



AGENDA OF THE SUSTAINABILITY COMMISSION

WEDNESDAY, OCTOBER 18, 2023, 5:00 PM

In person at City Hall, Room 310.

Virtual attendance also available via Zoom.

A. Zoom Meeting Information.

I. Join Zoom Meeting Online:

<https://us02web.zoom.us/j/82236285137?pwd=bzBScDVVRysrQlpSZEZpK2FMSnd4Zz09>

Or call in by phone: +1 312 626 6799

Meeting ID: 822 3628 5137

Passcode: 769016

If you wish to speak at this public meeting or leave a comment, please fill out the online [Comment Form](#) prior to the meeting. More detailed [Zoom Instructions](#) can be found online.

B. Roll Call.

- I. Chair- Seth Hoffmeister; Vice Chair-Ned Dorff; Alder Mark Steuer; Jenny Brinker; Amy Kox; Krista Kananen; Kaurie Mihm-Staff person; Julia Noordyk; Mark Walter.

C. Approval of the Agenda.

- I. Approval of the Sustainability Commission meeting agenda for October 18, 2023.

D. Approval of Minutes.

- I. Approval of minutes from September 20, 2023.

E. Presentations

- I. Overview of the draft City-Wide Green Stormwater Infrastructure Plan

F. Regular Business.

- I. To recommend the Citywide GSI Plan to the Improvement & Services Committee for

consideration of adoption and implementation.

G. Informational.

1. Upcoming Dates for GSI Plan: October 25 Improvement & Services Committee; November 7 Common Council.
2. Upcoming Dates for Clean Energy Plan: November 15 Sustainability Commission; November 29 Improvement & Services Committee; December 5 Common Council.

H. Announcements

1. Announcements from Sustainability Commission members

I. Adjournment.

- 1) THIS MEETING IS RECORDED: THE VIDEO OF THIS MEETING AND MINUTES ARE AVAILABLE ONLINE AT www.greenbaywi.gov
- 2) ACCESSIBILITY: Any person wishing to attend who requires special accommodation because of a disability, should contact the City Safety Manager at 920-448-3125 at least 48 hours before the scheduled meeting time so that arrangements can be made.
- 3) QUORUM: Please take notice that a majority or quorum of the Common Council will attend this Sustainability Commission meeting and will constitute a meeting of the Common Council for purposes of discussion and information gathering relative to this agenda.
- 4) REPRESENTATION: The party requesting the communication, or their representative, should be present at this meeting.



City of Green Bay City-Wide Green Stormwater Infrastructure Plan

Carrie Bristoll-Groll, PE, ENV SP
EVP Engineering Services/AQUALIS

Melissa Schmitz, CEM, LEED GA
Resiliency Coordinator/City of Green Bay



Project Overview

Purpose of the Project/Plan

- Provide steps toward flood and climate resiliency and water quality
- Guide the identification, prioritization, implementation, tracking and reporting of GSI projects within the City (public and private property)
- Develop solutions appropriate to the conditions found in the City of Green Bay area
- Reduce flood risk, especially along the East River and western slough neighborhoods
- Have prioritized actionable list of GSI projects
- Create processes and framework for implementation

GREEN STORMWATER INFRASTRUCTURE OPTIONS



BIOSWALES

Landscape features that capture and infiltrate runoff and can also remove pollutants.



GREEN ROOFS

Partially or completely planted roofs with vegetation growing in soil or other growing media to hold rainwater.



GREENWAYS

Riparian and non-riparian buffer zones and strips that store and drain stormwater runoff into the ground naturally.



NATIVE LANDSCAPING

The use of native plants that can tolerate drought and flooding cycles because of deep roots and climate-specific adaptations.



PERMEABLE PAVEMENT

Pavement that can reduce and infiltrate surface runoff through its permeable surface into a stone or filter media below.



RAIN GARDENS

Gardens that are watered by collected or pooled stormwater runoff, slowly infiltrating it into the ground along root pathways.

GREEN STORMWATER INFRASTRUCTURE OPTIONS



RAINWATER CATCHMENT

The capture and storage of water, potentially for reuse later.



REMOVAL OF PAVING & STRUCTURES

Removal of structures or paving in order to allow infiltration.



SOIL AMENDMENTS

Materials worked into the soil to enhance its ability to infiltrate or absorb water.



TREES

Trees that can hold rainwater on their leaves and branches, infiltrate it into the ground, absorb it through root systems, and evapotranspire it to the atmosphere.



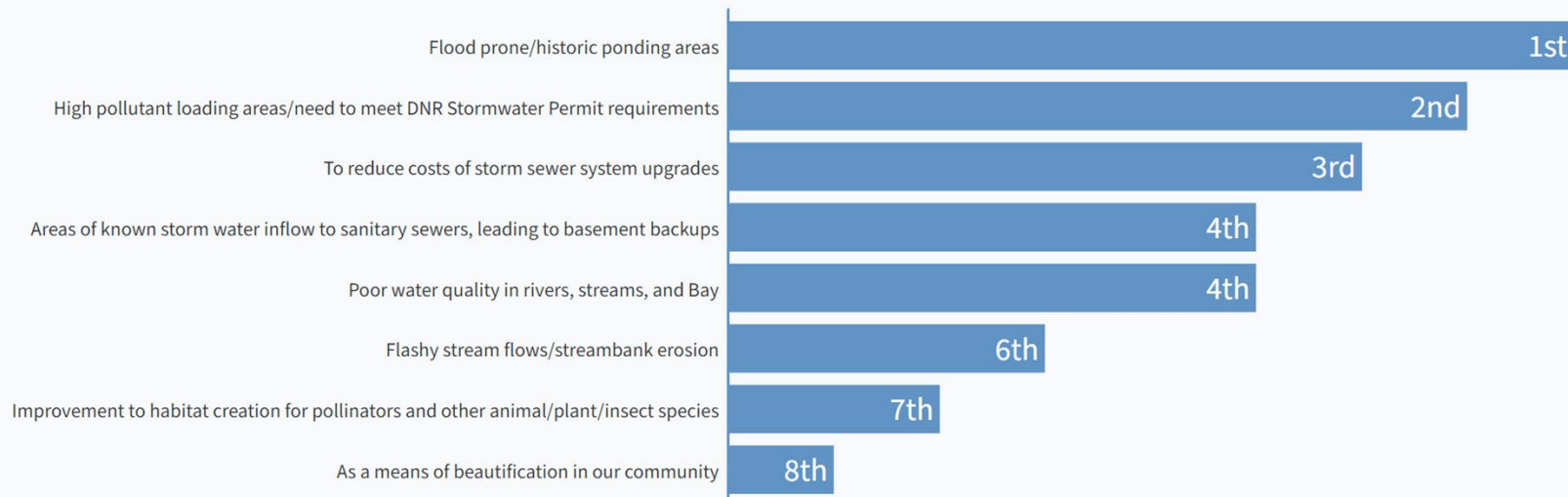
WETLANDS

Areas that have soils that are inundated or saturated for part of the year or the entire year.

Identify Priority Subbasins

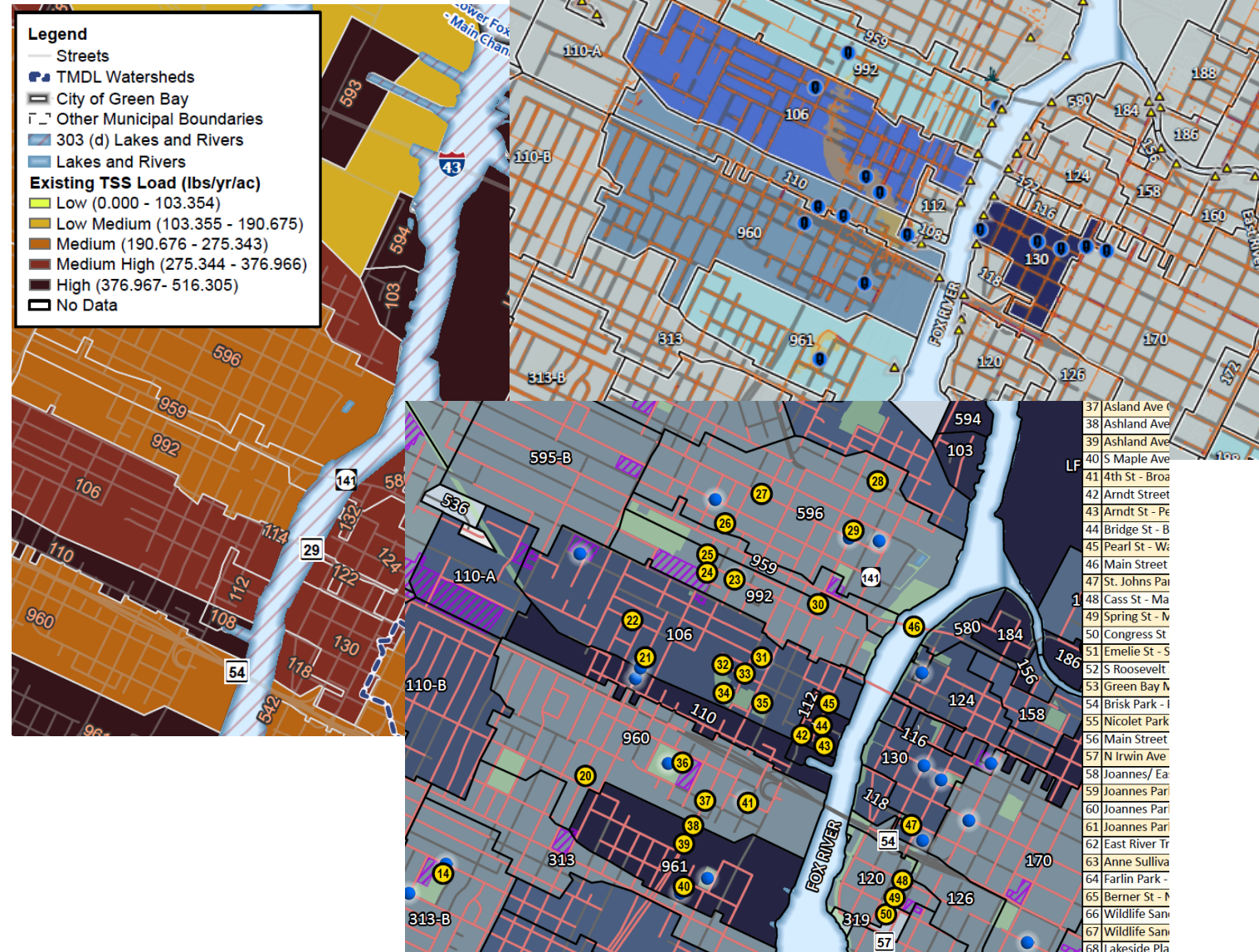
- Using water quality analysis and reports from flooding experienced, coupled with feedback from Stakeholders, perform GIS exercise to determine highest priority (NEED) subareas

Post Discussion: When considering the NEED for GSI, please arrange the following in order of importance, from most important to least important (click on each and use the arrows to move up and down).



ID and Prioritize the most impactful 30 Public and 20 Private GSI Projects

- Given data of proposed development, the City's capital improvement program, and gathering feedback from Stakeholders on Placement, determine projects within the highest need subareas
- Select from list of potential GSI Options for best fit given local constraints and needs



Perform Water Quality and Quantity Modeling for 30 public and 15-20 private GSI locations

Using hydrology software Hydrocad, and water quality software WinSLAMM, determine potential reduction in peak flows, total gallons captured, and total pounds of suspended solids and phosphorus captured in each project area.



City of Green Bay GSI Plan

Drainage Subbasin: 130

Project ID: PU-130

Site Location:

S Jefferson St & Stuart St,
Green Bay, WI

GSI Description:

Two bioswales placed at low points along streets. The proposed bioswale placements would capture the stormwater runoff from the street, resulting in better water quality and a reduced flood risk.

Drainage Area = 0.294 acres (12,800 sq. ft.)

Proposed Bioswale Area = 0.01 acre (535 sq.ft.)

Approximate Cost = \$27,000 + \$535/year

Annualized Cost = \$6.99 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

0.4199 lbs (78.33%)

Total Suspended Solids Reduction =

269.5 lbs (81.26%)

Volume Captured = 2,506 gallons

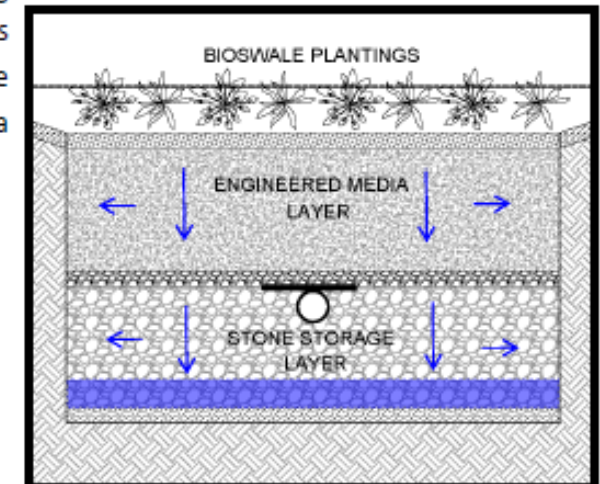
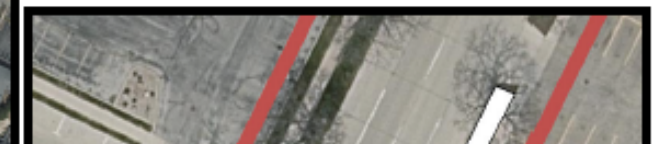


Figure 1: Typical bioswale detail.



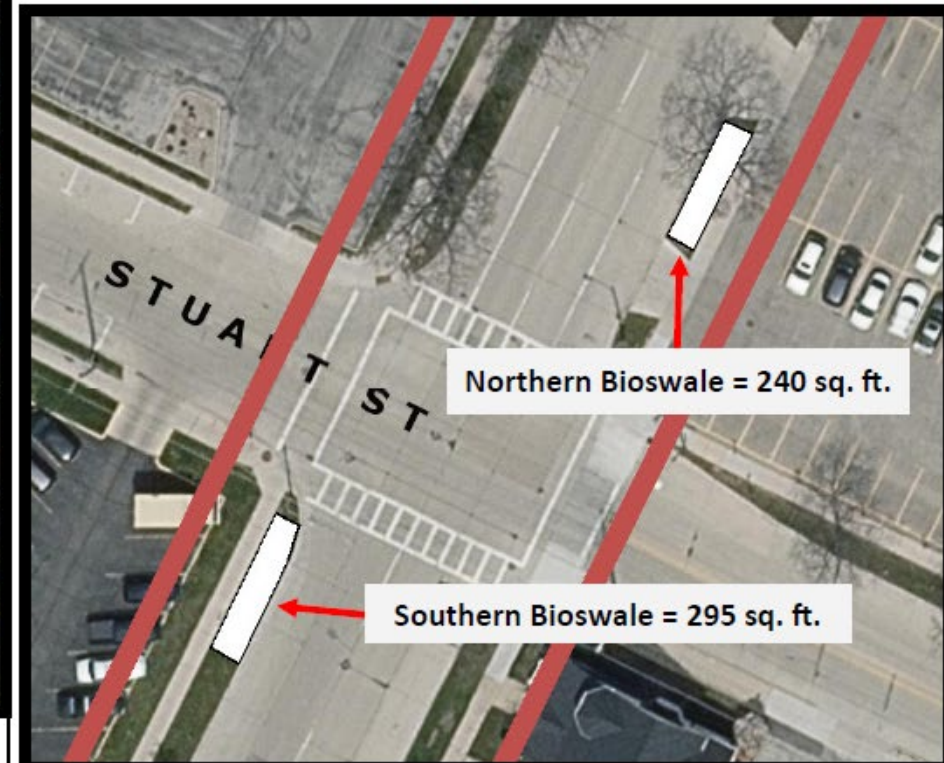
Perform Water Quality and Quantity Modeling for 30 public and 15-20 private GSI locations



Figure 2: Aerial image of CoGB with the project site outlined in red.



Figure 1: Typical bioswale detail.

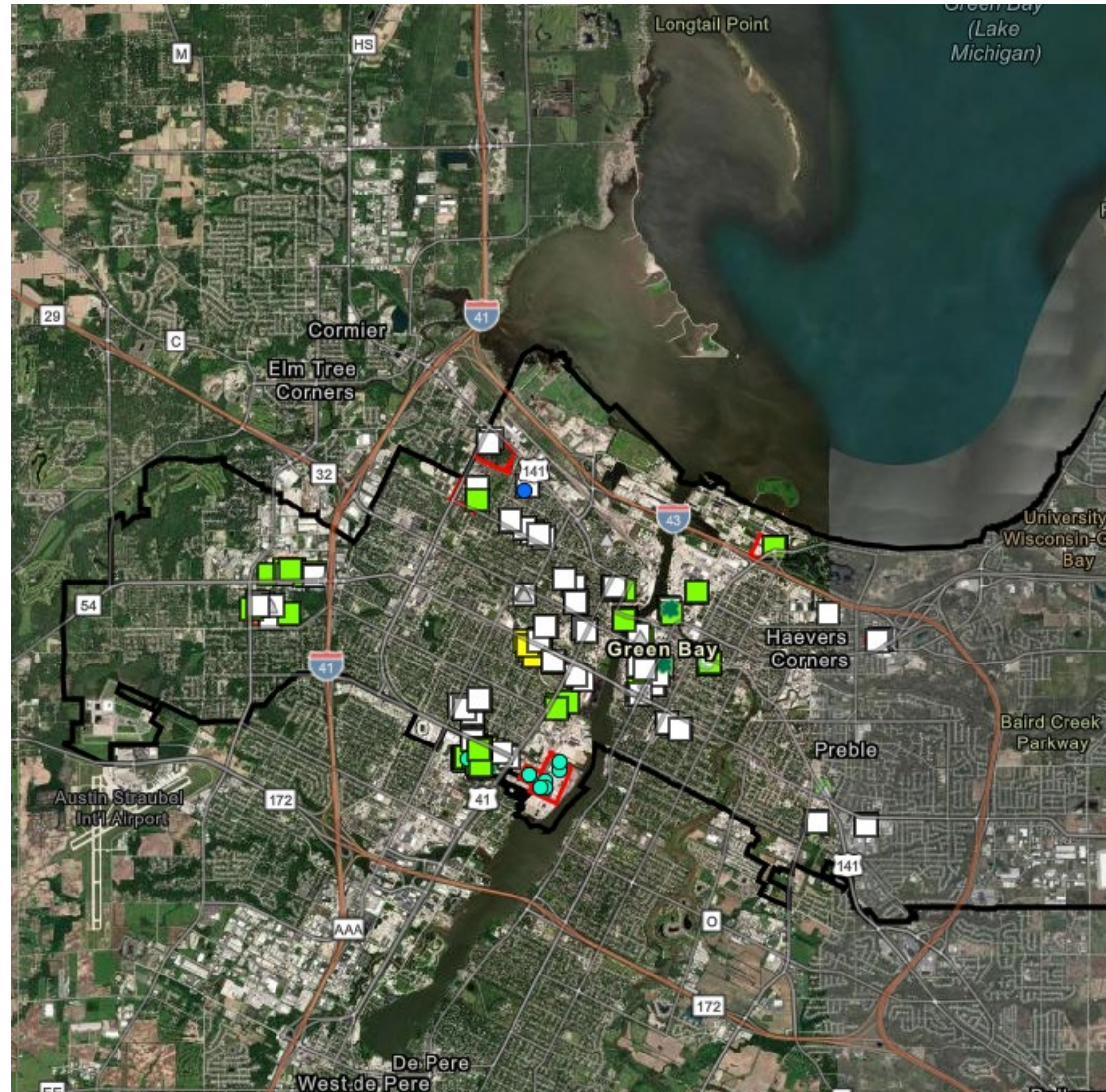


Northern Bioswale = 240 sq. ft.

