Tgal)	Volume Detain (Tgal)	Volume Total (Tgal)	Unit Cost ($/sf)	Capital Cost
Underground Arch Storage	26,000	775.7	0.0	775.7	$63	$1,628,230
Subtotal	26,000	776	0	776		$1,628,230
		Runoff (in) ->	*0.19*	*0.00*	*0.19*	

Linear Conveyance

Conveyance Practice Selection	Length (ft)	Unit Cost	Capital Cost
36" RCP, Shallow, Under Pavement	300	$168	$50,367
Subtotal			$50,367

OPINION OF PROBABLE COST

Capital Cost		$1,678,597	Average Annual NPV	$100
Contingencies (as a percentage of construction cost)	30%	$503,579		
Engineering, Inspection, Testing, Legal, Administration, and Financing	30%	$503,579	50-yr Net Present Value	$1,920,000
TOTAL Capital		$2,686,000		

Unitized Capital Cost $18,000 per acre $4 per gallon

BENEFITS

Targeted Practices and Locations

Drainage area (DA) | Area green infrastructure (GI) | Ratio DA:GI | Ratio Imp:GI	148.92	acres	0.60	acres	249.5:1	56.8:1

Environmental Benefits

Water quality treatment volume (90%) managed and retained	Volume Managed: Yes	Volume Retained: Yes
Average annual runoff volume retained on-site	1.54 Mgal	77% percent of total runoff retained

NOTES

Cost information represents Engineers Opinion of Probable Cost based on Conceptual Level Design

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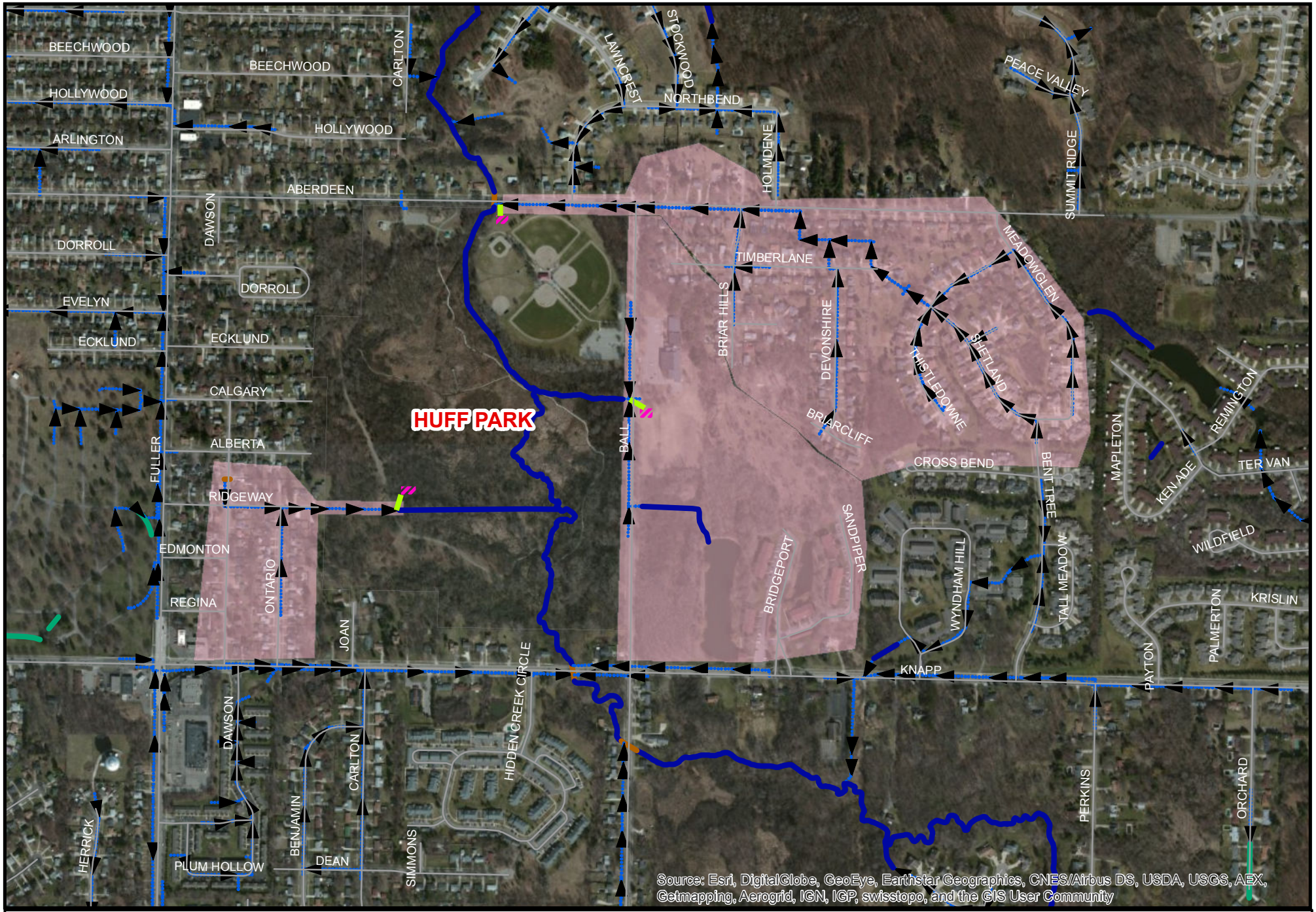
Tgal are units of thousands of gallons


HUFF PARK
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HOLLYWOOD
ARLINGTON
ABERDEEN
DORROLL
EVELYN
ECKLUND
CALGARY
ALBERTA
RIDGEWAY
EDMONTON
REGINA
DAWSON
CARLTON
LAWNCREST
STOCKWOOD
NORTHBEND
HOLMDENE
PEACE VALLEY
SUMMIT RIDGE
TIMBERLANE
BRIAR HILLS
DEVONSHIRE
MEADOWGLEN
THISTLEDOWNE
SHETLAND
BRIARCLIFF
BALL
FULLER
ONTARIO
JOAN
CROSS BEND
BENT TREE
MAPLETON
KEN-ADE
REMINGTON
TER VAN
WILDFIELD
SANDPIPER
BRIDGEPORT
WYNDHAM HILL
TALL MEADOW
KNAPP
PAYTON
PALMERTON
KRISLIN
HIDDEN CREEK CIRCLE
PERKINS
ORCHARD
HERRICK
BENJAMIN
DEAN
SIMMONS
PLUM HOLLOW
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
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DCollector
DOpenChannel
Underground Storage
Drainage Area
DCulvert
DUnderdrain
Sewer
City Parks
Green Infrastructure
Huff Park Opportunity Map
Subsurface Storage Alternative

Huff Park - Surface

Huff Park is a recreational and natural reserve area. Sheet flow from the portion of Ball Street east of the baseball diamonds could be captured and treated in a linear bioretention practice. The drainage area is 1.3 acres.

LAND COVER

RUNOFF (thousand gallons)

Description	Area (sf)	90%	2-yr	10-yr	100-yr	Avg Annual
Urban | Paved Parking, Roofs, Driveways (excl. ROW) | 100% impervious	57,985	29.1	85.0	128.6	218.8	920.9
Total	57,985	29	85	129	219	921
	Runoff (in) ->	*0.80*	*2.35*	*3.56*	*6.05*	*25.48*

PROPOSED IMPROVEMENTS

Green Infrastructure

SCM Practice Selection	Surface Area (sf)	Volume Retain (Tgal)	Volume Detain (Tgal)	Volume Total (Tgal)	Unit Cost ($/sf)	Capital Cost
Bioswale	9,100	85.1	0.0	85.1	$97	$882,427
Subtotal	9,100	85	0	85		$882,427
		Runoff (in) ->	*2.35*	*0.00*	*2.35*	

Linear Conveyance

Conveyance Practice Selection	Length (ft)	Unit Cost	Capital Cost
Subtotal			$0

OPINION OF PROBABLE COST

Capital Cost		$882,427	Average Annual NPV	$5,000
Contingencies (as a percentage of construction cost)	30%	$264,728		
Engineering, Inspection, Testing, Legal, Administration, and Financing	30%	$264,728	50-yr Net Present Value	$1,236,000
TOTAL Capital		$1,412,000		
Unitized Capital Cost	$1,061,000 per acre		$17 per gallon	

BENEFITS

Targeted Practices and Locations

Drainage area (DA) | Area green infrastructure (GI) | Ratio DA:GI | Ratio Imp:GI	1.33 acres	0.21 acres	6.4:1	6.4:1

Environmental Benefits

Water quality treatment volume (90%) managed and retained	Volume Managed: Yes	Volume Retained: Yes
Average annual runoff volume retained on-site	0.91 Mgal	99% percent of total runoff retained

NOTES

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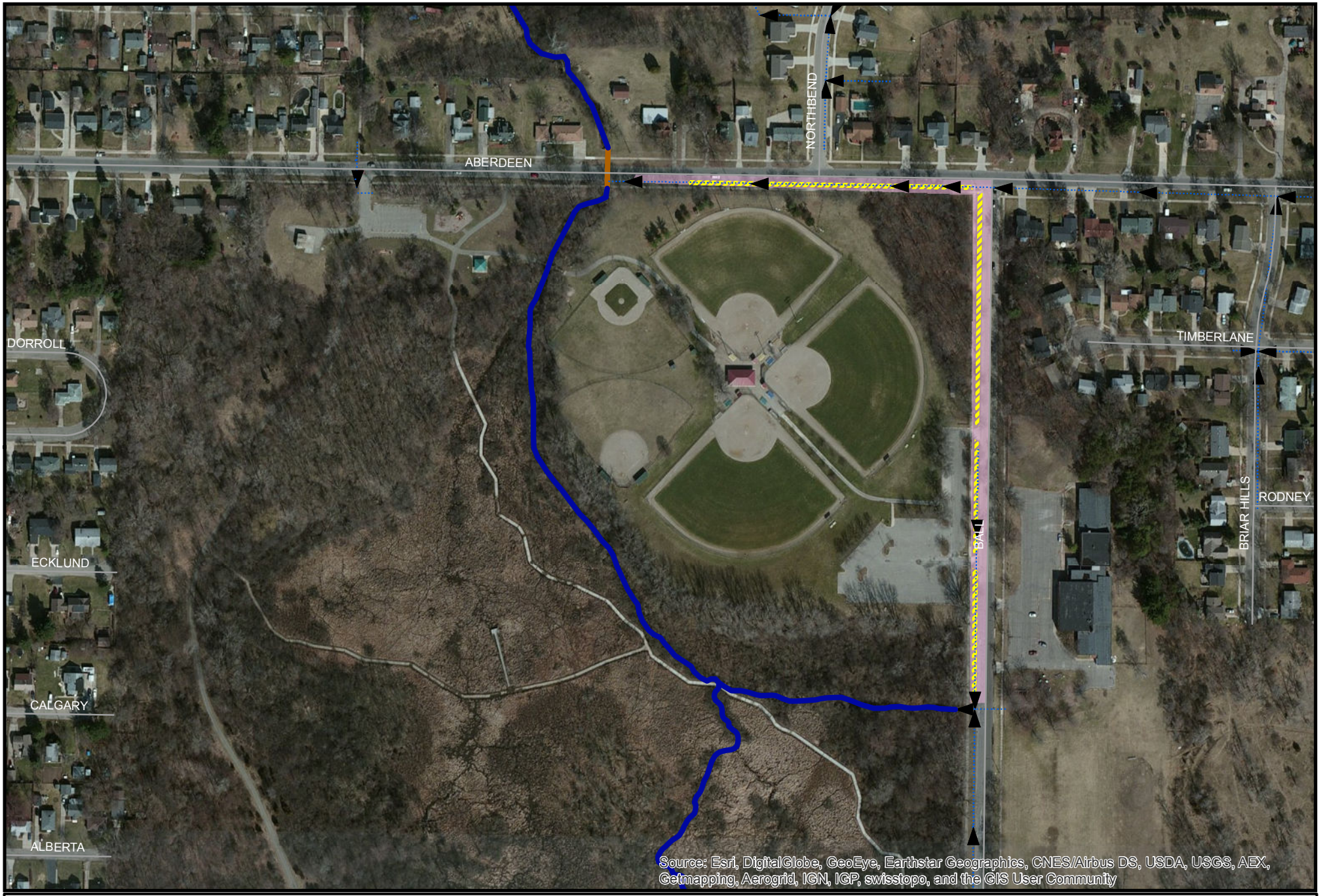
Tgal are units of thousands of gallons



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DCollector
DCulvert
DOpenChannel
Bioswale
Drainage Area

City Parks
Green Infrastructure
Huff Park Opportunity Map
Surface Storage Alternative

PROJECT SUMMARY

This summarizes conceptual green infrastructure projects within City of Grand Rapids parks having predominately HSG B soils.