Southern Bioswale = 295 sq. ft.

Figure 3: Proposed site with bioswales shown as white rectangles.

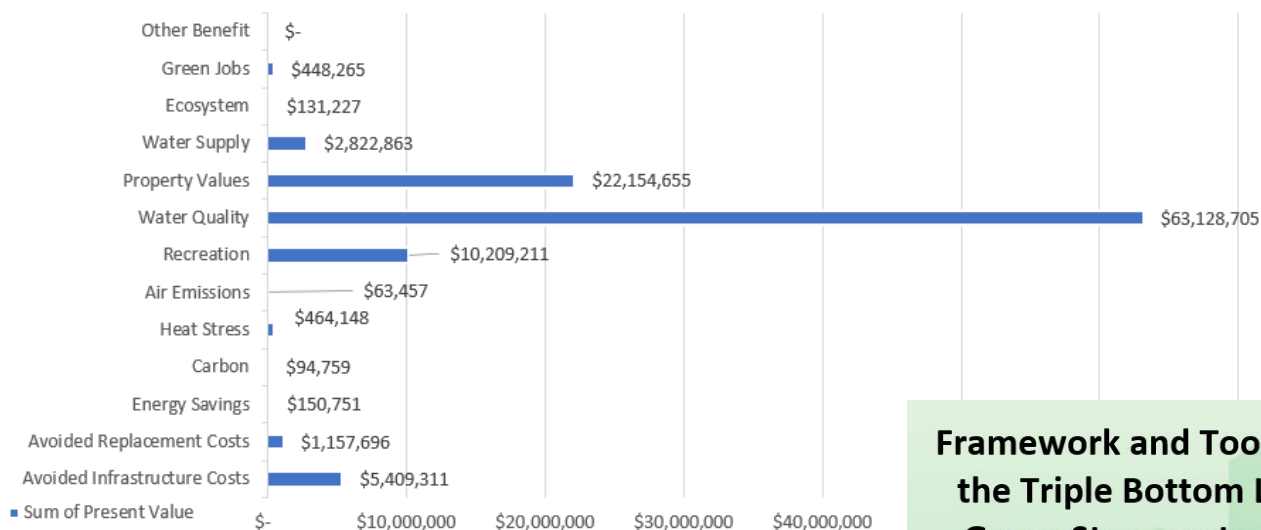
Creation of Maps for Integration to City's GIS



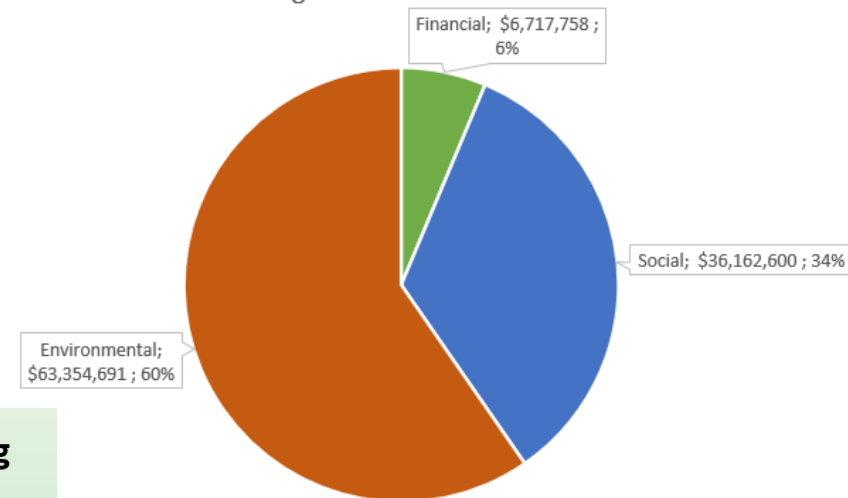
Triple Bottom Line (TBL) Analysis

- Evaluate the projects and/or types of GSI in terms of Economic, Social, and Environmental aspects

Present Value Benefits by GSI Benefit Category



TBL Accounting of GSI Benefits - Present Value



Framework and Tool for Quantifying the Triple Bottom Line Benefits of Green Stormwater Infrastructure



Enter TBL GSI Tool

Evaluation Process for City Staff Use to determine Feasibility of GSI in ROW Projects - Tool

Project Selection Questions	Rating					Weight
	Yes	Probably	Maybe	Unlikely	No	
Project Schedule and Budget						
Is the project construction scheduled for more than 6 months from today			x			3
Is sufficient budget or grant funding available to allow a GSI device?			x			3
Is the roadway/right-of-way designer on board with adding GSI?			x			3
Do you have the necessary staff available to design GSI for this project?		x				4
Project Area Needs						
Is the project area highly rated for water quality needs according to GSI Map 1?	x					5
Is the project area highly rated to be flood prone according to the GSI Map 2?					x	1
Does the project appear in the City's GSI Plan?					x	1
Is there interest for GSI here for other reasons not yet listed?			x			3
Project Area Constraints						
Does the area have high bedrock or high water table (see Map 5)			x			3
Does the area have sandy soils?	x		x			5
Are buried or overhead utilities buried constraints to the project area?*		x				2
Do residents or abutting property owners in favor of GSI?		x				4

GSI Design Guidance for GSI Projects

- Standard Specifications, Construction Details

SECTION XXX STORMWATER BIOSWALE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

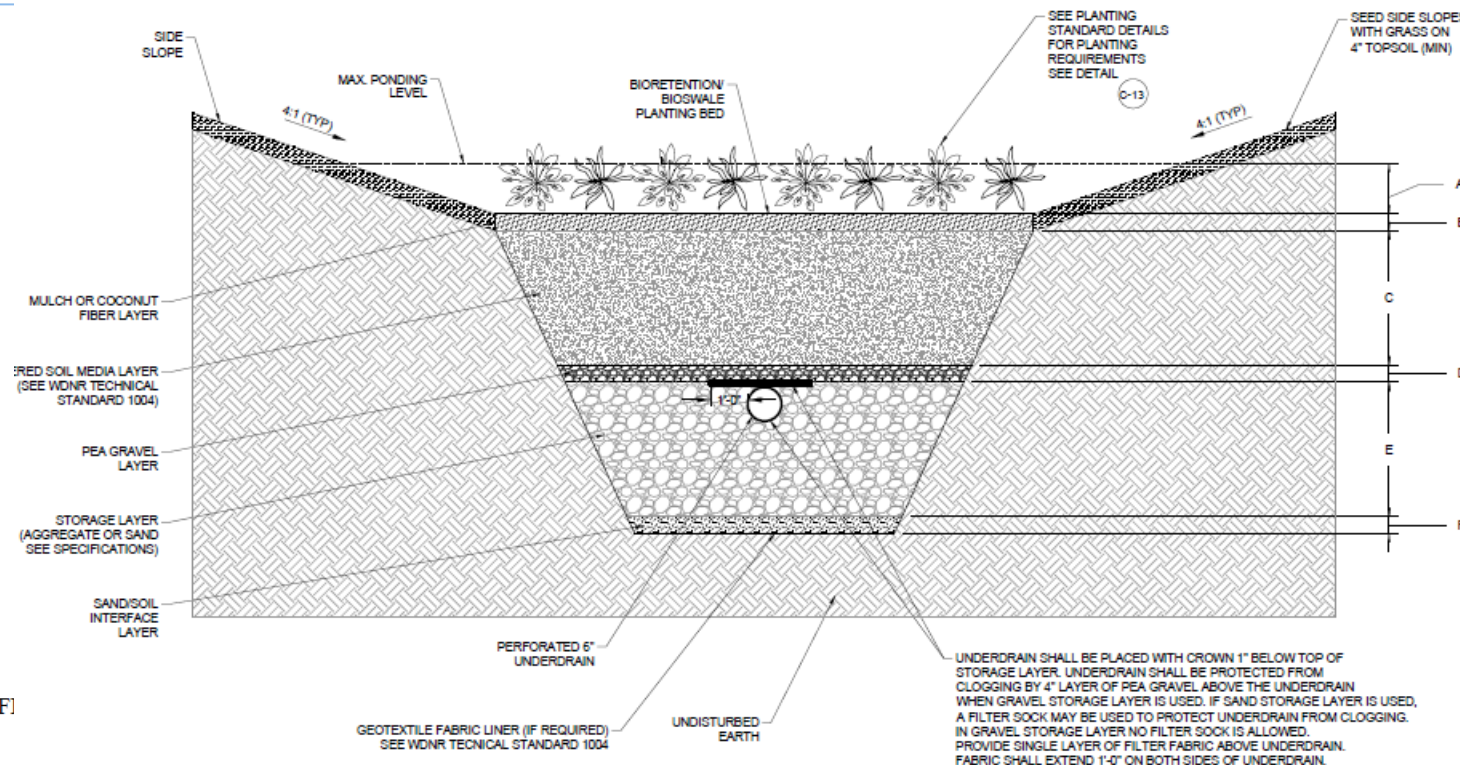
- Stormwater Bioswale
- Erosion Mat
- Site stormwater drainage piping, fitting and accessories.
- Cobble Channel Inlet
- Cobble Drain Inlet

B. Related Sections:

- Section 303 - EXCAVATION.
- Section 305 - FILL.
- Section 306 - GRANULAR BACKFILL.
- Section 308 - PREPARING THE FOUNDATION
- Section 313 - EROSION CONTROL.
- Section 314 - CONSTRUCTION STAKING.
- Section 404 - TRENCH EXCAVATION, BEDDING AND BACKFILL
- Section 413 - SEWER PIPE MATERIALS.
- Section 415 - STORM SEWER PIPES AND LATERALS
- Section 416 - STORM SEWER TRACH GRATES
- Section 418 - CULVERT PIPES
- Section 419 - SEWER STRUCTURES
- Section 421 - MINI STORM SEWERS
- Section 422 - MANHOLE REHABILITATION

1.2 REFERENCES

- ##### A. State of Wisconsin Department of Transportation Standard Specifications for Highway and Structure Construction:
- Section 310 - Open-Graded Base



C-4 BIORETENTION / BIOSWALE TYPICAL CROSS-SECTION

(SLOPED SIDES)

SECTION A

- Maintenance and Operations Guidance

For use by City design and field staff

- Final Plan

Summarizes all phases and deliverables





Questions/Feedback?

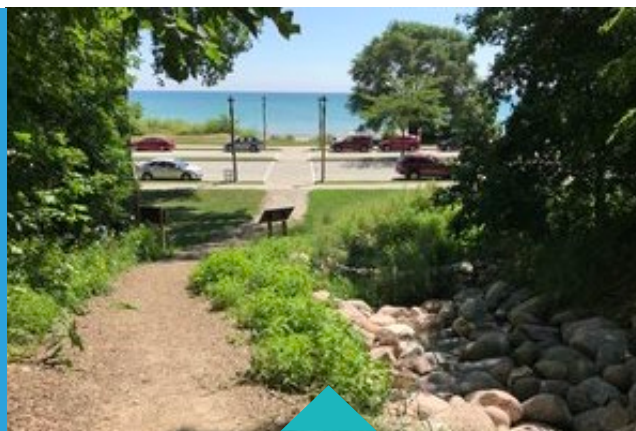
AQUALIS

Thank you!

Carrie Bristol-Groll | cbristollgroll@aqualisco.com

Office: 414-810-1245

Green Infrastructure for Water Quality and Watershed Management



Grey Infrastructure / Traditional Drainage Design



Watershed Modeling for Quality and Quantity



Facility and GI Inspection and Maintenance



Report to the
Sustainability Commission
of the City of Green Bay

MEETING DATE

October 18, 2023

AGENDA ITEM # F.1

To recommend the Citywide GSI Plan to the Improvement & Services Committee for consideration of adoption and implementation.

BACKGROUND

RECOMMENDATION

Recommend moving the GSI Plan forward to the Improvement & Services Committee.

FISCAL IMPACT

ATTACHMENTS

1. Public GSI Project Sheets-r
2. Private GSI Project Sheets-r
3. GSI Plan Maps
4. GSI Evaluation Process for ROW Projects
5. AQ_City of GB GSI OM Guidance FINAL
6. Executive Summary & Draft Report-CoGB GSI Plan



Site Location:

Lincoln Elementary School,

Green Bay, WI

Parcel ID #3-215

GSI Description:

An outdoor classroom featuring permeable pavement which drains to a bioswale. The bioswale is placed along a drainage path on a playground. The proposed bioswale placement would capture the runoff from the paved and unpaved playground and large sodded area. This will result in better water quality and reduced flooding risk.

Drainage Area = 0.790 acres (34,398 sq. ft.)

Proposed Bioswale Area = 0.082 acres (3,558 sq. ft.)

Approximate Cost = \$250,000 + \$3,558/year

Annualized Cost = \$727.59/ lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

0.0967 lbs (52.24%)

Total Suspended Solids Reduction =

22.07 lbs (81.76%)

Volume Captured = 19,045 gallons

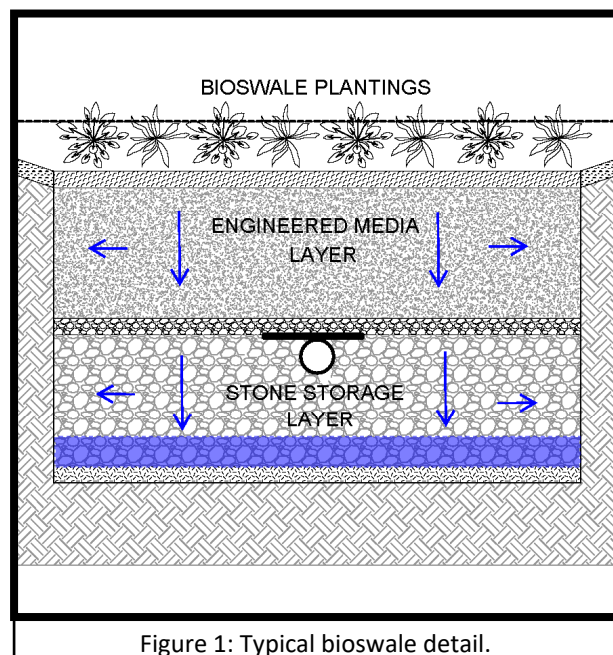


Figure 1: Typical bioswale detail.

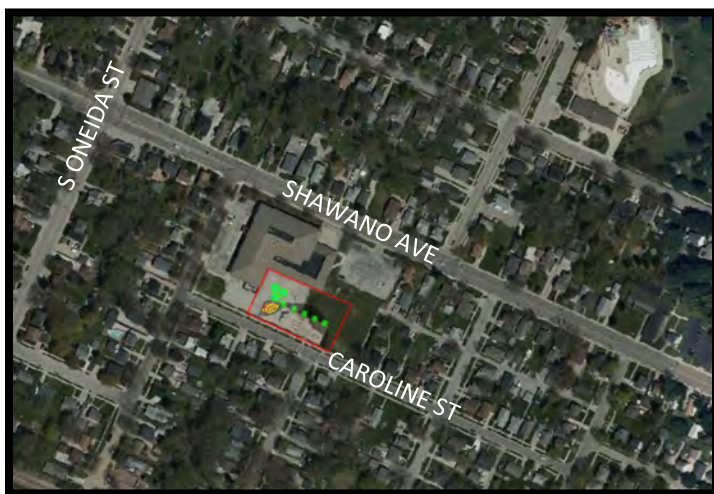


Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site with bioswale area shown by green hatch. Additional project element are called out.



Site Location:

Howard St from S Oakland Ave to S Ashland Ave,
Green Bay, WI

GSI Description:

Four bioswales placed along a mostly residential street. The proposed bioswales would capture stormwater runoff from the street and residential properties before it reaches storm sewer inlets. The bioswales can aid in reducing flood concerns and improving water quality.

Drainage Area = 0.639 acres (27,835 sq. ft.)

Proposed Bioswale Area = 0.014 acres (620 sqft)

Approximate Cost = \$39,000 + \$620/year

Annualized Cost = \$12.83/ lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

0.4545 lbs (61.34%)

Total Suspended Solids Reduction =

200.3 lbs (78.96%)

Volume Captured = 3,194 gallons

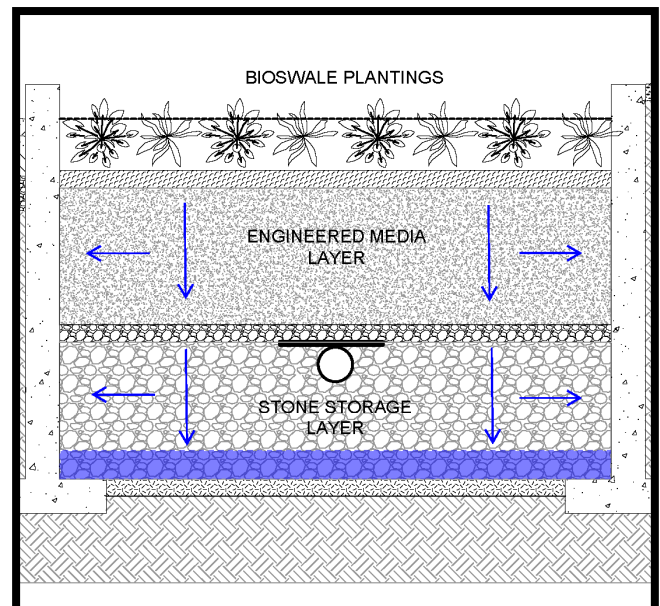


Figure 1: Typical bioswale detail.

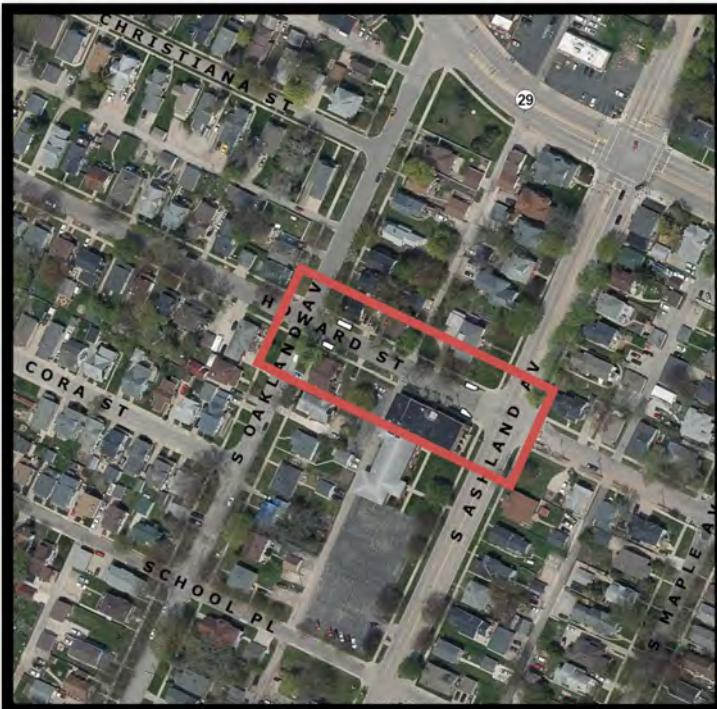


Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site with proposed bioswales in white.



Site Location:

13th Avenue & Clinton St,
Green Bay, WI

Benefits of Captured Stormwater:

Total Phosphorus Reduction = 0.6558 lbs (50.41%)

Total Suspended Solids Reduction = 244.2 lbs (72.39%)

Volume Captured = 18,140 gallons

GSI Description:

Two bioswales placed at low points along street. The proposed bioswale placements would capture stormwater runoff from the street, resulting in improved water quality and a reduced flooding risk.

Drainage Area = 1.489 acres (64,840 sq. ft.)

Proposed Bioswale Area = 0.018 acres (800 sq. ft.)