Design Standard or Objective

Description	ENR Cost Index	ENR Geographic Index
Enter a description of how the sites were assessed, i.e. Sites designed to retain the 2-year storm event	9972	0.92

Climatology Data

	Water Quality Treatment Volume	Channel Protection	Collection (Pipe) System	Site and Roadway Flooding
Recurrence Interval	90%	2-year	10-year	100-year
Duration (hr)	24-hr	24-hr	24-hr	24-hr
Precipitation (in)	0.99	2.56	3.77	6.27

Soil Infiltration

Texture Class	Min Infil Rate (in/hr)	Hydrologic Soil Group	Allowable Duration for Infiltration (days)
Loam	0.52	B	3

SITE SUMMARY

No.	Location	Green Infrastructure Area (sf)	GI Capital Cost	50-year NPV	Performance (cost per gallon)	Annual Retention (Mgal and percent of annual runoff)
1	Richmond Park - Surface	3,900	$248,000	$264,000	$6 per gallon	0.34 Mgal (90%)
2	Shawmut Hills Park - Subsurfac	12,100	$1,218,000	$894,000	$3 per gallon	1.22 Mgal (89%)
3	Shawmut Hills Park - Surface	12,000	$589,000	$482,000	$7 per gallon	0.88 Mgal (98%)
4	6th Street Bridge Park - Subsurf	35,562	$3,590,000	$2,626,000	$3 per gallon	8.53 Mgal (85%)
5	6th Street Bridge Park - Surface	7,817	$892,000	$823,000	$12 per gallon	0.63 Mgal (98%)
6						
7						
8						
9						
10						
11						
12						

NOTES

Cost information represents Engineers Opinion of Probable Cost based on Conceptual Level Design

Retained refers to water that is infiltrated onsite within 72 hours; Detained refers to water that is slowed down and released.

Richmond Park - Surface

Richmond Park has opportunities behind the curb to incorporate bioretention to capture road runoff. Care should be taken to protect trees. An existing pond lies within the park to detain stormwater. Therefore, subsurface storage was not included in the analysis.

LAND COVER

Description	Area (sf)	90%	2-yr	10-yr	100-yr	Avg Annual
			RUNOFF (thousand gallons)			
Urban | Open Space (lawns, parks, golf, cemeteries) | Good (grass cover :	43,214	0.4	8.1	19.2	51.8	21.6
Streets & Roads | Paved; curbs and storm sewers (excl. ROW)	22,714	11.4	33.3	50.4	85.7	360.7
Total	65,928	12	41	70	138	382
	Runoff (in) ->	*0.29*	*1.01*	*1.69*	*3.35*	*9.30*

PROPOSED IMPROVEMENTS

Green Infrastructure

SCM Practice Selection	Surface Area (sf)	Volume Retain (Tgal)	Volume Detain (Tgal)	Volume Total (Tgal)	Unit Cost ($/sf)	Capital Cost
Bioretention - Open Space	3,900	41.3	0.0	41.3	$40	$154,557
Subtotal	3,900	41	0	41		$154,557
	Runoff (in) ->	*1.01*	*0.00*	*1.01*		

Linear Conveyance

Conveyance Practice Selection	Length (ft)	Unit Cost	Capital Cost
Subtotal			$0

OPINION OF PROBABLE COST

Capital Cost		$154,557	Average Annual NPV O&M	$1,700
Contingencies (as a percentage of construction cost)	30%	$46,367		
Engineering, Inspection, Testing, Legal, Administration, and Financing	30%	$46,367	50-yr Net Present Value	$264,000
TOTAL Capital		$248,000		
Unitized Capital Cost	$164,000 per acre		$6 per gallon	

BENEFITS

Targeted Practices and Locations

Drainage area (DA) | Area green infrastructure (GI) | Ratio DA:GI | Ratio Ir	1.51 acres	0.09 acres	16.9:1	5.8:1

Environmental Benefits

Water quality treatment volume (90%) managed and retained	Volume Managed: Yes	Volume Retained: Yes
Average annual runoff volume retained on-site	0.34 Mgal	90% percent of total runoff retained

NOTES

Cost information represents Engineers Opinion of Probable Cost based on Conceptual Level Design

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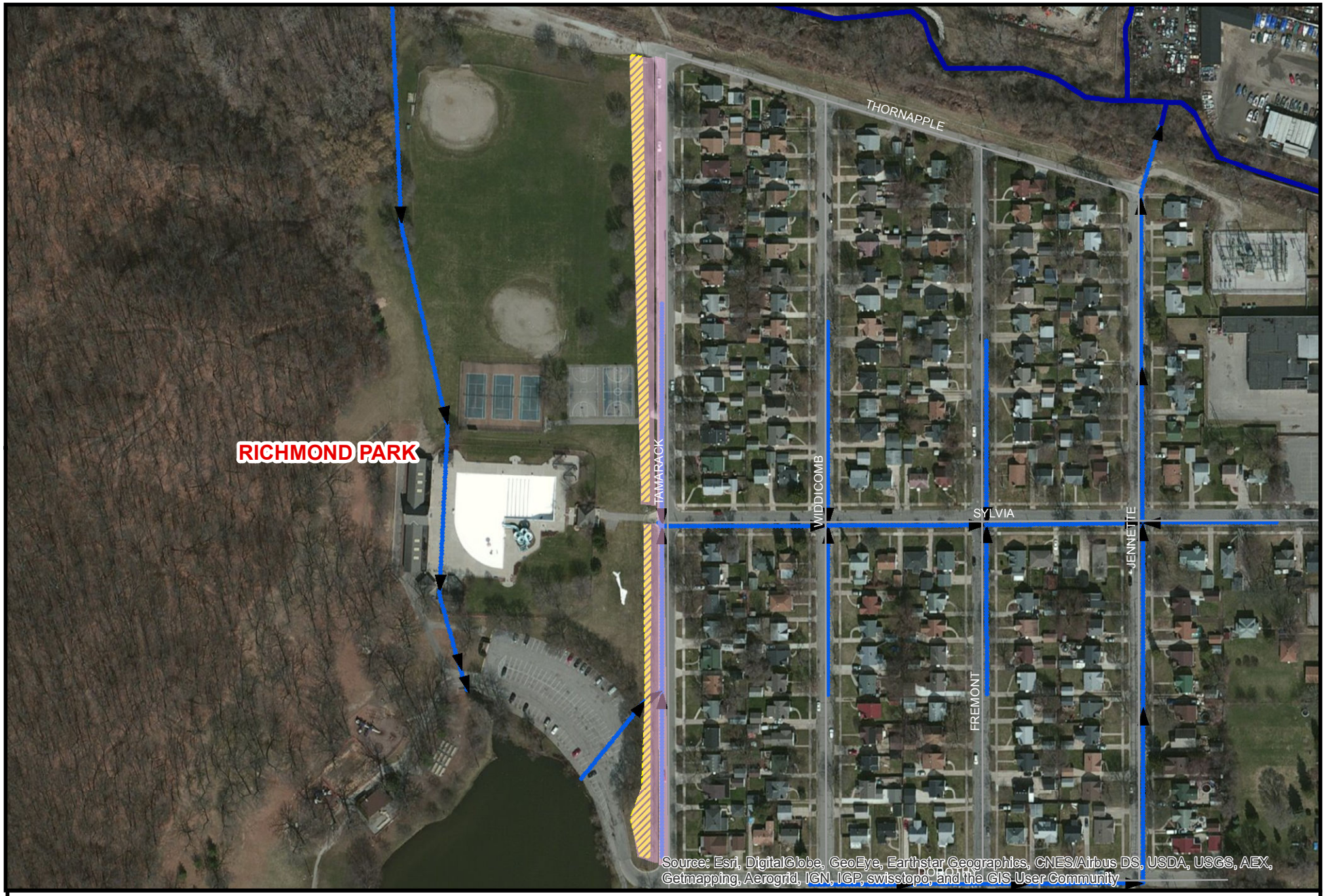

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Drainage Area

Linear Bioretention

DCollector

DOpenChannel

City Parks
Green Infrastructure
Richmond Park Opportunity Map
Subsurface Storage Alternative

Shawmut Hills Park - Subsurface

On the north end of Shawmut Hills Park, there is an opportunity to intercept a storm sewer and direct it to subsurface storage within the park. Trees would need to be removed.

LAND COVER

Description	Area (sf)	90%	2-yr	10-yr	100-yr	Avg Annual
			RUNOFF (thousand gallons)			
Mix | Woods-Grass Combination, Orchard, Tree Farm | Good	47,274	0.3	7.2	17.9	50.1	17.8
Urban | Residential | 1/4 acre lot (est. 38% imperv.)	822,528	44.6	354.9	714.3	1,633.6	1,364.3
Total	869,802	45	362	732	1,684	1,382
	Runoff (in) ->	*0.08*	*0.67*	*1.35*	*3.11*	*2.55*

PROPOSED IMPROVEMENTS

Green Infrastructure

SCM Practice Selection	Surface Area (sf)	Volume Retain (Tgal)	Volume Detain (Tgal)	Volume Total (Tgal)	Unit Cost ($/sf)	Capital Cost
Underground Arch Storage	12,100	282.4	78.6	361.0	$63	$757,753
Subtotal	12,100	282	79	361		$757,753
	Runoff (in) ->	*0.52*	*0.14*	*0.67*		

Linear Conveyance

Conveyance Practice Selection	Length (ft)	Unit Cost	Capital Cost
18" RCP, Medium, Under Pavement	31	$106	$3,299
Subtotal			$3,299

OPINION OF PROBABLE COST

Capital Cost		$761,052	Average Annual NPV O&M	$100
Contingencies (as a percentage of construction cost)	30%	$228,316		
Engineering, Inspection, Testing, Legal, Administration, and Financing	30%	$228,316	50-yr Net Present Value	$894,000
TOTAL Capital		$1,218,000		
Unitized Capital Cost	$61,000 per acre		$3 per gallon	

BENEFITS

Targeted Practices and Locations

Drainage area (DA) | Area green infrastructure (GI) | Ratio DA:GI | Ratio Ir	19.97 acres	0.28 acres	71.9:1	25.8:1

Environmental Benefits

Water quality treatment volume (90%) managed and retained	Volume Managed: Yes	Volume Retained: Yes
Average annual runoff volume retained on-site	1.22 Mgal	89% percent of total runoff retained

NOTES

Cost information represents Engineers Opinion of Probable Cost based on Conceptual Level Design