Approximate Cost = \$35,000 + \$800/year

Annualized Cost = \$10.44 / lb TSS reduction

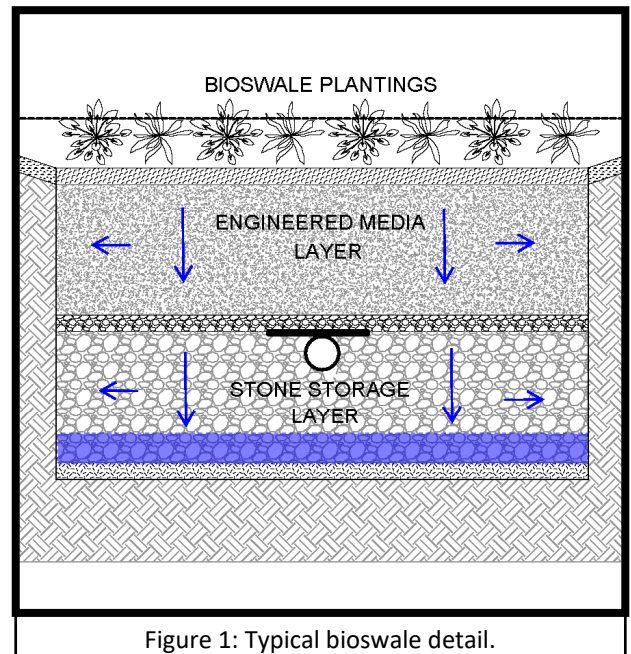


Figure 1: Typical bioswale detail.



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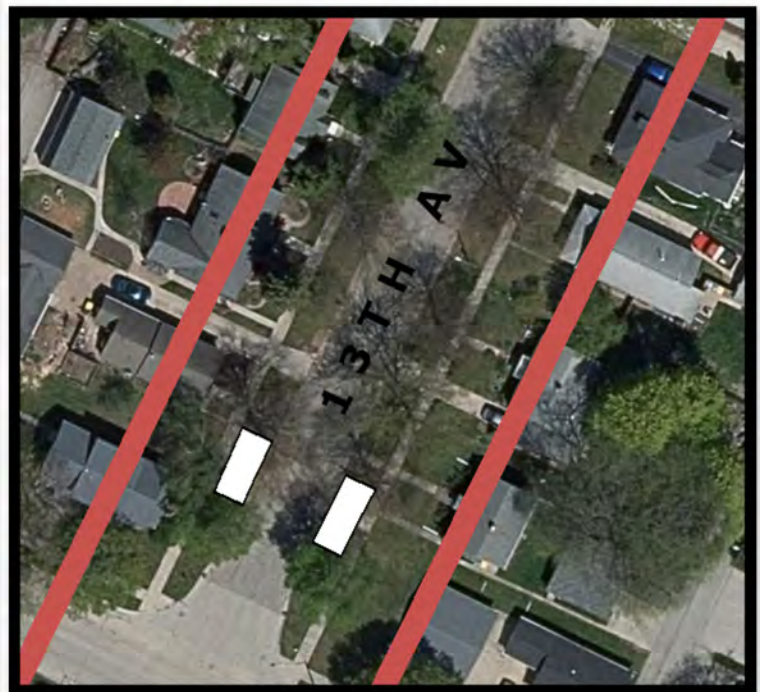


Figure 3: Proposed site showing bioswale areas as white rectangles.



Site Location:

Leonardo Da Vinci School

Green Bay, WI

GSI Description:

A bioswale placed to intercept runoff from the paved playground and grass open space. Trees and ground cover landscaping added to unvegetated area.

Drainage Area = 0.431 acres (18,780 sq. ft.)

Proposed Bioswale Area = 0.68 acres (2970 sq. ft.)

Proposed Tree Cell Area = 0.008 acres (345 sq. ft.)

Approximate Cost = \$85,000 + \$3,000/year

Annualized Cost = \$83.33 / lb TSS reduction



Figure 2: Aerial image of CoGB with the project site outlined.

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

0.2419 lbs (57.25%)

Total Suspended Solids Reduction =

87.0 lbs (79.96%)

Volume Captured = 17,781 gallons

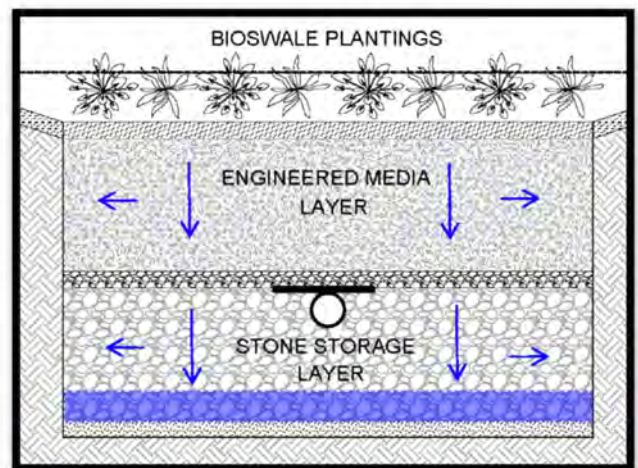


Figure 1: Typical bioswale detail.

Add SW trees and ground cover landscaping to unvegetated area.



Figure 3: Proposed site with bioswale area shown in white and tree shown by green and blue outlined circles.



Site Location:

N Washington St from Northland Ave to Cherry St,
Green Bay, WI

GSI Description:

A bioswale on the side of a street, collecting water through curb cut. The proposed bioswale would capture the stormwater runoff from a part of the street length, resulting in better water quality.

Drainage Area = 0.119 acres (5,170 sq. ft.)

Proposed Bioswale Area = 0.005 acres (200 sq. ft.)

Approximate Cost = \$15,000 + \$300/year

Annualized Cost = \$10.02 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

0.1632 lbs (75.54%)

Total Suspended Solids Reduction =

104.8 lbs (81.18%)

Volume Captured = 696 gallons

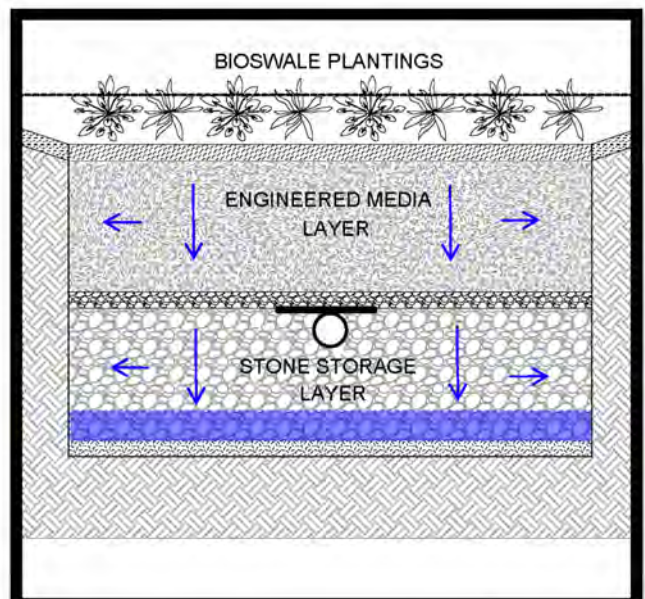


Figure 1: Typical bioswale detail.



Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site showing bioswale area as white rectangles.

Site Location:

S Jefferson St & Stuart St,
Green Bay, WI

GSI Description:

Two bioswales placed at low points along streets. The proposed bioswale placements would capture the stormwater runoff from the street, resulting in better water quality and a reduced flood risk.

Drainage Area = 0.294 acres (12,800 sq. ft.)

Proposed Bioswale Area = 0.01 acre (535 sq.ft.)

Approximate Cost = \$27,000 + \$535/year

Annualized Cost = \$6.99 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =
0.4199 lbs (78.33%)

Total Suspended Solids Reduction =
269.5 lbs (81.26%)

Volume Captured = 2,506 gallons

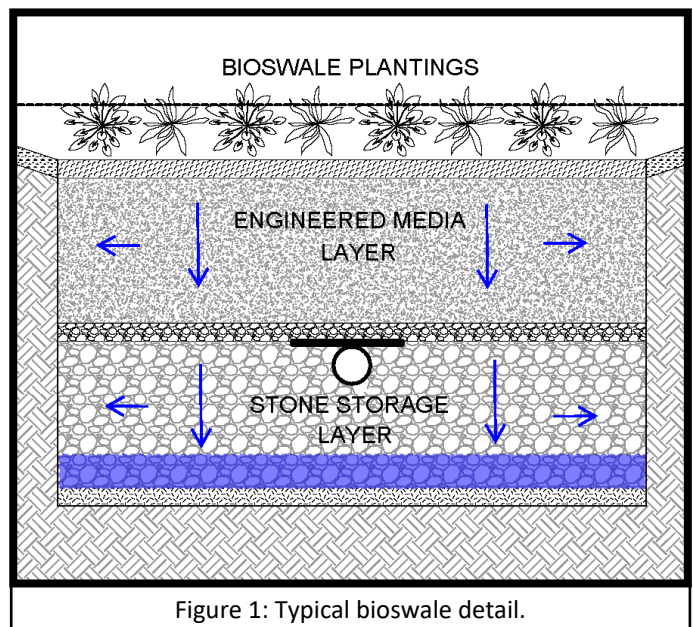


Figure 2: Aerial image of CoGB with the project site outlined in red.



Figure 3: Proposed site with bioswales shown as white rectangles.



Site Location:

S Madison St & Moravian St,
Green Bay, WI

GSI Description:

A bioswale placed along section of S Madison Street. The proposed bioswale placement would capture the runoff from the street, resulting in better water quality and a reduced flood risk.

Drainage Area = 0.192 acres (8350 sq. ft.)

Proposed Bioswale Area = 0.007 acres (305 sq. ft.)

Approximate Cost = \$18,000 + \$305/year

Annualized Cost = \$6.85 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

0.274 lbs (75.74%)

Total Suspended Solids Reduction =

175.9 lbs (81.15%)

Volume Captured = 1,945 gallons

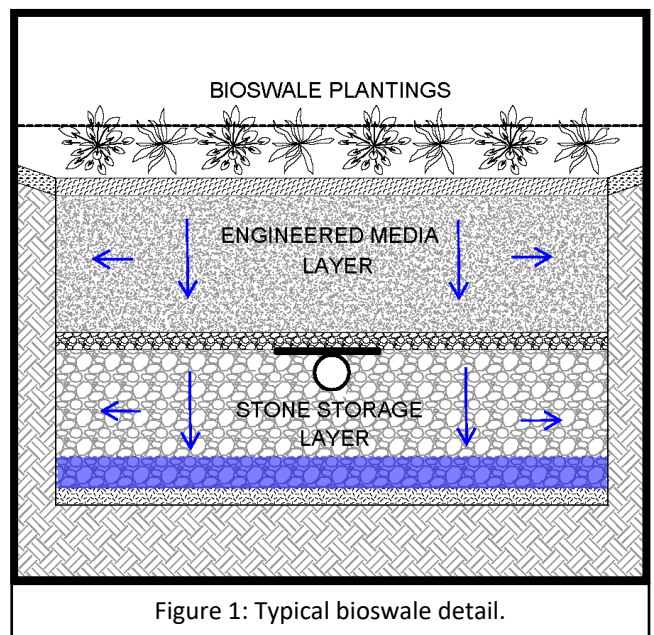


Figure 1: Typical bioswale detail.



Figure 2: Aerial image of CoGB with the project site outlined in red.



Figure 3: Proposed site with the bioswale shown as a white rectangle.



Site Location:

Howe Elementary School

525 S Madison St, Green Bay, WI

GSI Description:

Two bioswales placed at low points in paved parking areas. A raingarden placed on the side of the building. Permeable pavers for a section of parking lot. The proposed bioswale, raingarden, and permeable pavement placements would capture the stormwater runoff from paved parking and increase greenspace, resulting in reduced flood risk, better water quality and environmental benefits for the school.

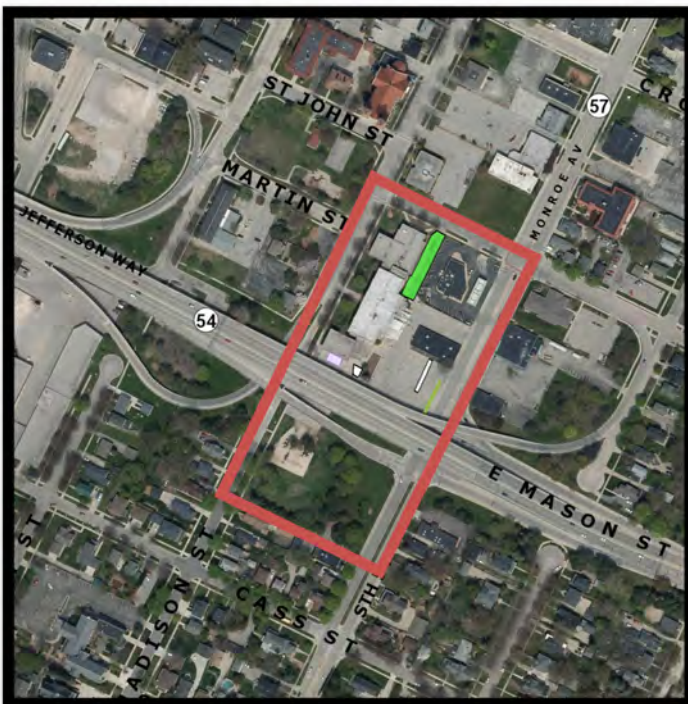


Figure 1: Aerial image of CoGB with the project site outlined.

Benefits of Captured Stormwater:

Total Phosphorus Reduction = 0.3304 lbs (68.65%)

TSS Reduction = 204.8 lbs (84.04%)

Volume Captured = 16,113 gallons

Drainage Area = 0.570 acres (24,810 sq. ft.)

Proposed Total Bioswale Area = 0.032 acres (1,400 sq. ft.)

Proposed Total PP Area = 0.141 acres (6,130 sq. ft.)

Proposed Total Rain Garden Area = 0.018 acres (800 sq. ft.)

Approximate Cost = \$315,000 + \$4,865/year

Annualized Cost = \$100.66/lb TSS reduction



Figure 2: Proposed site with bioswales shown as white rectangles, permeable paver area shown in green with black border, rain garden shown in purple, and removed pavement buffer shown in green.

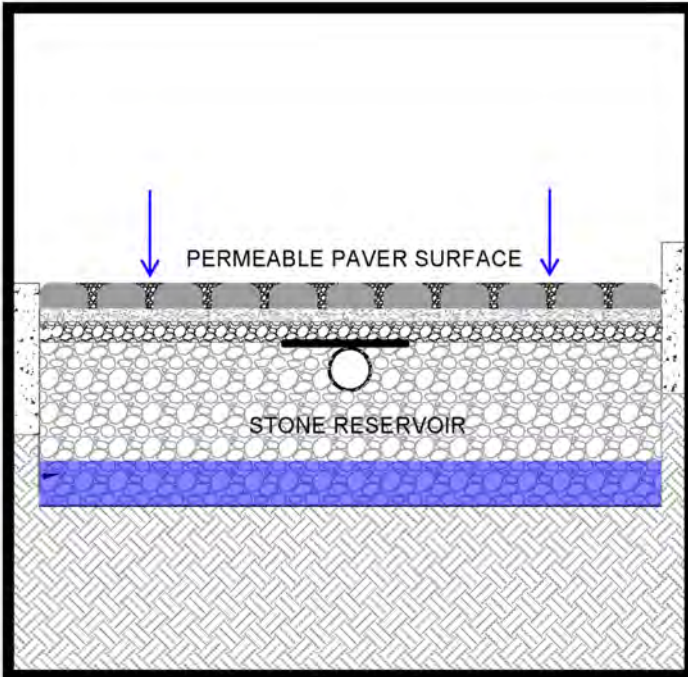


Figure 3: Typical permeable paver detail.

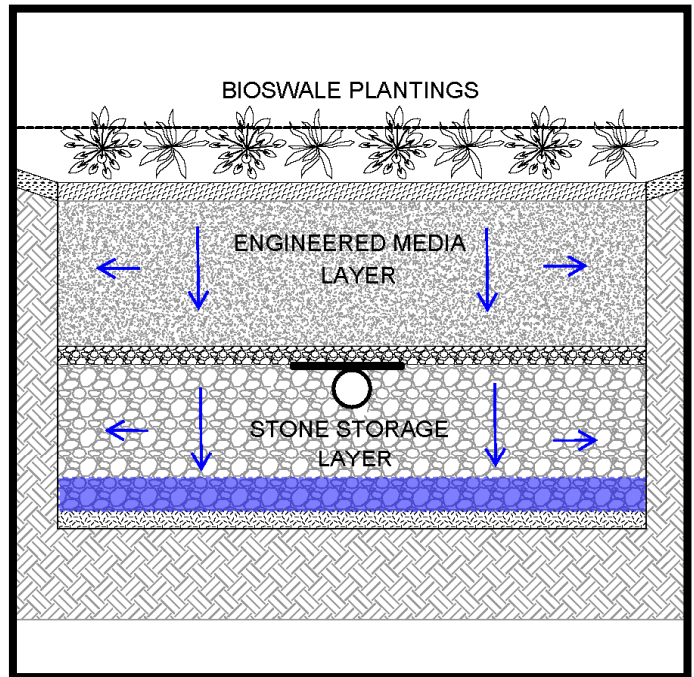


Figure 4: Typical bioswale detail.



Figure 5: Proposed site with permeable paver area shown in green.

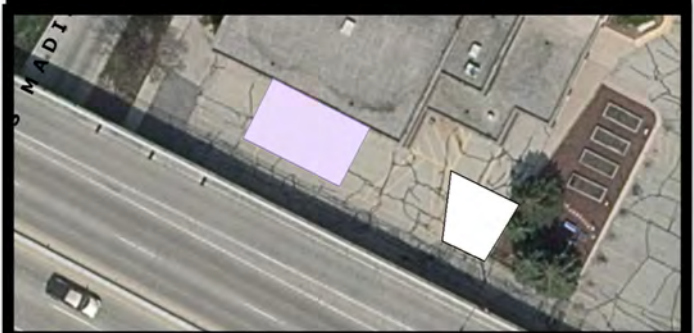


Figure 6: Proposed site with bioswales in white, pavement removal buffer in green, and rain garden in purple.



Site Location:

Dr. Rosa Minoka-Hill School, Green Bay, WI

Parcel ID #14-10

GSI Description:

A rain garden to collect runoff from a paved and unpaved playground. Permeable pavers placed to intercept runoff from the two sections of parking lot.

Drainage Area = 2.725 acres (118,720 sq. ft.)

Proposed PP Area = 0.15 acres (6,534 sq. ft.)

Proposed Rain Garden Area = 0.007 acres (290 sf)

Approximate Cost = \$285,000 + \$1,900/year

Annualized Cost = \$59.46 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction = 0.4371 lbs (66.05%)

Total Suspended Solids Reduction = 271.6 lbs (80.79%)

Volume Captured = 17,071 gallons

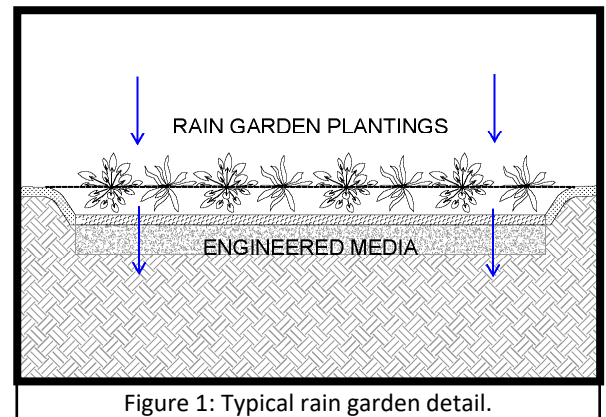


Figure 1: Typical rain garden detail.