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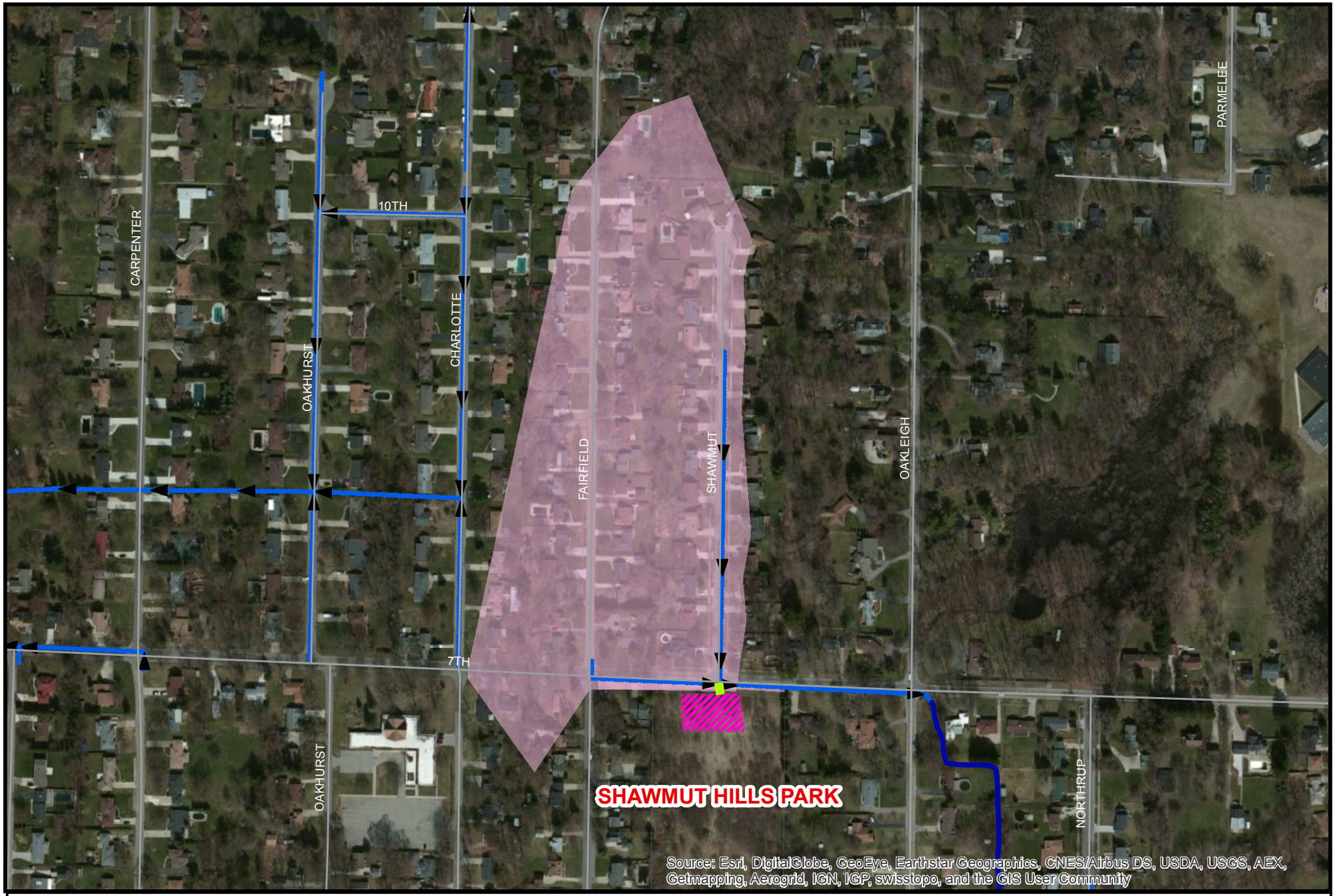
Tgal are units of thousands of gallons



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DCollector
DOpenChannel
Sewer

Drainage Area
Underground Storage

City Parks
Green Infrastructure
Shawmutt Hills Park Opportunity Map
Subsurface Storage Alternative

Shawmut Hills Park - Surface

The parking lot at the Shawmutt Hills School could be retrofit with permeable pavement. There is no nearby storm sewer to connect an underdrain to, but HSG B soil will likely drain well enough. There is also an opportunity on the north side of the open space to direct road runoff

LAND COVER		RUNOFF (thousand gallons)				
Description	Area (sf)	90%	2-yr	10-yr	100-yr	Avg Annual
Urban | Paved Parking, Roofs, Driveways (excl. ROW) | 100% impervious	51,136	25.6	75.0	113.4	192.9	812.1
Streets & Roads | Paved; curbs and storm sewers (excl. ROW)	5,023	2.5	7.4	11.1	19.0	79.8
Mix | Woods-Grass Combination, Orchard, Tree Farm | Good	5,660	0.0	0.9	2.1	6.0	2.1
Total	61,819	28	83	127	218	894
Runoff (in) ->		*0.73*	*2.16*	*3.29*	*5.65*	*23.20*

PROPOSED IMPROVEMENTS

Green Infrastructure

SCM Practice Selection	Surface Area (sf)	Volume Retain (Tgal)	Volume Detain (Tgal)	Volume Total (Tgal)	Unit Cost ($/sf)	Capital Cost
Permeable Paver Parking Stall	11,100	74.7	0.0	74.7	$25	$280,608
Bioswale	900	8.4	0.0	8.4	$97	$87,273
Subtotal	12,000	83	0	83		$367,881
Runoff (in) ->		*2.16*	*0.00*	*2.16*		

Linear Conveyance

Conveyance Practice Selection	Length (ft)	Unit Cost	Capital Cost
Subtotal			$0

OPINION OF PROBABLE COST

Capital Cost		$367,881	Average Annual NPV O&M	$1,100
Contingencies (as a percentage of construction cost)	30%	$110,364		
Engineering, Inspection, Testing, Legal, Administration, and Financing	30%	$110,364	50-yr Net Present Value	$482,000
TOTAL Capital		$589,000		
Unitized Capital Cost	$415,000 per acre		$7 per gallon	