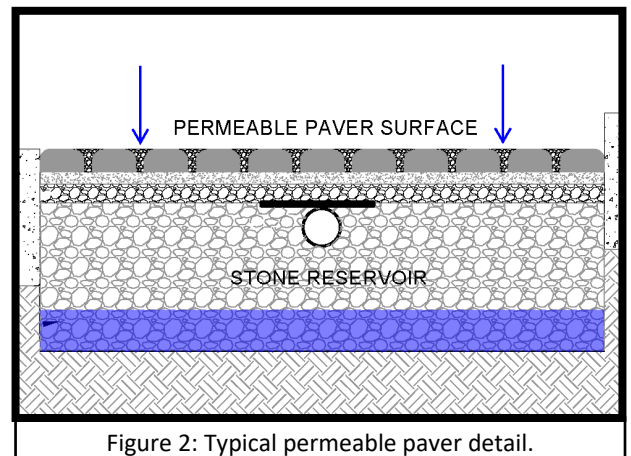


Figure 2: Typical permeable paver detail.



Figure 3: Aerial image of CoGB with the project site outlined.

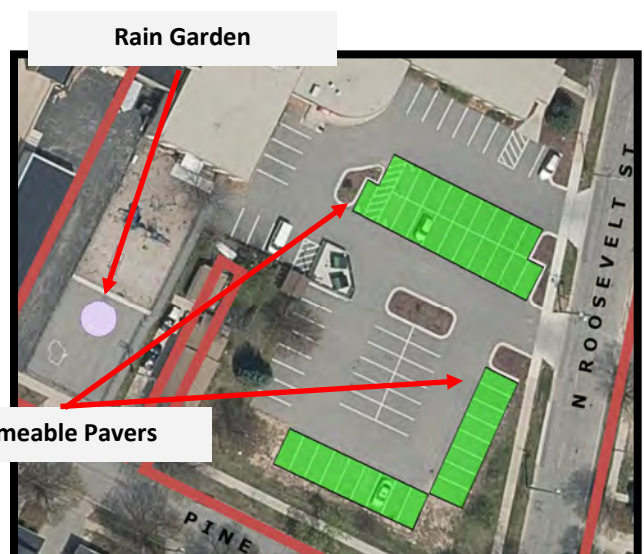


Figure 4: Proposed site with permeable paver areas denoted in green and rain garden area denoted in purple.



Site Location:

S Quincy St from Chicago St to Stuart Street,
Green Bay, WI

GSI Description:

Three bioswales placed before inlets along the street. The proposed bioswale placements would capture stormwater runoff from the street, resulting in improved water quality.

Drainage Area = 3.163 acres (137,790 sq. ft.)

Proposed Bioswale Area = 0.018 acres (780 sq. ft.)

Approximate Cost = \$39,000 + \$780/year

Annualized Cost = \$5.48/ lb TSS removal

Benefits of Captured Stormwater:

Total Phosphorus Reduction = 1.301 lbs
(45.36%)

Total Suspended Solids Reduction =
498.3 lbs (63.74%)

Volume Captured = 37,836 gallons

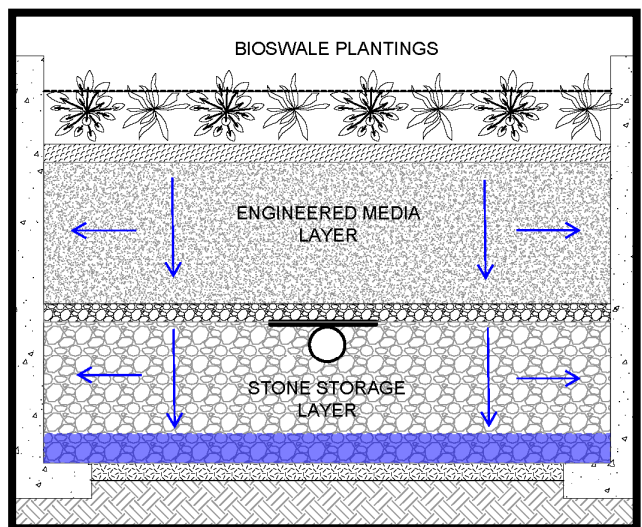


Figure 1: Typical bioswale detail.



Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site showing bioswale areas as white rectangles.



Site Location:

Cass St at S Clay St & S Roosevelt St,
Green Bay, WI

GSI Description:

Four bioswales placed before inlets along the street. The proposed bioswale placements would capture stormwater runoff from the street, resulting in improved water quality.

Drainage Area = 4.558 acres (198,540 sq. ft.)

Proposed Bioswale Area= 0.033 acres (1440 sq. ft.)

Approximate Cost = \$62,500 + \$1,440 / year

Annualized Cost = \$6.02 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

1.998 lbs (49.13%)

Total Suspended Solids Reduction =

757.7 lbs (68.82%)

Volume Captured = 59,216 gallons

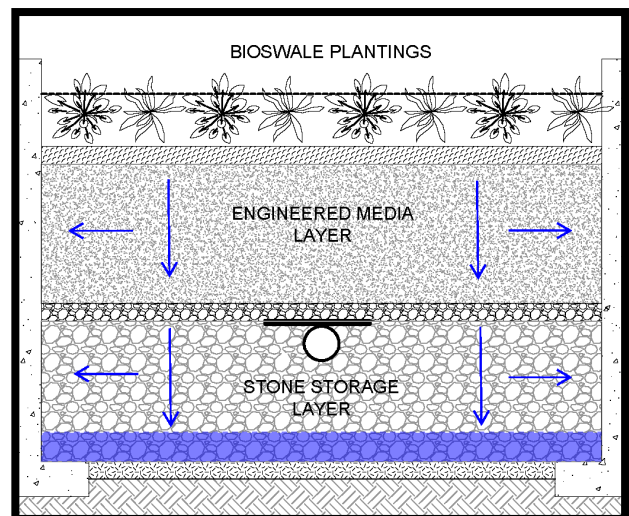


Figure 1: Typical bioswale detail.



Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site showing bioswale areas as white rectangles.



Site Location:

Packerland Drive, South of Mason Street

Green Bay, WI

GSI Description:

One section of permeable pavement (PP) that would be installed in the northbound parking lane. The PP will capture, treat, and temporarily store runoff before conveying flows to the existing storm sewer. This process would improve the stormwater quality in this high traffic area.

Drainage Area = 0.85 acres (36,850 sq. ft.)

Proposed PP Area = 0.07 acres (3,160 sq. ft.)

Approximate Cost = \$150,000 + \$1,580/year

Annualized Cost = \$10.97 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

1.322 lbs (76.97%)

Total Suspended Solids Reduction =

828 lbs (82.06%)

Volume Captured = 2,506 gallons

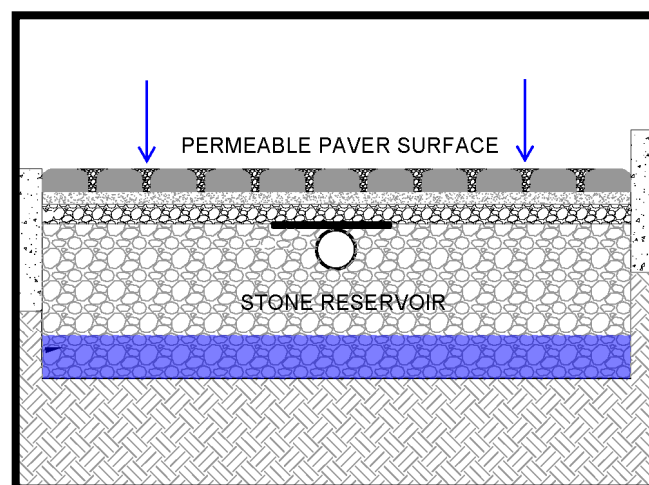


Figure 1: Typical permeable pavement detail.

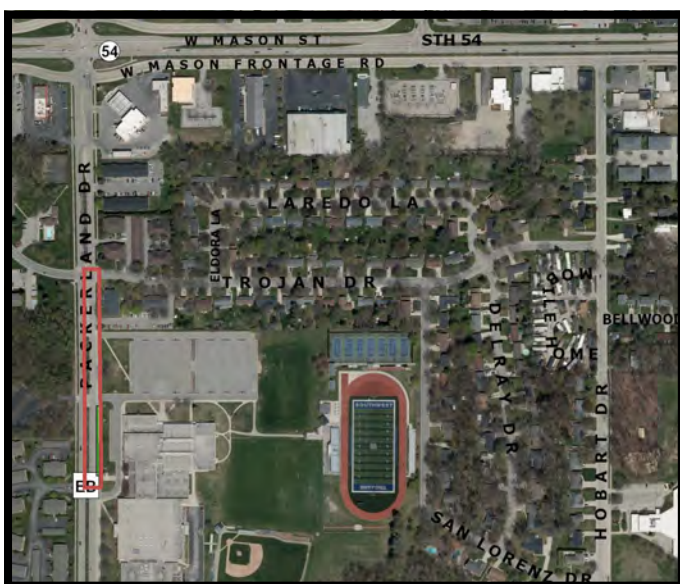


Figure 2: Aerial image of the CoGB with the proposed project site outlined in red.



Figure 3: Proposed site with PP area shown as a green rectangle.



Site Location:

Southwest High School

Packer Dr, Green Bay, WI

GSI Description:

Two bioswales to be placed in medians in the northern parking lot. Another bioswale placed at the western side the of the northern parking lot, to capture stormwater at a low point. The proposed bioswale placements would capture the stormwater runoff from paved parking, resulting in better water quality.

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

1.734 lbs (67.17%)

Total Suspended Solids Reduction = 1,215 lbs (78.24%)

Volume Captured = 156,059 gallons

Drainage Area = 3.363 acres

(146,490 sq. ft.)

Proposed Total Bioswale Area =

0.178 acres (7,755 sq. ft.)

Approximate Cost = \$235,000 + \$5,000/year

Annualized Cost = \$13.79 / lb TSS reduction



Figure 1: Aerial image of CoGB with the project site outlined.



Figure 2: Proposed site with bioswales shown as by white rectangles.



Site Location:

Lombardi Ave from Gross St to S Northwood Ave,
Green Bay, WI

GSI Description:

Ten bioswales placed along street. The proposed bioswale placements would capture the stormwater runoff from the street, resulting in better water quality.

Drainage Area = 0.717 acres (31,230 sq. ft.)

Proposed Bioswale Area = 0.07 acre (2,900 sq. ft.)

Approximate Cost = \$140,000 + \$2,900/year

Annualized Cost = \$6.94 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

2.266 lbs (92.71%)

Total Suspended Solids Reduction =

1427 lbs (94.48%)

Volume Captured = 14,490 gallons

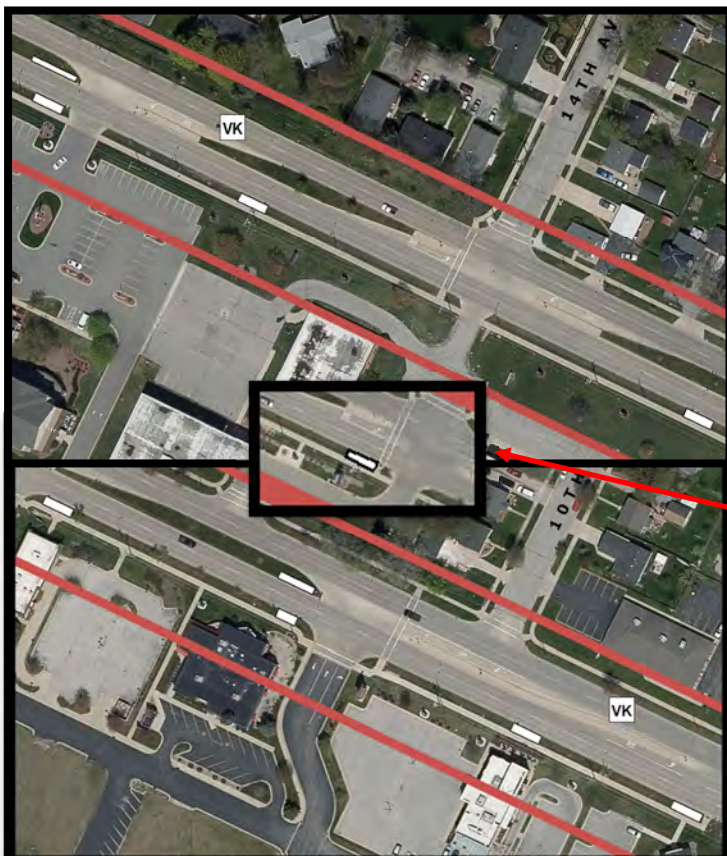
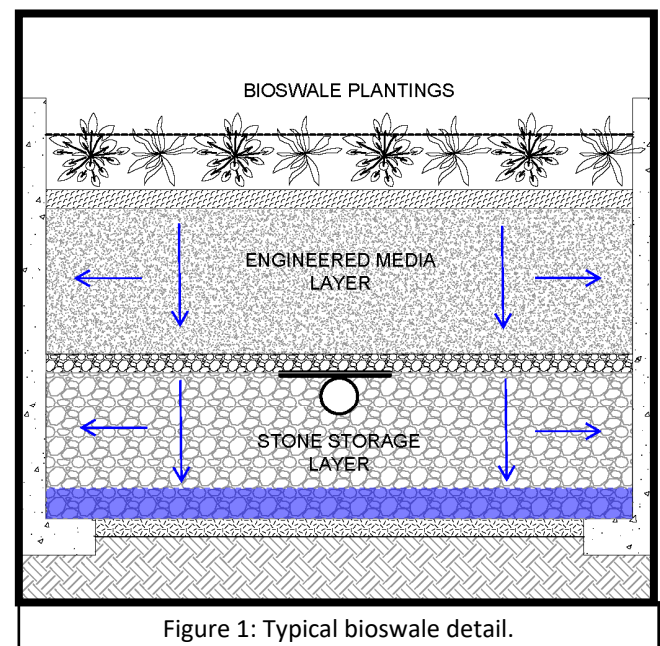


Figure 3: Proposed site with bioswales shown as white rectangles.

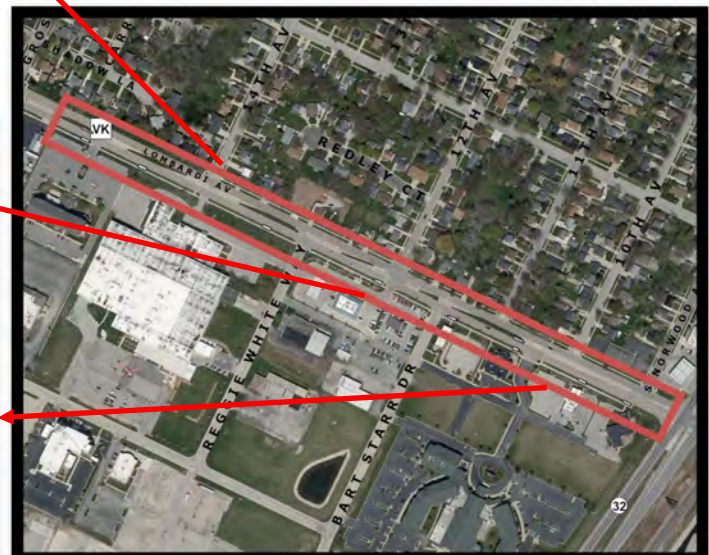


Figure 2: Aerial image of CoGB with the project site outlined.



Site Location:

Liberty St from S Oneida St to Sue Lane,
Green Bay, WI

GSI Description:

Bioswales placed at low points along street. The proposed bioswale placements would capture the runoff from the street, resulting in better water quality.

Drainage Area = 3.069 acres (133,670 sq. ft.)

Proposed Bioswale Area = 0.043 acres (1860 sq. ft.)

Approximate Cost = \$85,000 + \$1,860/year

Annualized Cost = \$9.56 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

1.744 lbs (59.28%)

Total Suspended Solids Reduction =

639.3 lbs (78.36%)

Volume Captured = 35,076 gallons

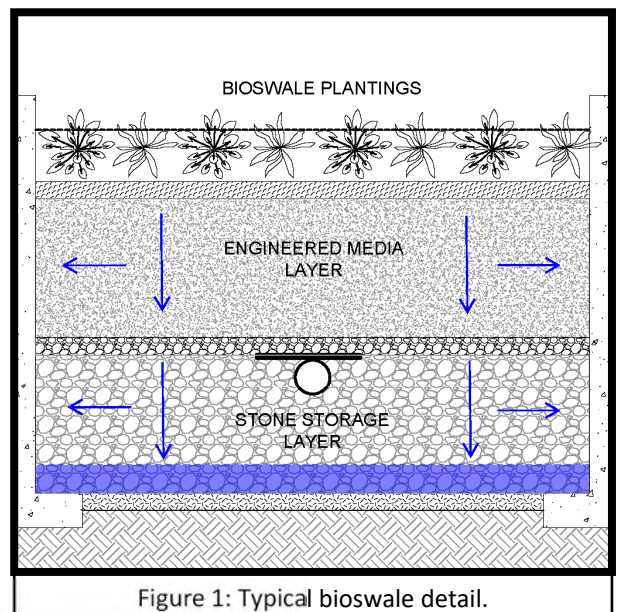


Figure 1: Typical bioswale detail.



Figure 2: Aerial image of CoGB with the project site outlined.

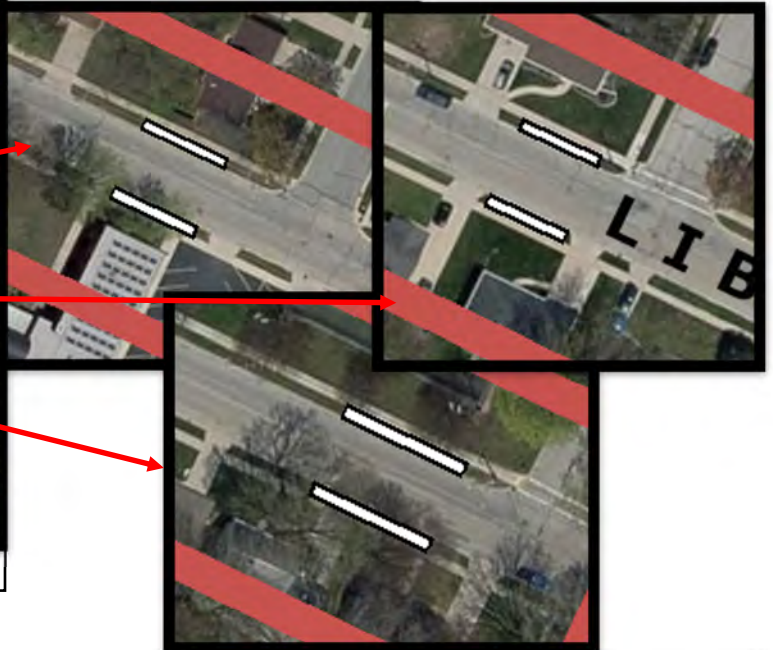


Figure 3: Proposed site with bioswale areas denoted by white rectangles.



Site Location:

Biemeret St & Sue Lane,
Green Bay, WI

GSI Description:

Bioswales placed at low points along street. The proposed bioswale placements would capture the stormwater runoff from the street, resulting in better water quality.

Drainage Area = 1.057 acres (46,035 sq. ft.)

Proposed Bioswale Area = 0.015 acres (675 sq. ft.)

Approximate Cost = \$30,000 + \$675/year

Annualized Cost = \$8.04/ lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

0.5479 lbs (58.77%)

Total Suspended Solids Reduction =

270.6 lbs (78.67%)

Volume Captured = 10,779 gallons

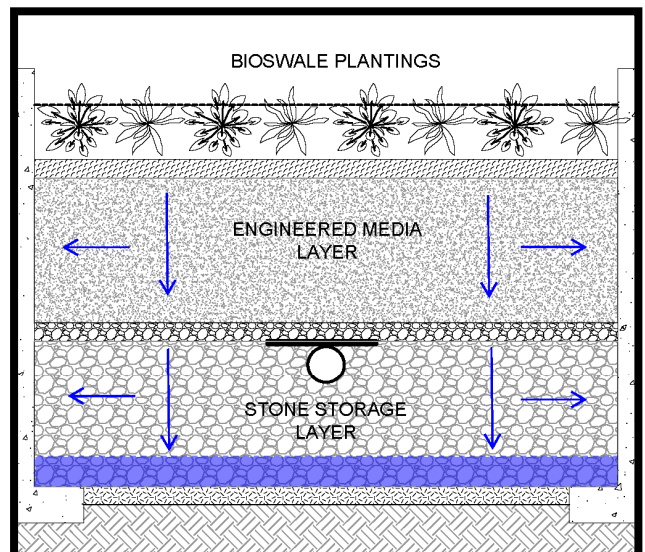


Figure 1: Typical bioswale detail.

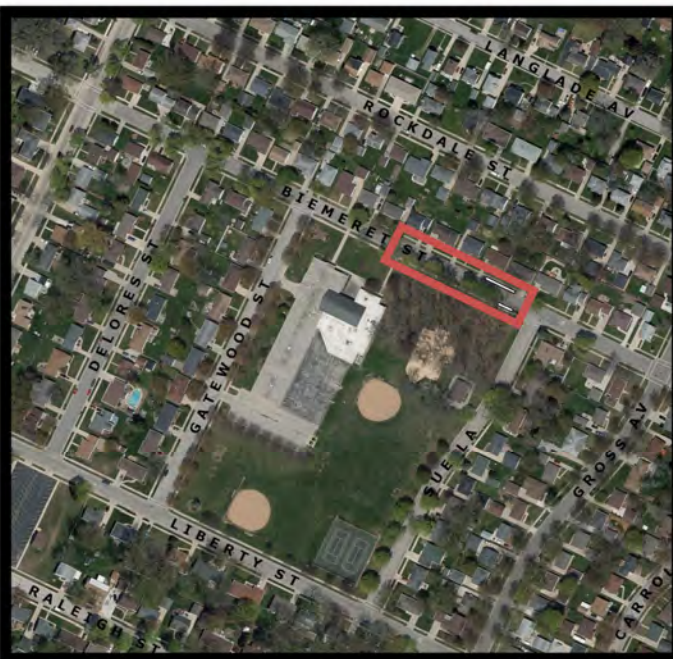


Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site. The bioswales are shown as white rectangles.



Site Location:

2300—2500 Farlin Avenue, Green Bay, WI

GSI Description:

A series of 3 bioswales installed in the ROW along the southern edge of Farlin Avenue would maximize pollutant reduction while minimizing the footprint. The proposed locations for the bioswales have been chosen due to their proximity to the catch basins and distance from other utilities.

Drainage Area = 0.43 acres (18,730 sq. ft.)

Proposed Bioswale Areas = 0.03 acres (1,500 sq.ft)

Approximate Cost = \$67,500 + \$1,500/year

Annualized Cost = \$20.47/ lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction = 0.5490 lbs (62.32%)

Total Suspended Solids Reduction =

238.1 lbs (80.32%)

Volume Captured = 6,112 gallons

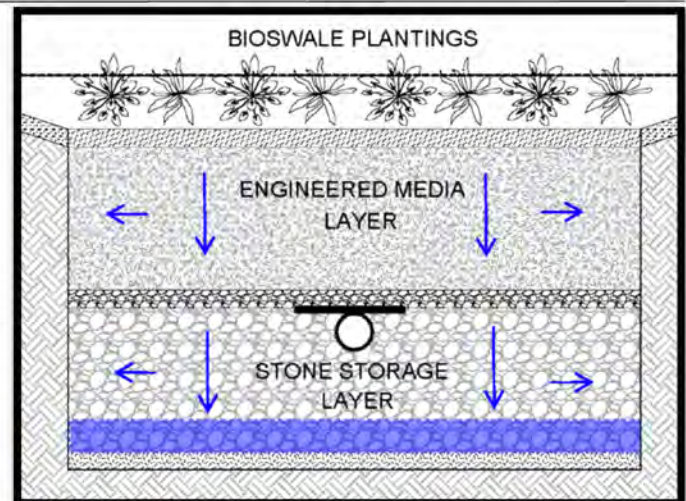


Figure 1: Typical bioswale detail.



Figure 2: Aerial image of CoGB with the project site outlined .

Figure 3: Proposed site with the bioswale areas shown as a white rectangles.





Site Location:

Mather Heights Park, Green Bay, WI

Parcel # 18-1366

GSI Description:

Underground storage beneath playground area. A bioswale placed to intercept runoff from the park's open space and baseball field. The proposed storage and bioswale placements would capture runoff from large grass areas of the park, resulting in better water quality.

Drainage Area = 2.73 acres (118,720 sq. ft.)

Proposed Bioswale Area = 0.15 acres
(6,710 sq. ft.)

Proposed Storage Area = 0.236 acres
(10,280 sq. ft.)

Approximate Cost = \$260,000 + \$4,250/year

Annualized Cost = \$18.63 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

0.7377 lbs (55.13%)

Total Suspended Solids Reduction =

159.3 lbs (85.42%)

Volume Captured = 90,469 gallons

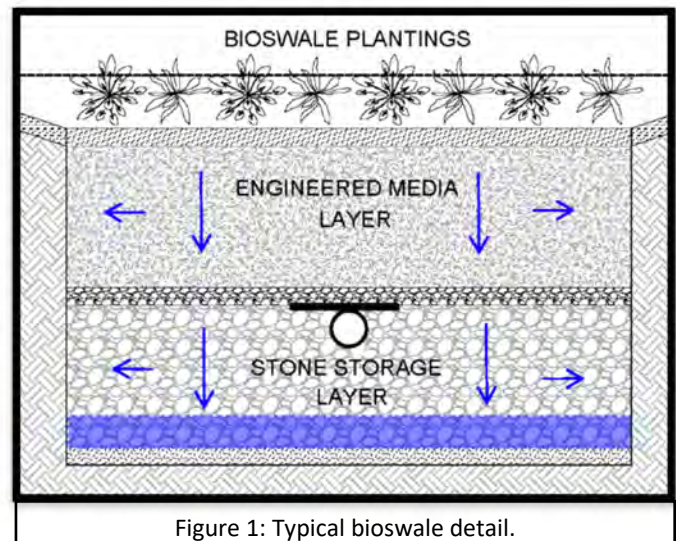


Figure 1: Typical bioswale detail.

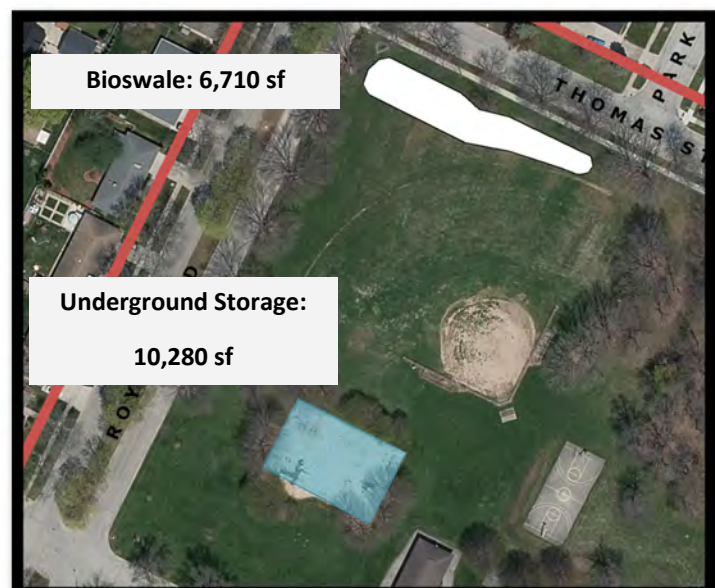


Figure 3: Proposed site with underground storage area denoted in blue and bioswale area denoted in white.



Figure 2: Aerial image of CoGB with the project site outlined.



Site Location:

Mather St from Royal Blvd to N Buchanan St,
Green Bay, WI

GSI Description:

Nine bioswales placed before inlets along the street. The proposed bioswale placements would capture stormwater runoff from the street, resulting in better water quality.

Drainage Area = 4.778 acres (208,140 sq. ft.)

Proposed Bioswale Area = 0.041 acres (1770 sq. ft.)

Approximate Cost = \$90,000 + \$1,770/year

Annualized Cost = \$6.77 / lb TSS removal

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

2.394 lbs (50.09%)

Total Suspended Solids Reduction =

925.8 lbs (69.19%)

Volume Captured = 40,514 gallons

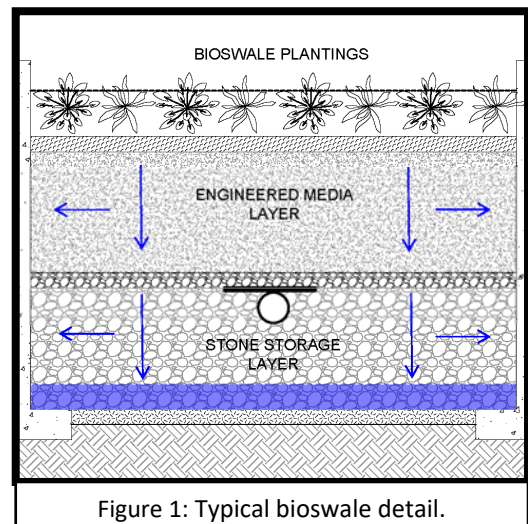


Figure 1: Typical bioswale detail.

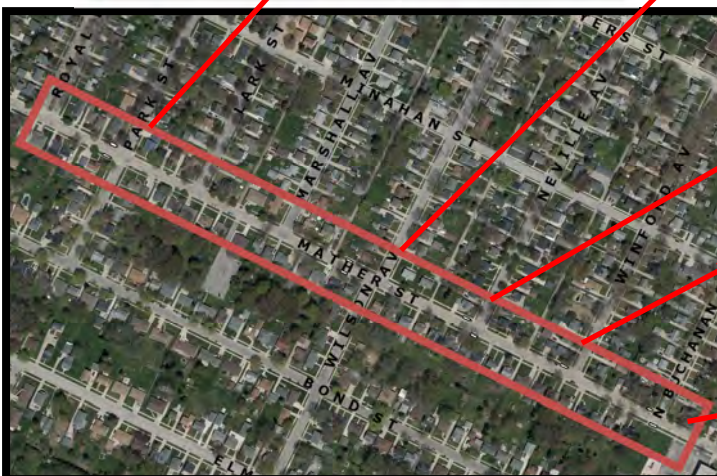


Figure 2: Aerial image of CoGB with the project site outlined.

Figure 3: Proposed site showing bioswale areas as white rectangles.



Site Location:

Elmore St & N Maple Ave,
Green Bay, WI

GSI Description:

Four bioswales placed at low points along streets. The proposed bioswale placements would capture the stormwater runoff from the street, resulting in better water quality.

Drainage Area = 1.652 acres (71,980 sq. ft.)

Proposed Bioswale Area = 0.028 acre (1200 sq. ft.)

Approximate Cost = \$58,500 + \$1,200/year

Annualized Cost = \$12.60 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

0.8733 lbs (57.49%)

Total Suspended Solids Reduction =

327.4 lbs (77.36%)

Volume Captured = 18,986 gallons

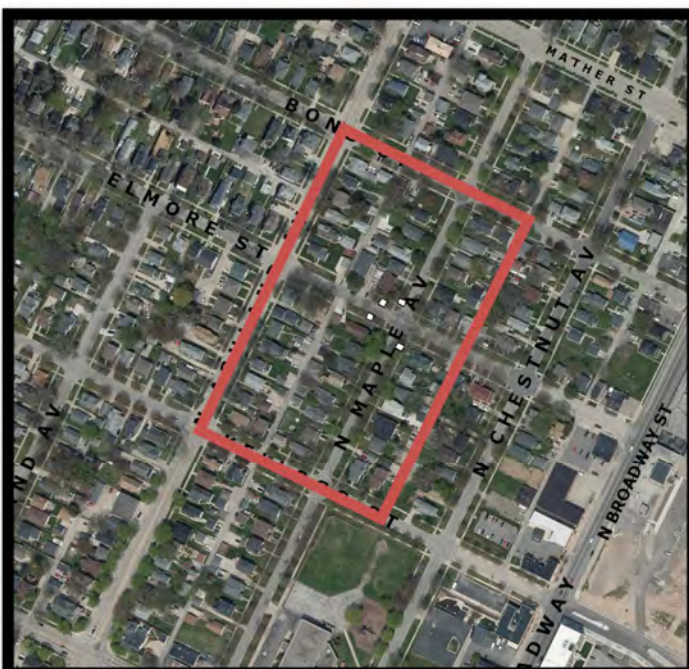
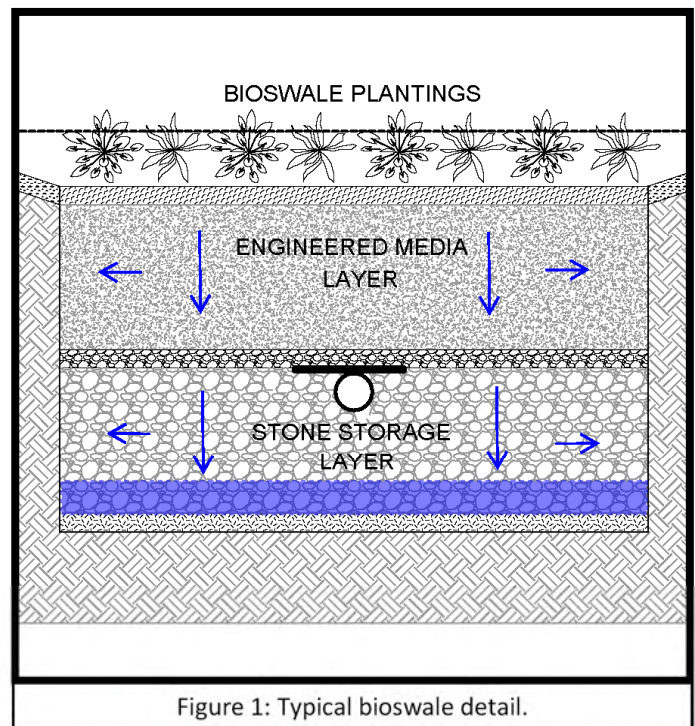


Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site with bioswales shown as white rectangles.



Site Location:

Division St from Northern Ave to Vroman St
Green Bay, WI

GSI Description:

Two bioswales placed before inlets along the street. The proposed bioswale placements would capture stormwater runoff from the street, resulting in better water quality.

Drainage Area = 1.579 acres (68,780 sq. ft.)

Proposed Bioswale Area = 0.014 acres (600 sq. ft.)

Approximate Cost = \$29,000 + \$600/year

Annualized Cost = \$5.87 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

0.8760 lbs (46.77%)

Total Suspended Solids Reduction =

349.3 lbs (61.87%)

Volume Captured = 17,273 gallons

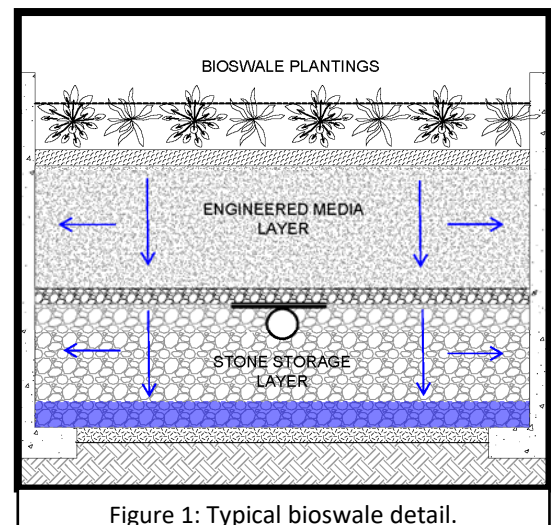


Figure 1: Typical bioswale detail.

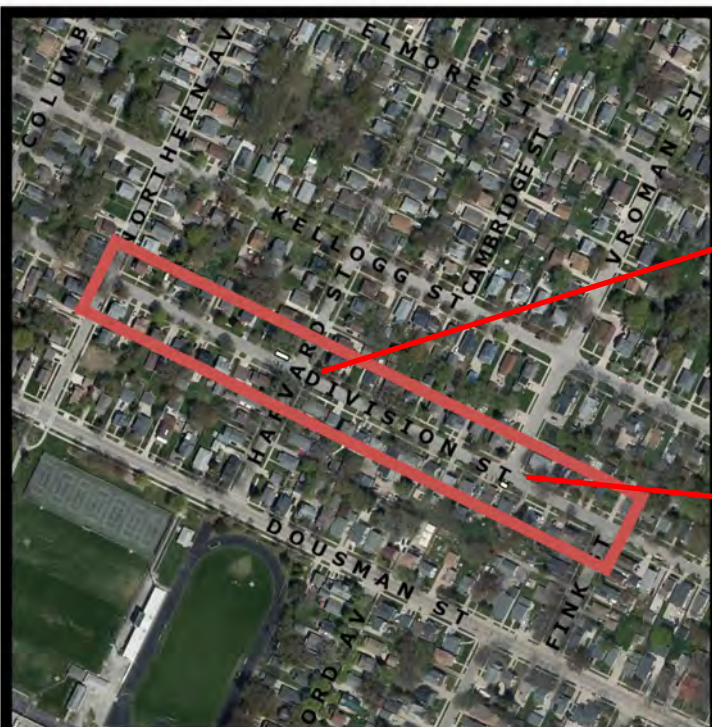


Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site showing bioswale areas as white rectangles.



Site Location:

Alley between N Chestnut Ave & N Broadway
From Bond St to Elmore St

GSI Description:

Permeable pavers (PP) in an alley, that will store and treat stormwater, as well as convey excess water to existing structures. The proposed PP placement would capture runoff from the neighboring residential plots and the alley, resulting in better water quality.

Drainage Area = 0.668 acres (29,090 sq. ft.)

Proposed PP Area = 0.027 acres (1176 sq. ft.)

Approximate Cost = \$75,000 + \$588/year

Annualized Cost = \$53.89 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

0.2145 lbs (56.11%)

Total Suspended Solids Reduction =

80.50 lbs (81.49%)

Volume Captured = 21,477 gallons

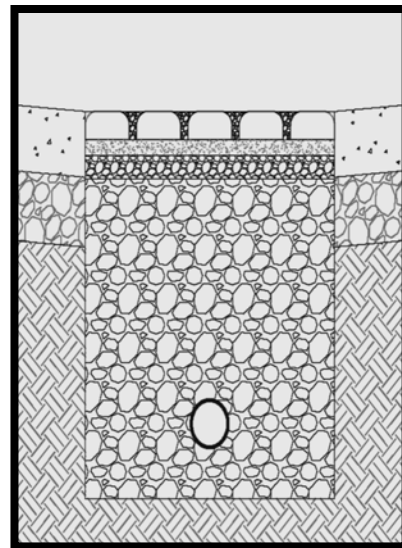


Figure 1: Typical permeable pav-



Figure 2: Aerial image of the CoGB with the project area located inside the red rectangle.



Figure 3: Proposed site with the permeable pavers shown as green rectangles.



Site Location:

4th Street bound by

S Broadway Street and S Maple Avenue

Description:

The Chestnut and 4th St. intersection is in a low spot and has flooding issues. The 3 proposed bioswales in the ROW will capture and treat the runoff to reduce flood risk and also improve water quality.