BENEFITS

Targeted Practices and Locations

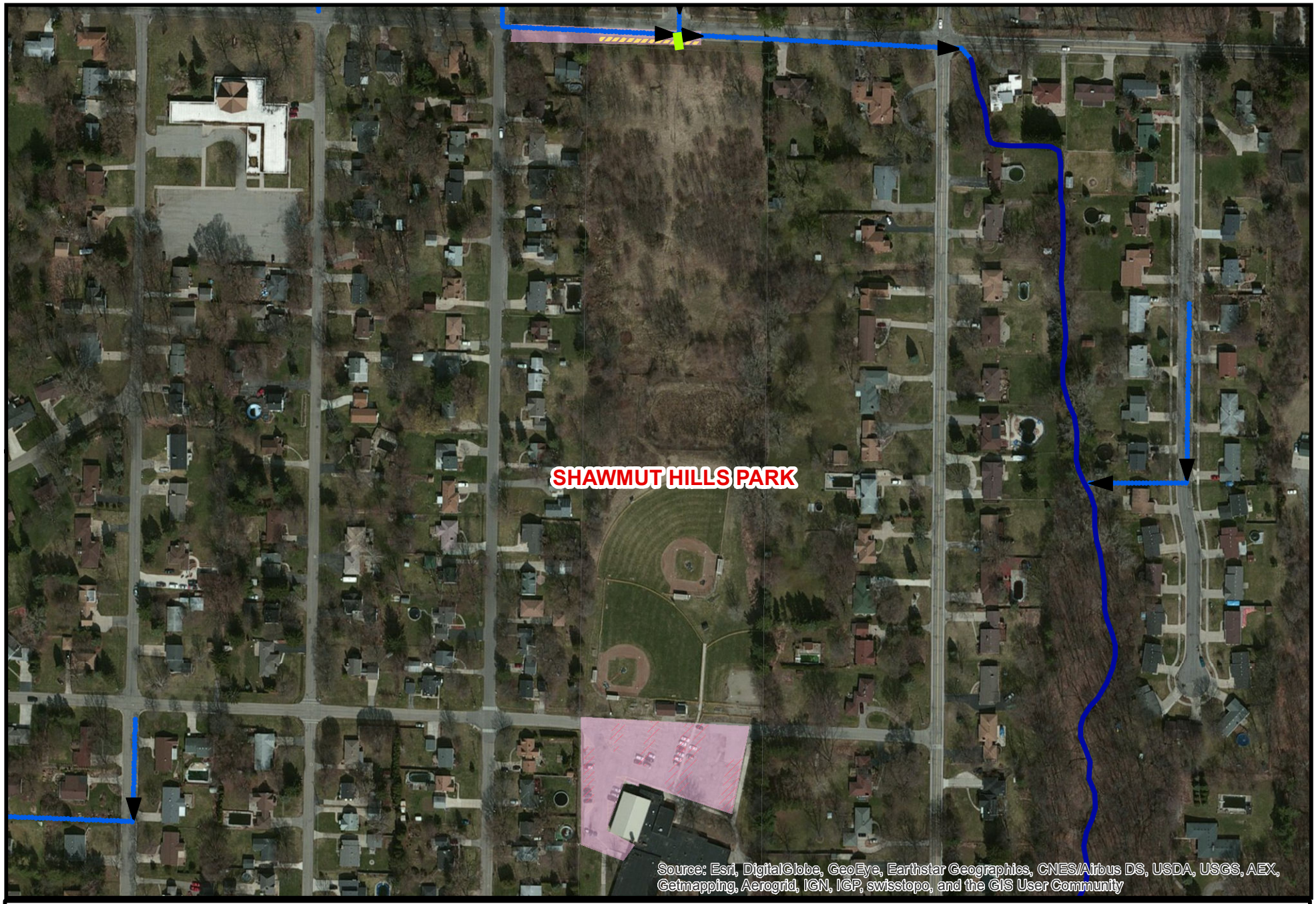
Drainage area (DA) | Area green infrastructure (GI) | Ratio DA:GI | Ratio Ir	1.42 acres	0.28 acres	5.2:1	4.7:1

Environmental Benefits

Water quality treatment volume (90%) managed and retained	Volume Managed: Yes	Volume Retained: Yes
Average annual runoff volume retained on-site	0.88 Mgal	98% percent of total runoff retained

NOTES

Cost information represents Engineers Opinion of Probable Cost based on Conceptual Level Design
Retained refers to water that is infiltrated onsite within 72 hours; Detained refers to water that is slowed down and releasea
Tgal are units of thousands of gallons



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Drainage Area
DCollector
DOpenChannel
Sewer
Permeable Pavers
Linear Bioretention

City Parks
Green Infrastructure
Shatmutt Hills Park Opportunity Map
Surface Storage Alternative

6th Street Bridge Park - Subsurface

There is an opportunity within Sixth Street Bridge Park to divert flow from two adjacent storm sewers to a subsurface storage practice witin the park.

LAND COVER

Description	Area (sf)	RUNOFF (thousand gallons) 90%	2-yr	10-yr	100-yr	Avg Annual
Urban | Paved Parking, Roofs, Driveways (excl. ROW) | 100% impervious	571,227	286.2	837.5	1,266.6	2,155.2	9,072.3
Urban | Open Space (lawns, parks, golf, cemeteries) | Good (grass cover :	20,562	0.2	3.9	9.1	24.7	10.3
Urban | Open Space (lawns, parks, golf, cemeteries) | Fair (grass cover 5(	14,724	0.4	4.5	9.7	23.8	14.9
Natural | Woods | Good | Protected from Grazing, litter/brush cover soi	911,200	2.2	111.7	289.5	847.9	253.8
Streets & Roads | Paved; curbs and storm sewers (incl. ROW)	121,045	23.8	110.8	190.4	366.2	664.0
Total	1,638,758	313	1,068	1,765	3,418	10,015
	Runoff (in) ->	*0.31*	*1.05*	*1.73*	*3.35*	*9.80*

PROPOSED IMPROVEMENTS

Green Infrastructure

SCM Practice Selection	Surface Area (sf)	Volume Retain (Tgal)	Volume Detain (Tgal)	Volume Total (Tgal)	Unit Cost ($/sf)	Capital Cost
Underground Arch Storage	35,562	830.0	231.0	1,061.0	$63	$2,227,043
Subtotal	35,562	830	231	1,061		$2,227,043
	Runoff (in) ->	*0.81*	*0.23*	*1.04*		

Linear Conveyance

Conveyance Practice Selection	Length (ft)	Unit Cost	Capital Cost
54" RCP, Medium	17	$265	$4,500
30" RCP, Medium, Under Pavement	84	$139	$11,637
Subtotal			$16,136

OPINION OF PROBABLE COST

Capital Cost		$2,243,179	Average Annual NPV O&M	$200
Contingencies (as a percentage of construction cost)	30%	$672,954		
Engineering, Inspection, Testing, Legal, Administration, and Financing	30%	$672,954	50-yr Net Present Value	$2,626,000
TOTAL Capital		$3,590,000		
Unitized Capital Cost	$95,000 per acre		$3 per gallon	

BENEFITS

Targeted Practices and Locations

Drainage area (DA) | Area green infrastructure (GI) | Ratio DA:GI | Ratio Ir	37.62 acres	0.82 acres	46.1:1	18.6:1