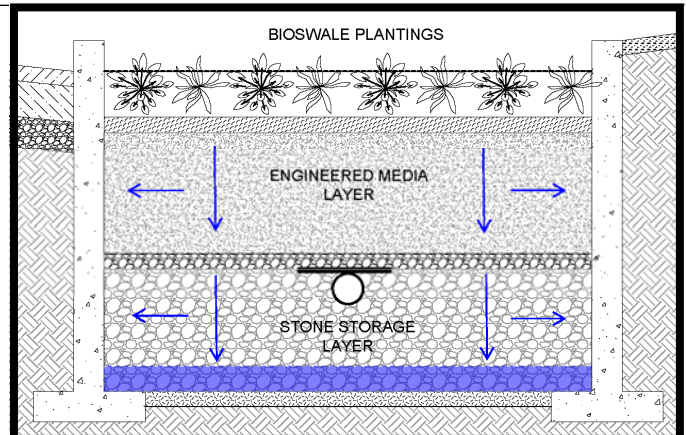


Figure 1: Typical bioswale detail

GSI Characteristics:

Drainage Area = 0.31 acres

Total Bioswale Area = 1,900 sq. ft.

Estimated Cost = \$77,500 + \$1,900/year

Annualized Cost = \$41.07 / lb TSS reduction

Benefits for Captured Runoff:

Total Phosphorus Reduction = 0.3436 lbs (61.03%)

Total Suspended Solids Reduction = 140.6 lbs (75.88%)

Volume Captured = 3,137 gallons

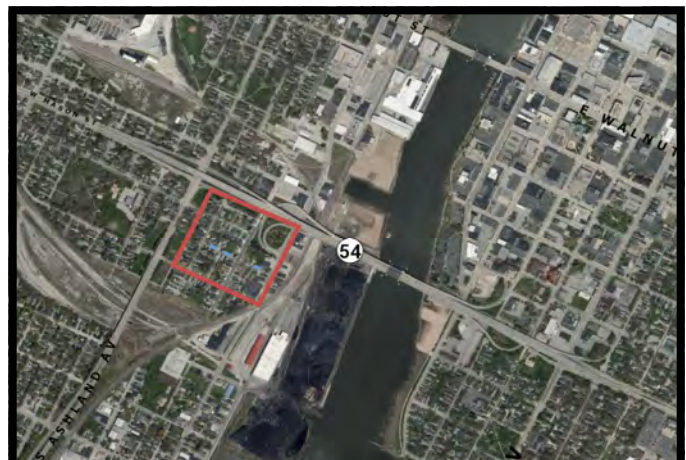


Figure 2: Aerial image of the CoGB with the project site outlined



Figure 3: White rectangles indicate intended bioswale location



Site Location:

13th St from School Pl to W Mason St,
Green Bay, WI

Benefits of Captured Stormwater:

Total Phosphorus Reduction = 1.618 lbs (38.27%)

Total Suspended Solids Reduction = 642.9 lbs (51.76%)

Volume Captured = 44,598 gallons

GSI Description:

Five bioswales placed before inlets along the street. The proposed bioswale placements would capture stormwater runoff from the street, resulting in better water quality. The proposed bioswales would also aid in reducing flood risk in this area.

Drainage Area = 3.945 acres (171,850 sq. ft.)

Proposed Bioswale Area = 0.022 acres (980 sq. ft.)

Approximate Cost = \$57,500 + \$1,750/year

Environmental ROI = \$89.44 / lb TSS reduction

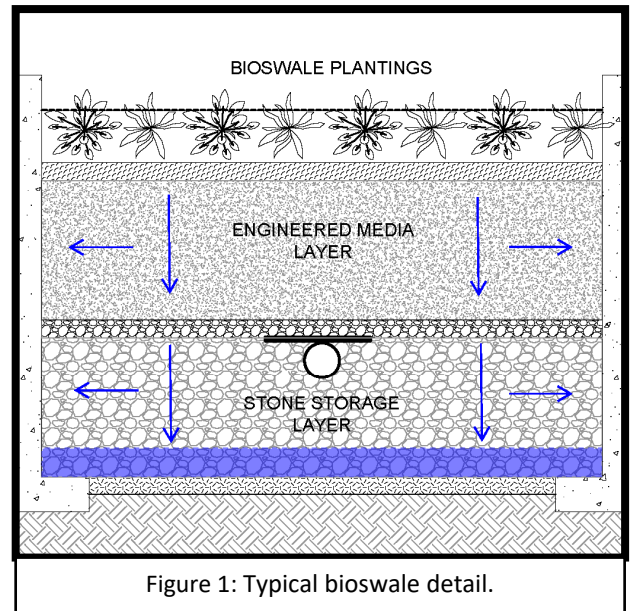


Figure 1: Typical bioswale detail.

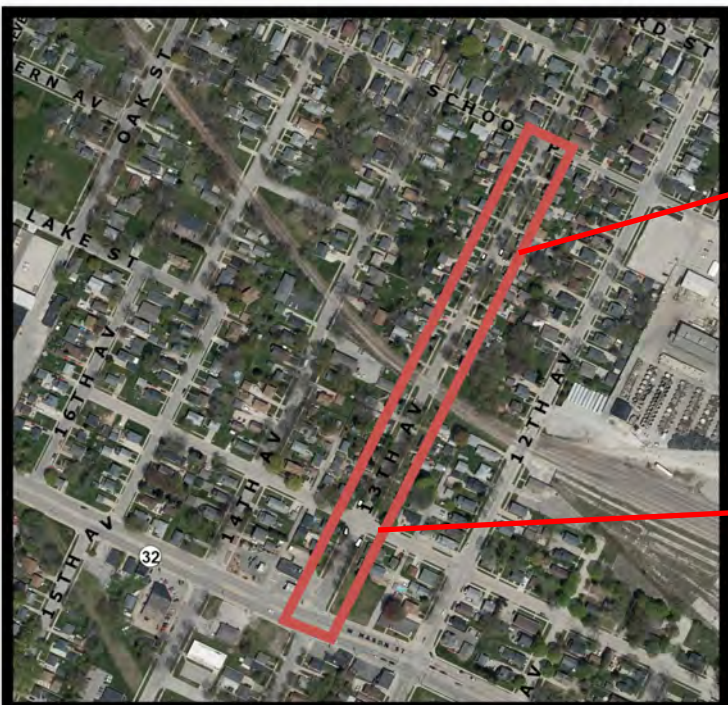


Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site with bioswale areas as white rectangles.



Site Location:

Tank Park, 830 5th St, Green Bay, WI

Parcel # 2-363-1

GSI Description:

One large bioswale would capture runoff water from the majority of impervious surfaces in the park, as well as approximately half of the grassed area. The captured runoff would be stored in a 2' layer of stone prior to being conveyed into the nearby storm sewer system.

Drainage Area = 4.49 acres (195,580 sq. ft.)

Proposed Bioswale Area = 0.21 acres
(9,000 sq. ft.)

Approximate Cost: \$206,000 + \$6,200/year

Annualized Cost = \$63.33/ lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

0.9731 lbs (50.60%)

Total Suspended Solids Reduction =

219.6 lbs (80.20%)

Volume Captured: 245,203 gallons

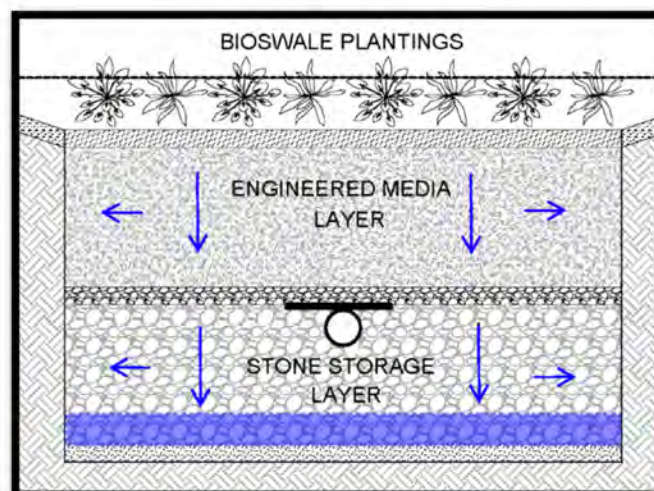


Figure 1: Typical bioswale detail.

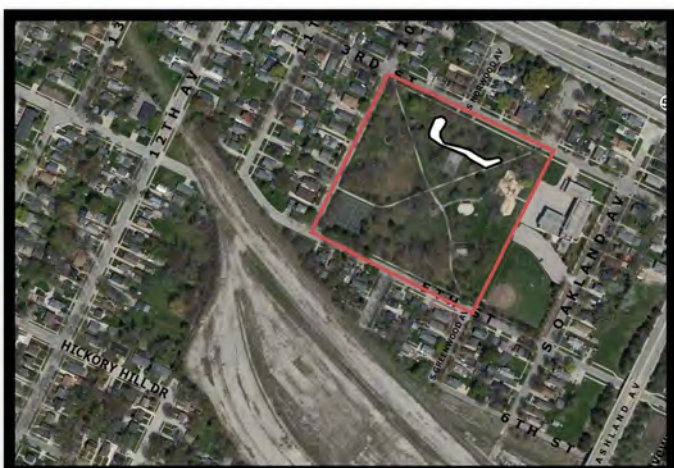


Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site with bioswale areas denoted in white.



Site Location:

Maple Ave bound by
9th Street and N Termini

Description:

Multiple flooding concerns, poor water quality, and a CIP make this an ideal area to install GSI. The proposed permeable pavement system can capture, treat, and temporarily store storm-water runoff, providing flood relief and improved water quality. Also, the expanded underground storage provides more storage capacity for the footprint of surface treatment.

GSI Characteristics:

PP Area = 0.06 acres (2,500 sq. ft.)

Storage Area = 0.12 acres (5,000 sq. ft.)

Approximate Cost = \$180,000 + \$2,500/yr

Annualized Cost = \$70.47/lb TSS reduction

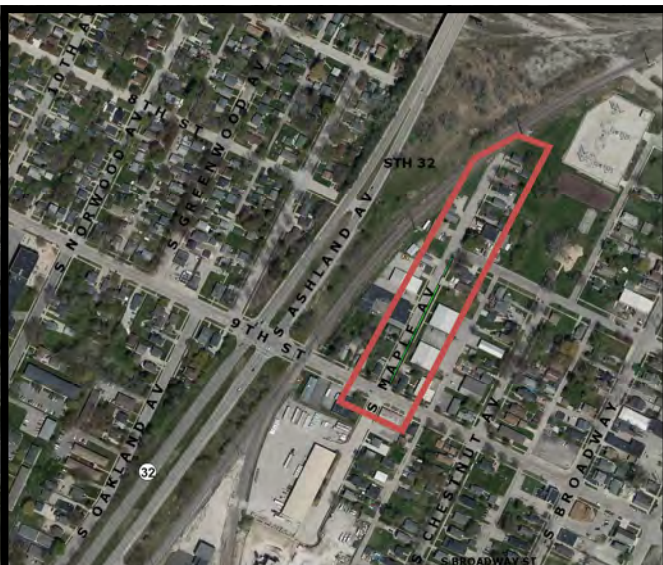


Figure 3: Aerial image of the City of Green Bay with the project area inside the red polygon.

Benefits for Captured Runoff:

Particulate Solids Reduction = 163.2 lbs (90.17%)

Total Phosphorus Reduction = 0.3761 lbs (73.24%)

Volume Captured = 8,565 gallons

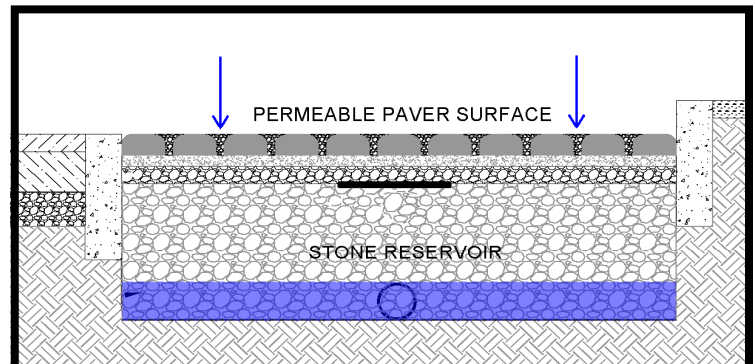


Figure 1: Typical permeable pavement detail.

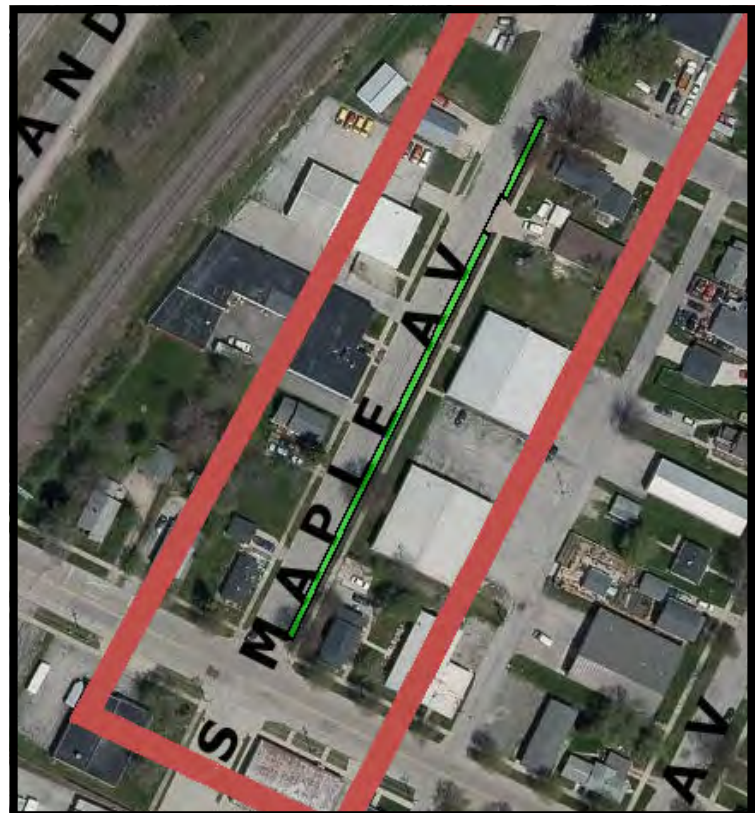


Figure 2: Plan view of the proposed project site. The green rectangles indicate proposed porous pavement location.



Site Location:

Eighth St Park, 508 8th St, Green Bay, WI

Parcel ID # 1-836

GSI Description:

A large bioswale will collect runoff flows from 70% of the site and will be positioned in the low-spot of the parcel. This parcel has had issues flooding, so this GI would aim to store and treat the rainwater before conveying it to a nearby storm sewer. A field inlet and piping would need to be installed in order to properly drain the bioswale.

Drainage Area = 1.34 acres (25,340 sq. ft.)

Proposed Bioswale Area = 0.057 acres (2,500 sq. ft)

Approximate Cost = \$102,800 + \$3,188/year

Annualized Cost = \$117.95 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

0.312 lbs (50.49 %)

Total Suspended Solids Reduction =

70.6 lbs (80.07 %)

Volume Captured = 45,765 gallons

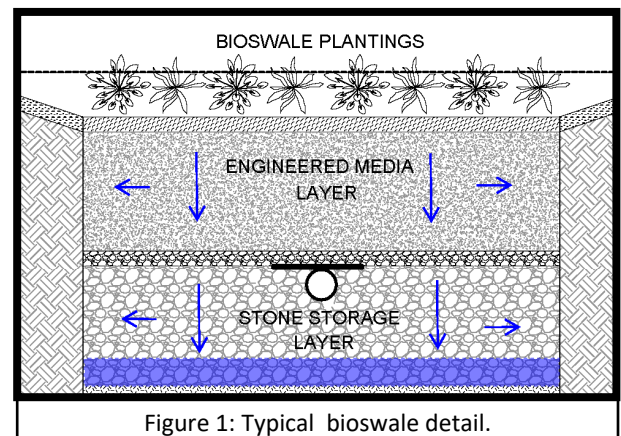


Figure 1: Typical bioswale detail.



Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site with the bioswale area denoted by the white shape. The dashed line indicates buried piping.



Site Location:

Perkins Park, 600 N Fisk St, Green Bay, WI 54303

Parcel ID #6-62

GSI Description:

Permeable pavement (PP) in parking lot to the east. A bioswale placed at a low point in the north of the park to capture the northern field runoff.

Drainage Area = 4.227 acres (184,128 sq. ft.)

Proposed Bioswale Area = 0.091 acres (3,955 sq.ft.)

Proposed PP Area = 0.712 acres (31,000 sq. ft.)

Approximate Cost = \$1,360,000 + \$10,000/year

Annualized Cost = \$149.13 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction = 1.435 lbs (64.13%)

Total Suspended Solids Reduction = 523.05 lbs (91.60%)

Volume Captured = 147,534 gallons

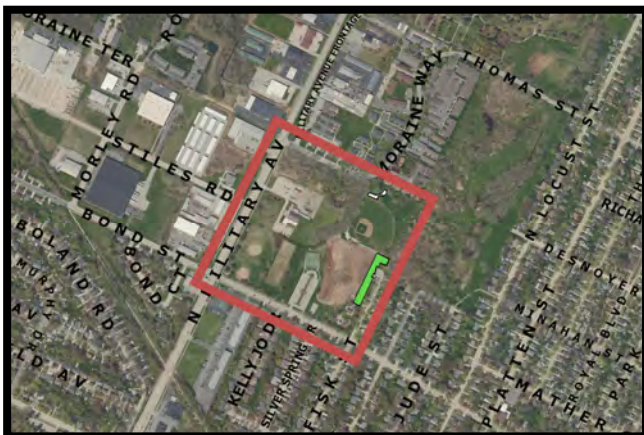


Figure 3: Aerial image of CoGB with the project site out-

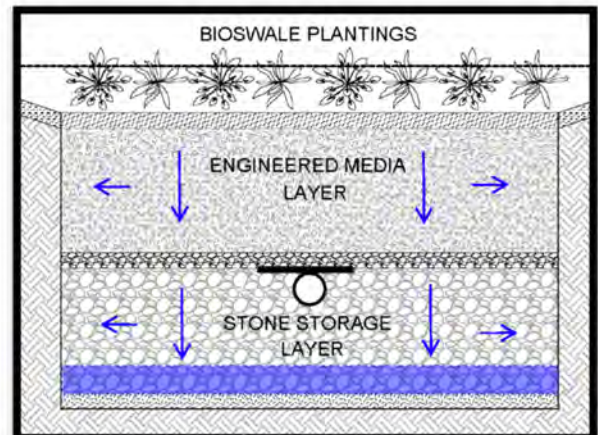


Figure 1: Typical bioswale detail.

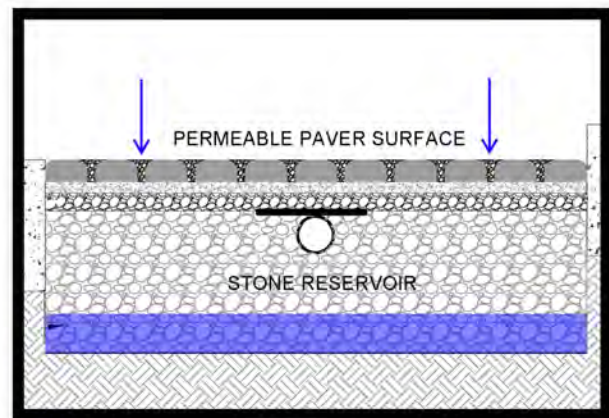


Figure 2: Typical permeable pavement detail.



Figure 4: Proposed site with permeable paver area denoted in green and bioswale areas denoted in white.



Site Location:

MacArthur Elementary School, Green Bay, WI

Parcel ID #6H-1133-A

GSI Description:

Permeable pavers (PP) replacement of old parking lot. The proposed PP would capture the runoff from the large paved area of parking.

Drainage Area = 0.562 acres (24,500 sq. ft.)

Proposed PP Area = 0.360 acres (15,690 sq. ft.)

Approximate Cost = \$635,000 + \$5,000/year

Annualized Cost = \$190.02 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

0.3281 lbs (74.18%)

Total Suspended Solids Reduction =

193.4 lbs (94.11%)

Volume Captured = 43,941 gallons

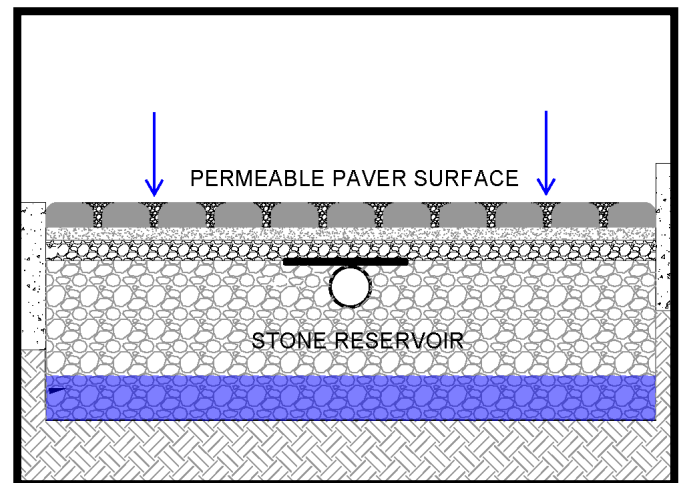


Figure 1: Typical permeable pavement detail.



Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site with permeable pavement area shown as green rectangle.



Site Location:

Woodlawn Ave and Hubbard Street

Green Bay, WI

Benefits of Captured Stormwater:

Total Phosphorus Reduction = 1.409 lbs (46.18%)

Total Suspended Solids Reduction = 548.6 lbs (63.01%)

Volume Captured = 24,738 gallons

GSI Description:

Four bioswales placed along a residential street. The proposed bioswale would capture runoff from the street and residential properties, reducing flood risk and improving water quality. The related CIP is a road reconstruction, which would be an ideal time to install GSI.

Drainage Area = 3.11 acres (135,330 sq. ft.)

Proposed Bioswale Area = 0.02 acres (750 sq. ft.)

Approximate Cost = \$45,000 + \$750/year

Annualized Cost = \$5.47 / lb TSS reduction

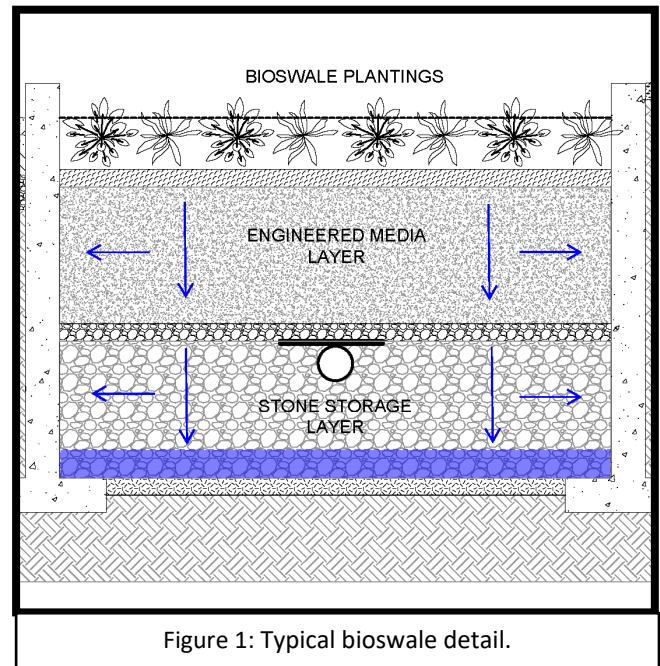


Figure 1: Typical bioswale detail.

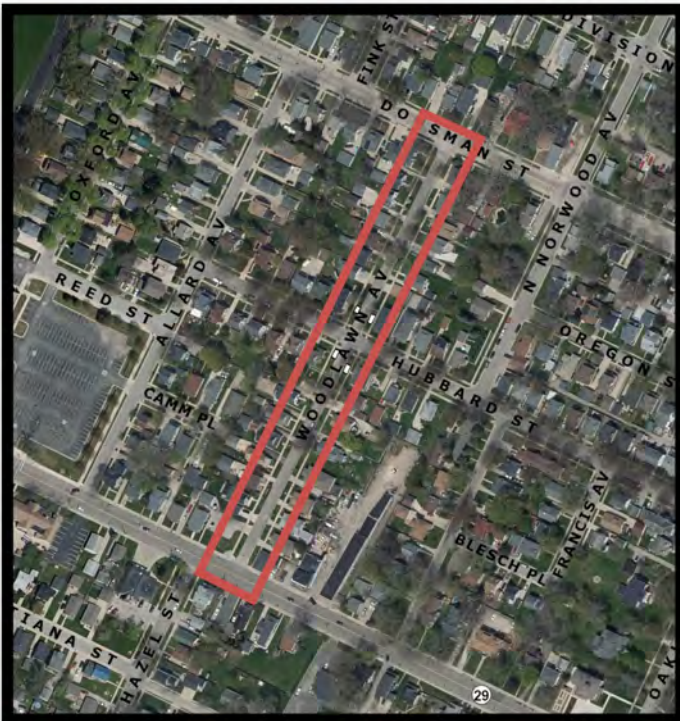


Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site with bioswale areas shown in white.



Site Location:

Between 3177 & 3379 Nicolet Dr,

Green Bay , WI

Parcel # 22-128

Regenerative Stormwater Conveyance (RSC) is a step-pool treatment device that captures, stores, and infiltrates runoff in steep or channelized areas to prevent erosion and provide water quality.

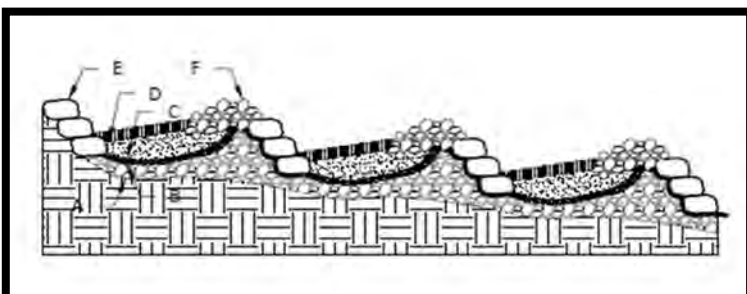


Figure 1: Typical regenerative stormwater conveyance (RSC) design

GSI Description:

A RSC that outfalls into the roadside ditch along Nicolet Dr. The proposed RSC would reduce runoff from the large expanses of fields and help to prevent flooding in the adjacent neighborhood.

Drainage Area = 16.5 acres

(720,530 sq. ft.)

Proposed RSC Length = 185 ft

Approximate Cost = \$55,000 + \$1,700/year

Annualized Cost = \$6.29 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

3.691 lbs (45.46%)

TSS Reduction = 708 lbs (62.75%)

Volume Captured = 90,858 gallons

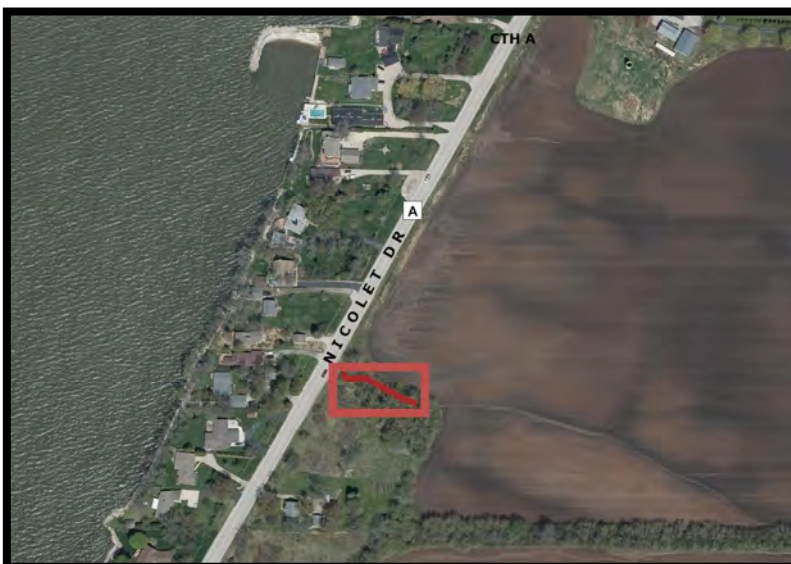


Figure 2: Aerial image of the CoGB with the project site outlined in red.



Figure 3: Proposed site with RSC length denoted by red line.



Site Location:

Between 3304 & 3376 Nicolet Dr,
Green Bay, WI

Regenerative Stormwater Conveyance (RSC) is a step-pool treatment device that captures, stores, and infiltrates runoff in steep or channelized areas to prevent erosion and provide water quality.

GSI Description:

RSC in the ditch between fields, that outfalls onto the roadside ditch along Nicolet Dr. The proposed RSC would reduce runoff from the large expanses of fields and help to prevent flooding in the adjacent neighborhood.

Drainage Area = 15.7 acres (683,600 sq. ft.)

Proposed RSC Length = 130 ft

Approximate Cost = \$36,000 + \$1,200/year

Annualized Cost = \$6.08 / lb TSS reduction

Benefits of Captured Stormwater

Total Phosphorus Reduction =

2.627 lbs (37.16%)

TSS Reduction = 493.8 lbs (52.61%)

Volume Captured = 48,660 gallons

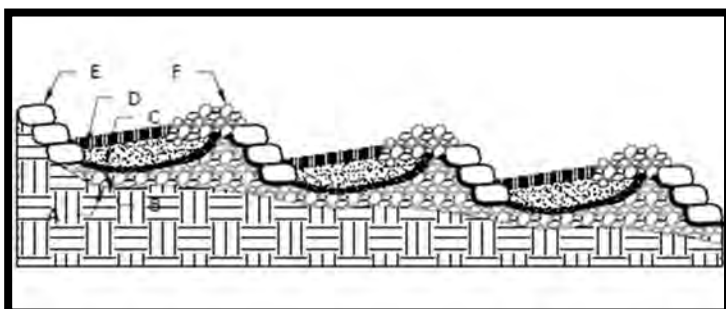


Figure 1: Typical regenerative stormwater conveyance (RSC) design

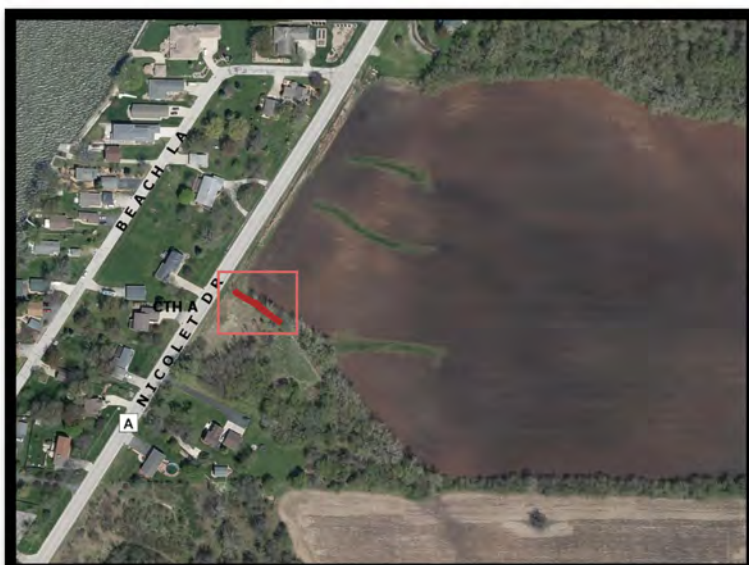


Figure 2: Aerial image of the CoGB with the project site outlined.



Figure 3: Proposed site with RSC length denoted by red line.



Site Location:

221 Cherry St, Green Bay, WI

Green Bay Redevelopment Authority (Public Lot)

Parcel ID #12-112

GSI Description:

Permeable pavers (PP) in west and section of parking lot. The plan also includes the scenario of a possible new development for the parking lot. The proposed PP would capture the runoff from large paved areas of parking.

Drainage Area = 0.76 acres (33,245 sq. ft.)

Proposed PP Area = 0.355 acres (15,460 sq. ft.)

Approximate Cost = \$635,000 + \$5,000/year

Annualized Cost = \$228.97/ lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

0.2374 lbs (22.63%)

Total Suspended Solids Reduction =

160.5 lbs (39.39%)

Volume Captured = 32,742 gallons

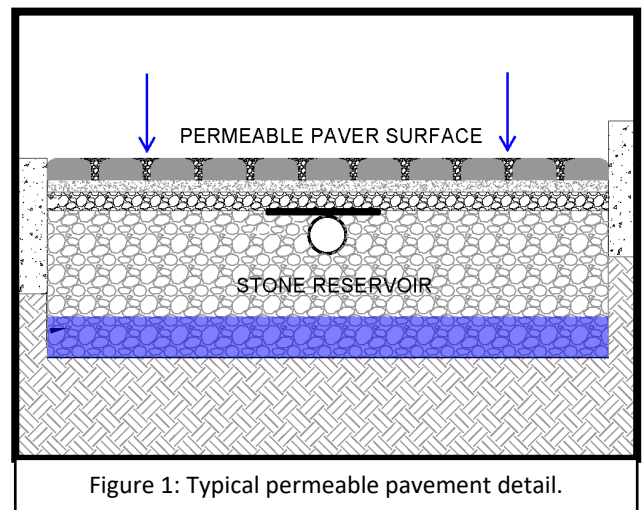


Figure 1: Typical permeable pavement detail.



Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site with permeable pavement areas shown as green rectangles. Area that could be used for new development is shaded in orange.



Site Location:

Utility Ct & N Madison St, Green Bay, WI

Parcel ID # 11-134

GSI Description:

Permeable pavers (PP) in low point parking spaces. A bioswale with trees placed to intercept runoff. The proposed PP and bioswale placements would capture the runoff from large paved areas of parking, resulting in better water quality.

Drainage Area = 2.903 acres (126,465 sq. ft.)

Proposed Bioswale Area = 0.057 acres (2500 sq. ft.)

Proposed PP Area = 1.240 acres (54,000 sq. ft.)

Approximate Cost = \$2,200,000 + \$7,500/year

Annualized Cost = \$96.08 / lb TSS reduction

Benefits of Captured Parking Lot Water:

Total Phosphorus Reduction = 1.7431 (78.06 %)

Total Suspended Solids Reduction = 1223 (90.83 %)

Volume Captured = 248,121 gallons

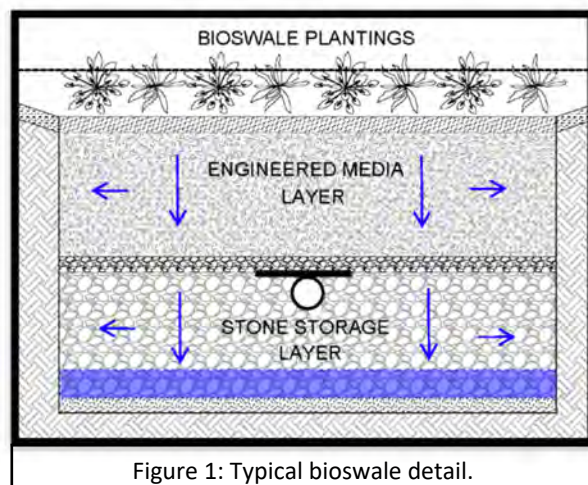


Figure 1: Typical bioswale detail.

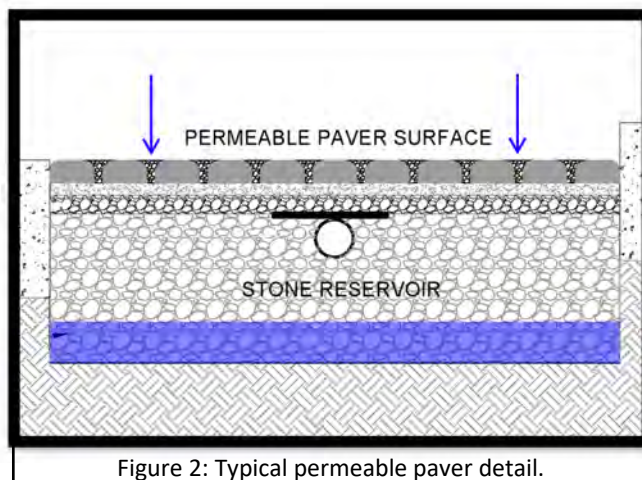


Figure 2: Typical permeable paver detail.



Figure 4: Proposed site with permeable paver areas outlined and shaded in green and bioswale areas in white with trees.



Figure 3: Aerial image of CoGB with the project site outlined.



Site Location:

1957 Main St, Green Bay, WI

Parcel ID #21-1329

GSI Description:

Two rain gardens placed to capture runoff from landscaping and pavement areas. Potential new building footprints are also considered.

Drainage Area = 1.44 acres (62,596 sq. ft.)

Proposed Rain Garden Area = 0.164 acres (7130 sq. ft.)

Approximate Cost = \$62,500 + \$1,500/year

Annualized Cost = \$23.63 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction = 0.4856 lbs (50.25%)

Total Suspended Solids Reduction = 238.0 lbs (73.67%)

Volume Captured = 65,312 gallons

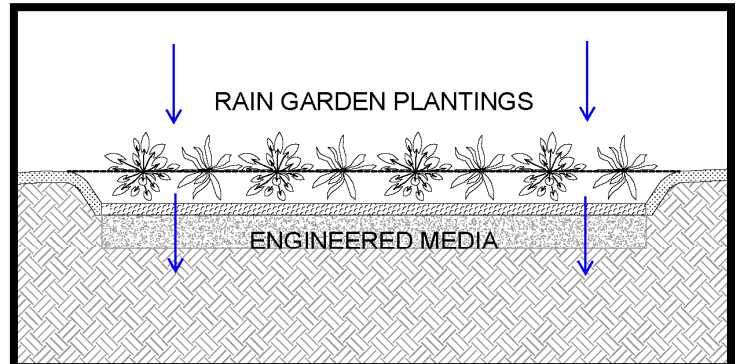


Figure 1: Typical rain garden detail.

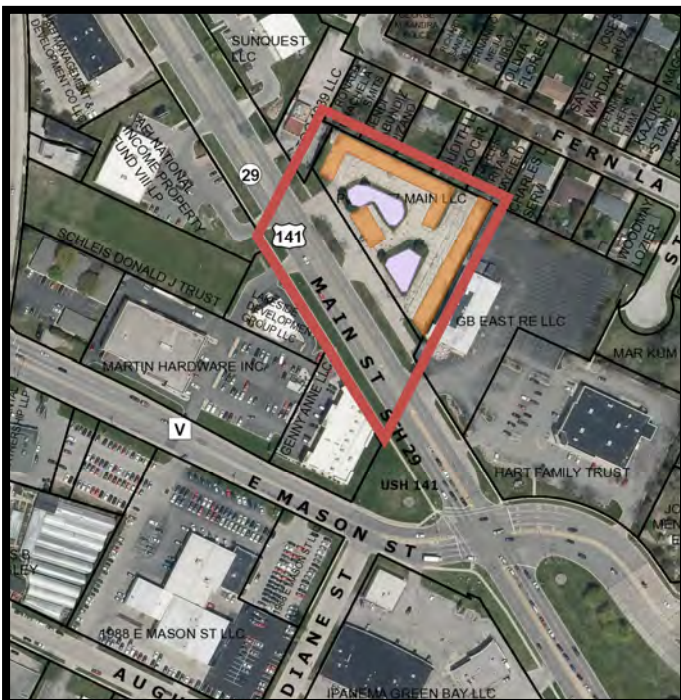


Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site with rain garden areas shown in purple and potential building footprints shaded in orange.