Environmental Benefits

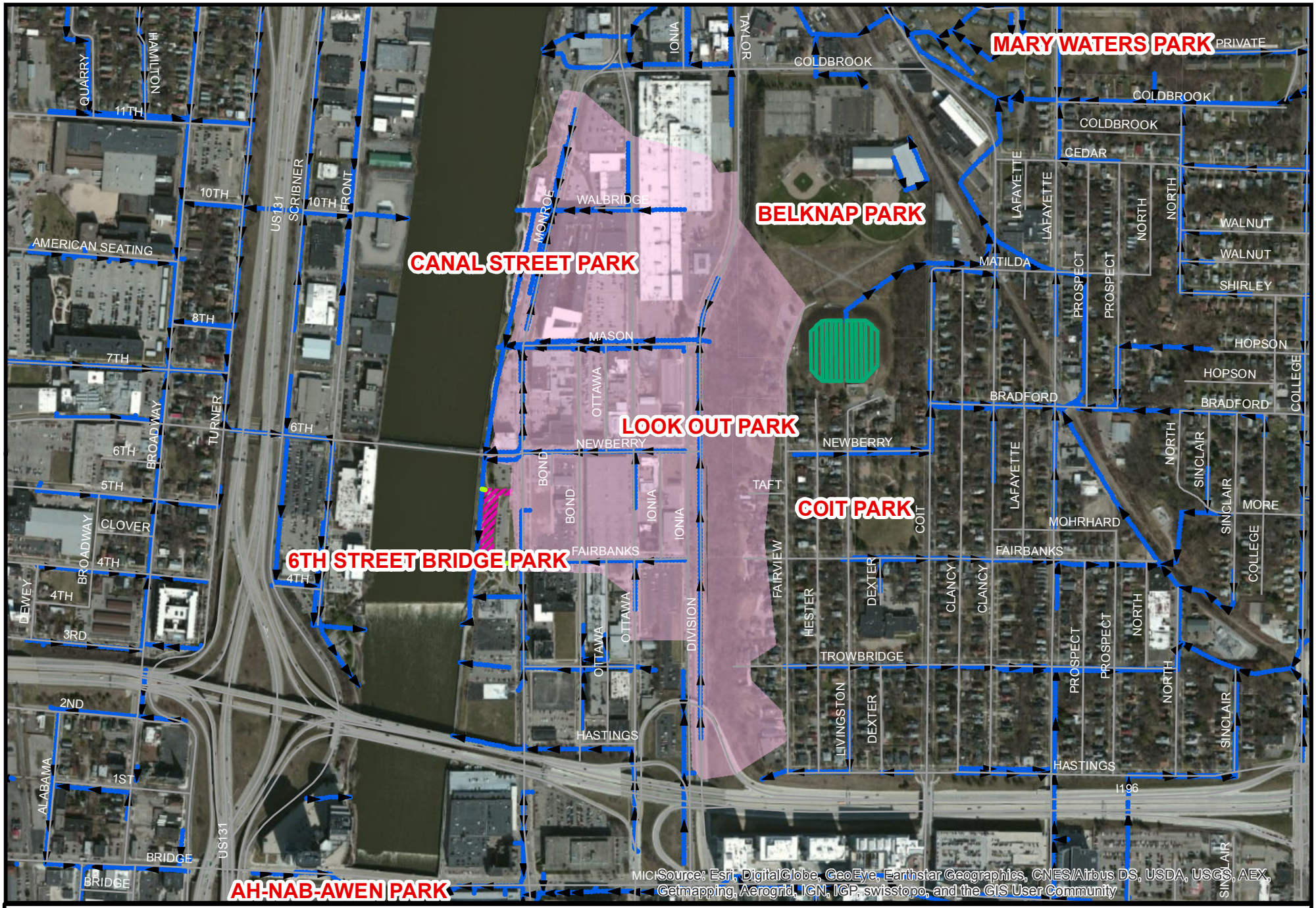
Water quality treatment volume (90%) managed and retained	Volume Managed: Yes	Volume Retained: Yes
Average annual runoff volume retained on-site	8.53 Mgal	85% percent of total runoff retained

NOTES

Cost information represents Engineers Opinion of Probable Cost based on Conceptual Level Design

Retained refers to water that is infiltrated onsite within 72 hours; Detained refers to water that is slowed down and released

Tgal are units of thousands of gallons



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Drainage Area

City Parks
Green Infrastructure
6th Street Bridge Park Opportunity Map
Subsurface Storage Alternative

6th Street Bridge Park - Surface

There is an opportunity within 6th Street Bridge Park to capture road and parking lot runoff into green infrastructure surface features. The inlets to the proposed bioswale along Monroe would need to pass beneath the sidewalk.

LAND COVER

Description	Area (sf)	RUNOFF (thousand gallons) 90%	2-yr	10-yr	100-yr	Avg Annual
Urban | Paved Parking, Roofs, Driveways (excl. ROW) | 100% impervious	26,526	13.3	38.9	58.8	100.1	421.3
Streets & Roads | Paved; curbs and storm sewers (incl. ROW)	40,242	7.9	36.8	63.3	121.8	220.7
Total	66,768	21	76	122	222	642
	Runoff (in) ->	*0.51*	*1.82*	*2.93*	*5.33*	*15.43*

PROPOSED IMPROVEMENTS

Green Infrastructure

SCM Practice Selection	Surface Area (sf)	Volume Retain (Tgal)	Volume Detain (Tgal)	Volume Total (Tgal)	Unit Cost ($/sf)	Capital Cost
Bioswale	4,317	40.4	0.0	40.4	$97	$418,619
Bioretention - Open Space	3,500	37.1	0.0	37.1	$40	$138,705
Subtotal	7,817	77	0	77		$557,324
	Runoff (in) ->	*1.86*	*0.00*	*1.86*		

Linear Conveyance

Conveyance Practice Selection	Length (ft)	Unit Cost	Capital Cost
Subtotal			$0

OPINION OF PROBABLE COST

Capital Cost		$557,324	Average Annual NPV O&M	$3,900
Contingencies (as a percentage of construction cost)	30%	$167,197		
Engineering, Inspection, Testing, Legal, Administration, and Financing	30%	$167,197	50-yr Net Present Value	$823,000
TOTAL Capital		$892,000		
Unitized Capital Cost	$582,000 per acre		$12 per gallon	

BENEFITS

Targeted Practices and Locations

Drainage area (DA) | Area green infrastructure (GI) | Ratio DA:GI | Ratio Ir	1.53 acres	0.18 acres	8.5:1	7.3:1

Environmental Benefits

Water quality treatment volume (90%) managed and retained	Volume Managed: Yes	Volume Retained: Yes
Average annual runoff volume retained on-site	0.63 Mgal	98% percent of total runoff retained

NOTES

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Tgal are units of thousands of gallons

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Linear Bioretention

Bioretention

Drainage Area

DCollector

City Parks
Green Infrastructure
6th Street Bridge Park Opportunity Map
Surface Storage Alternative

PROJECT SUMMARY

This summarizes conceptual green infrastructure projects within City of Grand Rapids parks having predominately HSG C soils.

Design Standard or Objective

Description	ENR Cost Index	ENR Geographic Index
Enter a description of how the sites were assessed, i.e. Sites designed to retain the 2-year storm event	9972	0.92

Climatology Data

	Water Quality Treatment Volume	Channel Protection	Collection (Pipe) System	Site and Roadway Flooding
Recurrence Interval	90%	2-year	10-year	100-year
Duration (hr)	24-hr	24-hr	24-hr	24-hr
Precipitation (in)	0.99	2.56	3.77	6.27

Soil Infiltration

Texture Class	Min Infil Rate (in/hr)	Hydrologic Soil Group	Allowable Duration for Infiltration (days)
Sandy clay loam	0.17	C	3

SITE SUMMARY

No.	Location	Green Infrastructure Area (sf)	GI Capital Cost	50-year NPV	Performance (cost per gallon)	Annual Retention (Mgal and percent of annual runoff)
1	Graham Horticulture Station - Surface	5,300	$823,000	$720,000	$17 per gallon	0.53 Mgal (97%)
2	Oxford Place - Surface	10,581	$1,642,000	$1,437,000	$17 per gallon	0.51 Mgal (79%)
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4						
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6						
7						
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NOTES

Cost information represents Engineers Opinion of Probable Cost based on Conceptual Level Design

Retained refers to water that is infiltrated onsite within 72 hours; Detained refers to water that is slowed down and released.

Graham Horticulture Station - Surface

Graham Horticultural Station is located northeast of the intersection of Maynard Avenue NW and Lake Michigan Drive NW. There is an opportunity to capture and treat runoff for a 2-year 24-hour storm event from the adjacent roads with a Bioswale.

LAND COVER		RUNOFF (thousand gallons)				
Description	Area (sf)	90%	2-yr	10-yr	100-yr	Avg Annual
Streets & Roads | Paved; curbs and storm sewers (excl. ROW)	34,403	17.2	50.4	76.3	129.8	546.4
Total	34,403	17	50	76	130	546
	Runoff (in) ->	*0.80*	*2.35*	*3.56*	*6.05*	*25.48*

PROPOSED IMPROVEMENTS

Green Infrastructure

SCM Practice Selection	Surface Area (sf)	Volume Retain (Tgal)	Volume Detain (Tgal)	Volume Total (Tgal)	Unit Cost ($/sf)	Capital Cost
Bioswale	5,300	40.4	9.1	49.6	$97	$513,941
Subtotal	5,300	40	9	50		$513,941
	Runoff (in) ->	*1.89*	*0.43*	*2.31*		

Linear Conveyance

Conveyance Practice Selection	Length (ft)	Unit Cost	Capital Cost
Subtotal			$0

OPINION OF PROBABLE COST

Capital Cost		$513,941	Average Annual NPV O&M	$2,900
Contingencies (as a percentage of construction cost)	30%	$154,182		
Engineering, Inspection, Testing, Legal, Administration, and Financing	30%	$154,182	50-yr Net Present Value	$720,000
TOTAL Capital		$823,000		
Unitized Capital Cost	$1,042,000 per acre		$17 per gallon	

BENEFITS

Targeted Practices and Locations

Drainage area (DA) | Area green infrastructure (GI) | Ratio DA:GI | Ratio Ir	0.79 acres	0.12 acres	6.5:1	6.5:1

Environmental Benefits

Water quality treatment volume (90%) managed and retained	Volume Managed: Yes	Volume Retained: Yes
Average annual runoff volume retained on-site	0.53 Mgal	97% percent of total runoff retained

NOTES

Cost information represents Engineers Opinion of Probable Cost based on Conceptual Level Design
Retained refers to water that is infiltrated onsite within 72 hours; Detained refers to water that is slowed down and released
Tgal are units of thousands of gallons

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Drainage Area

DCollector

Bioswale

City Parks
Green Infrastructure
Graham Horticulture Station Opportunity Map
Surface Storage Alternative

Oxford Place - Surface

Oxford Place is a natural city park near a single-family and multi-family residential neighborhood. The park slopes toward East Castle Street making storage within the park infeasible. There is however space available within the right-of-way along East Castle to capture road runoff.

LAND COVER		RUNOFF (thousand gallons)				
Description	Area (sf)	90%	2-yr	10-yr	100-yr	Avg Annual
Streets & Roads | Paved; curbs and storm sewers (incl. ROW)	49,327	13.0	53.0	87.5	161.6	364.7
Natural | Woods | Good | Protected from Grazing, litter/brush cover soi	256,630	8.4	83.7	177.6	430.4	281.6
Total	305,957	21	137	265	592	646
	Runoff (in) ->	*0.11*	*0.72*	*1.39*	*3.10*	*3.39*

PROPOSED IMPROVEMENTS

Green Infrastructure

SCM Practice Selection	Surface Area (sf)	Volume Retain (Tgal)	Volume Detain (Tgal)	Volume Total (Tgal)	Unit Cost ($/sf)	Capital Cost
Bioswale	10,581	80.7	18.2	98.9	$97	$1,026,040
Subtotal	10,581	81	18	99		$1,026,040
	Runoff (in) ->	*0.42*	*0.10*	*0.52*		

Linear Conveyance

Conveyance Practice Selection	Length (ft)	Unit Cost	Capital Cost
Subtotal			$0

OPINION OF PROBABLE COST

Capital Cost		$1,026,040	Average Annual NPV O&M	$5,800
Contingencies (as a percentage of construction cost)	30%	$307,812		
Engineering, Inspection, Testing, Legal, Administration, and Financing	30%	$307,812	50-yr Net Present Value	$1,437,000
TOTAL Capital		$1,642,000		
Unitized Capital Cost	$234,000 per acre		$17 per gallon	

BENEFITS

Targeted Practices and Locations

Drainage area (DA) | Area green infrastructure (GI) | Ratio DA:GI | Ratio Ir	7.02 acres	0.24 acres	28.9:1	3.5:1

Environmental Benefits

Water quality treatment volume (90%) managed and retained	Volume Managed: Yes	Volume Retained: Yes
Average annual runoff volume retained on-site	0.51 Mgal	79% percent of total runoff retained

NOTES

Cost information represents Engineers Opinion of Probable Cost based on Conceptual Level Design
Retained refers to water that is infiltrated onsite within 72 hours; Detained refers to water that is slowed down and released
Tgal are units of thousands of gallons

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Drainage Area
Linear Bioretention
DCollector
DOpenChannel

City Parks
Green Infrastructure
Oxford Place Opportunity Map
Surface Storage Alternative