Site Location:

East Town Mall, 2350 E Mason St, Green Bay, WI

Parcel # 21-126-7-2

GSI Description:

Permeable pavers placed to capture runoff from the parking lot. Two bioswales placed to intercept other runoff.

Drainage Area = 1.426 acres (62,120 sq. ft.)

Proposed Bioswale Area = 0.023 acres (1,000 sq. ft.)

Proposed PP Area = 0.631 acres (27,500 sq. ft.)

Approximate Cost = \$1,125,000 + \$7,000/year

Annualized Cost = \$104.82 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction = 0.858 lbs (78.09%)

Total Suspended Solids Reduction =

603.4 lbs (90.79%)

Volume Captured = 123,660 gallons

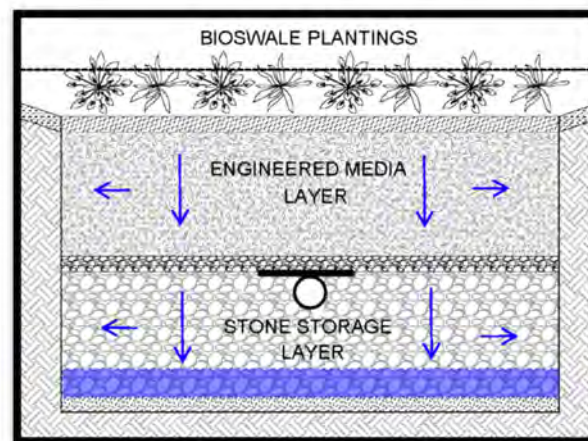


Figure 1: Typical bioswale detail.

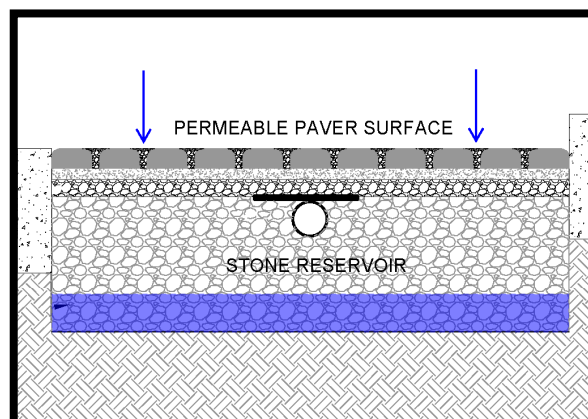


Figure 2: Typical permeable pavement detail.



Figure 3: Aerial image of CoGB with the project site outlined.



Figure 4: Proposed site with permeable pavement area denoted in green and bioswale areas denoted in white. An area of new development is shaded in orange.



Site Location:

Ricky Drive between Vine Street and Richmond Street

Parcels # 21-1361-1 & 21-1361-6

Project Area = 3 acres

Captured Area = 1.5 acres

Proposed Bioswale Areas = 1,200 sq. ft.

Proposed StormGUARDen Quantity: 17

Approximate Cost = \$100,000 + \$2,500/year

Annualized Cost = \$13.98 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

1.39 lbs (45.5%)

Total Suspended Solids Reduction =

536.5 lbs (62.6%)

Volume Captured = 19,741 gallons

GSI Description:

A new 17 lot development between Vine and Richmond Streets on Ricky Drive capture and treat stormwater captured by utilizing StormGUARDens™ and bioswales.

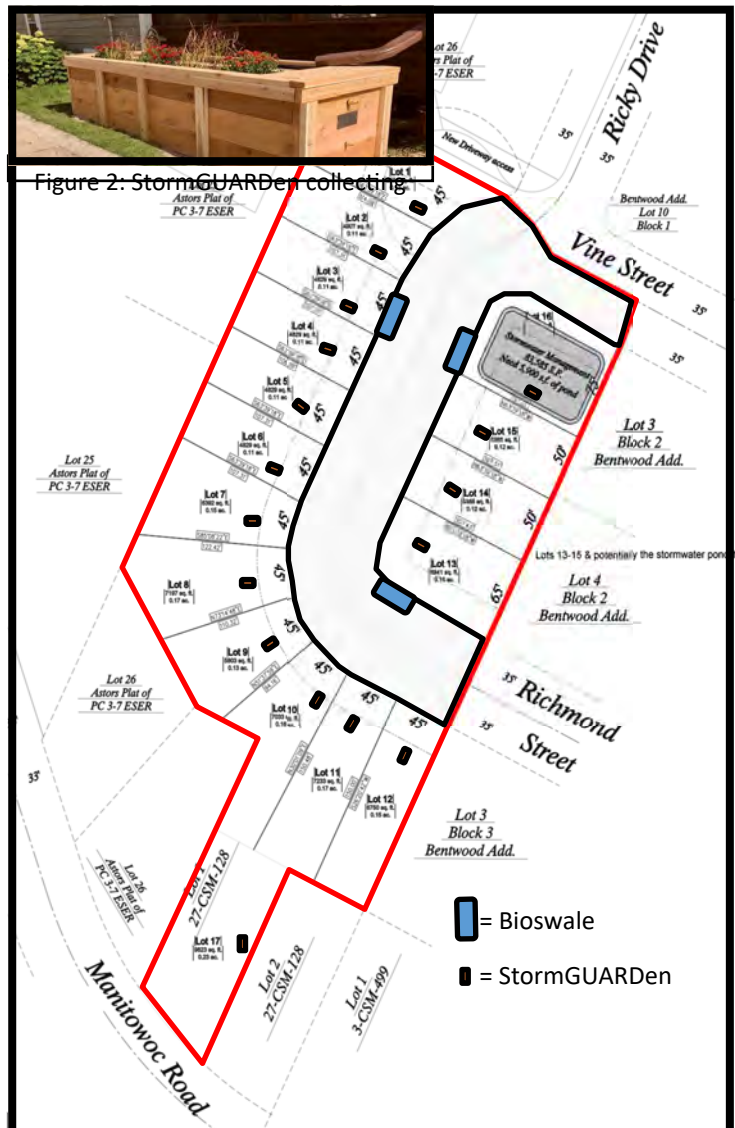


Figure 2: Preliminary Plat of the proposed project site. The area inside the red polygon is the project site, the black outlined shape is the ROW area on site.



Figure 1: Aerial image of CoGB with the project site





Site Location:

Lombardi Ave & S Broadway St

Green Bay, WI

GSI Description:

Six green roof sections added to industrial buildings. The proposed extensive green roofs have the possibility to be retrofitted on existing buildings and reduced the roof runoff in an area with minimal permeable surface area.

Drainage Area = 11.77 acres (512,730 sq. ft.)

Approximate Cost = \$22,500,000 + \$120,000/year

Annualized Cost = \$914.10 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction = 3.939 lbs (100%)

Total Suspended Solids Reduction = 1362 lbs (100%)

Volume Captured = 176,099 gallons

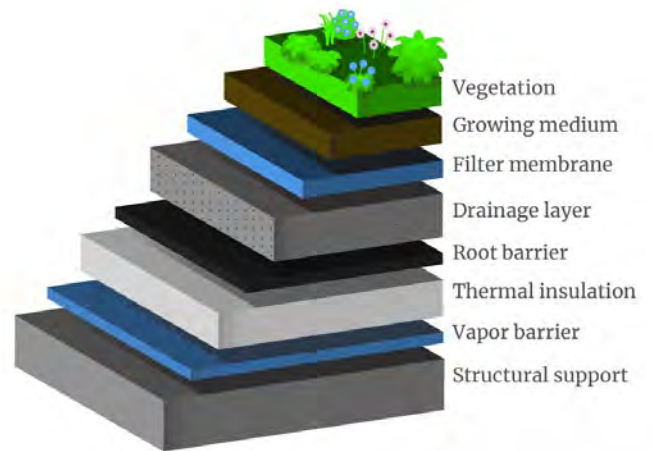


Figure 1: Typical green roof layers (Taken from EPA's Common Green Roof Layers, [Using Green Roofs to Reduce Heat Islands | US EPA](#)).



Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site with proposed green roofs in shaded in green.



Site Location:

Lombardi Ave & Reggie White Way

Parcel ID #1-1841-C

GSI Description:

Private development plans taken from the Legends District Master Plan: City of Green Bay (March 2017). Permeable pavement (PP) placed in walkways and in parking spaces of lots. Bioswales collect some lot runoff not captured by PP. Additional bioswales placed to capture runoff from the road through the development, alongside native landscaping. Native landscaping also added to large grass landscaped areas. Green roofs added to buildings D and E. Trees cells placed for capture and transpiration of runoff.

Drainage Area = 13.4 acres (583,880 SF)

Approximate Cost = \$5,100,000 + \$80,000/year

Annualized Cost = \$92.72/lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction = 6.53 lbs (55.63%)

Total Suspended Solids Reduction = 3613 lbs (76.3%)

Volume Captured = 644,911 gallons

GSI Areas:

Permeable Pavement: 81,800 SF (1.88 acres)

Bioswales = 29,200 SF (0.670 acres)

Native Landscaping = 10,500 SF (0.241 acres)

Green Roof = 55,000 SF (1.26 acres)



Figure 1: Aerial image of the CoGB with the project area located inside the red rectangle.



Figure 2: Proposed site with GSI areas highlighted and outlined.



Site Location:

Brett Favre Pass & Tony Canadeo Run

Green Bay, WI

Parcel ID #1-1841-B-1

GSI Description:

Private development plans taken from the Legends District Master Plan: City of Green Bay (March 2017). Permeable pavement (PP) placed in walkways and in parking spaces of lots. A bioswale collects portion of parking lot runoff not captured by permeable pavement. A green roof for building B.

Drainage Area = 2.99 acres (130,420 sq.ft)

Approximate Cost =

\$1,770,000 + \$22,900/year

Annualized Cost=\$147.59/lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

1.264 lbs (52.80%)

Total Suspended Solids Reduction =

754.8 lbs (77.23%)

Volume Captured = 131,964 gallons

Area of Bioswales =

0.046 acres (2,000 sq. ft.)

Area of Permeable Pavement =

0.750 acres (32,650 sq. ft.)

Area of Green Roof =

0.209 acres (9,100 sq. ft.)



Figure 1: Aerial image of the CoGB with the project area located inside the red rectangle.

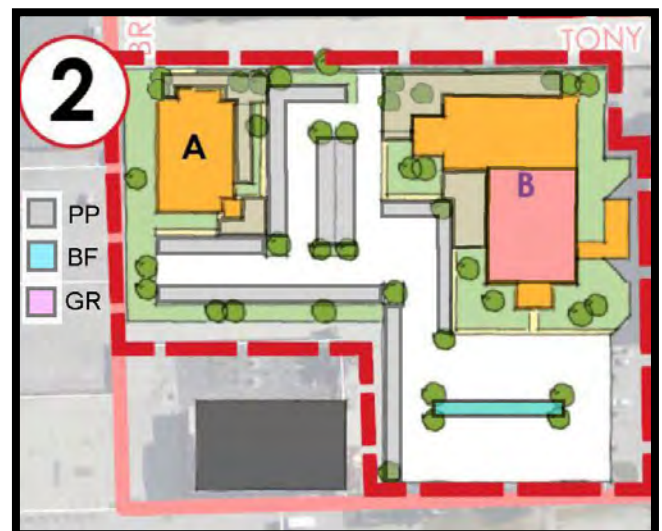


Figure 2: Proposed site with GSI areas highlighted and out-



Site Location:

Tony Canadeo Run & Bart Starr Dr

Green Bay, WI

Parcel ID #1-1841-J

GSI Description:

Private development plans taken from the Legends District Master Plan: City of Green Bay (March 2017). Permeable pavement (PP) placed in parking spaces of lots. Bioswales will collect runoff from the pedestrian walkway, as well as the runoff from the driveway. Green roofs for building A. Rain gardens placed for capturing runoff from building B/C walkways. Tree cells will be distributed throughout the site for capture and transpiration of other runoff.

GSI Footprint:

Rain Garden = 950 sq-ft; Tree Cells = 15

Green Roof = 18,000 sq-ft; Bioswale = 1,400 sq-ft

Permeable Pavement = 25,400 sq-ft

Drainage Area:

6.004 acres (261,530 sq. ft.)

Approximate Cost:

\$1,902,000 + \$50,000/year

Annualized Cost:

\$107.15 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

2.304 lbs (39.22%)

Total Suspended Solids Reduction =

1337 lbs (62.06%)

Volume Captured = 149,588 gallons

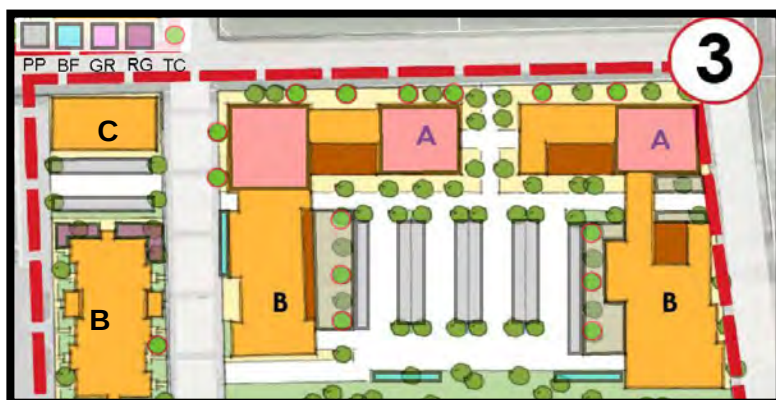


Figure 1: Proposed site with GSI areas highlighted and outlined.



Figure 2 Aerial image of the CoGB with the project area located inside the red rectangle.



Site Location:

2020 Angie Ave, Green Bay, WI

Parcel ID #20-694

Description:

Permeable pavement (PP) with 12" of stone as a storage layer will infiltrate and hold stormwater that falls on the parking lot surface and unpaved driveway to the north. A 6" underdrain pipe will convey the stormwater to an existing manhole. This facility will reduce peak flows through culverts during heavy rain events and improve the quality of runoff before it enters surface or ground waters.

Current parking lot area = 0.653 acres (28,434 sq.ft.)

Proposed PP area = 0.275 acres (11,980 sq.ft.)

Approximate Cost = \$525,000 + \$2,500/year

Annualized Cost = \$26.52 / lb TSS reduction

Benefits of Captured Parking Lot Water:

Particulate Solids Reduction = 93.40 % (1,084 lbs)

Total Phosphorus Reduction = 86.33 % (2.21 lbs)

Volume Captured = 55,595 gallons

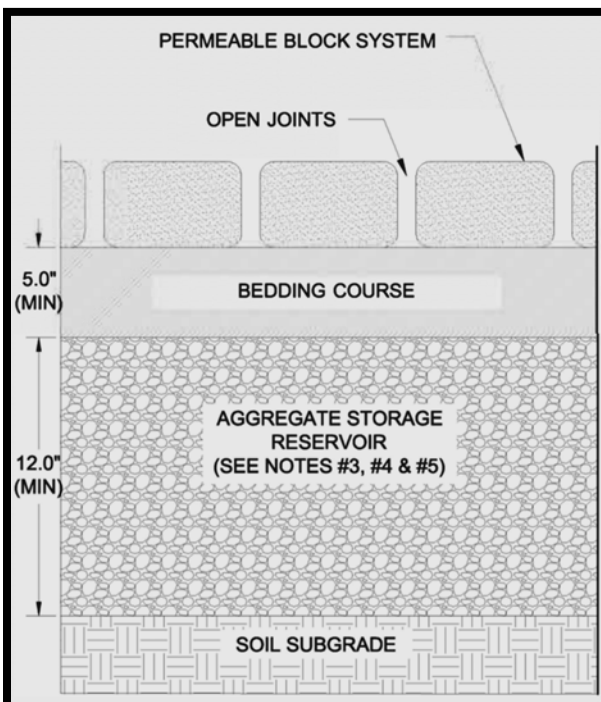


Figure 1: Typical permeable pavement detail.



Figure 2: Aerial image of CoGB with project site outlined.



Figure 3: Northeast section of project site with proposed permeable pavement areas as green rectangles.



Site Location:

1950 Cofrin Drive, Green Bay, WI

Parcel ID # 21-1183-C

GSI Description:

A bioswale installed on the Northwest corner of the property would intercept street runoff and convey the flow through existing on site storm infrastructure. The added GI will improve water quality, as well as fill a location that has had 5 matured trees removed recently.

Drainage Area = 0.42 acres (18,298 sq. ft.)

Proposed Bioswale Area = 0.05 acres (2,000 sq.ft)

Approximate Cost = \$ 45,000 + \$1,000/year

Annualized Cost = \$8.97 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction = 0.5258 lbs (69.50%)

Total Suspended Solids Reduction =

362.3 lbs (90.82%)

Volume Captured = 14,497 gallons

Figure 3: Proposed site with the bioswale area shown as a white polygon.

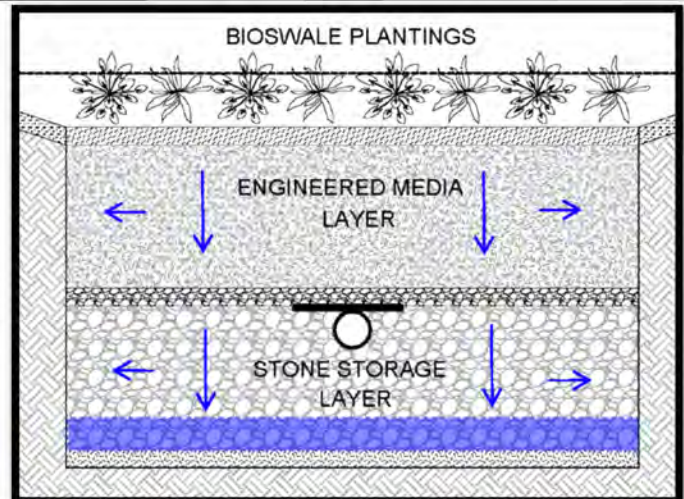


Figure 1: Typical bioswale detail.



Figure 2: Aerial image of CoGB with the project site outlined .





Site Location:

210 Museum Pl, Green Bay, WI

Parcel ID # 4-56, 4-57

GSI Description:

Porous pavement (PP) placed in parking spaces to collect runoff across the paved parking lot. The parking lot is already in poor condition and will be improved with replaced pavement. Additionally, a shallow bioswale placed to collect runoff from part of the parking lot and improve water quality. This proposed system will reduce flood risk in the surrounding area.

Drainage area = 0.898 acres (39,120 sq. ft.)

Proposed PP area = 0.190 acres (8,270 sq. ft.)

Proposed bioswale area = 0.015 acres (650 sq. ft.)

Approximate Cost = \$365,000 + \$3,000/year

Annualized Cost = \$90.12/ lb TSS reduction

Benefits of Captured Parking Lot Water:

Particulate Solids Reduction = 235.8 lbs (83.65%)

Total Phosphorus Reduction = 0.407 lbs (63.91%)

Volume Captured = 33,535 gallons

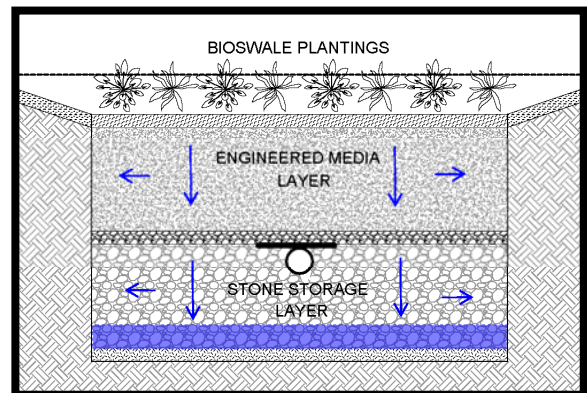


Figure 1: Typical bioswale detail.

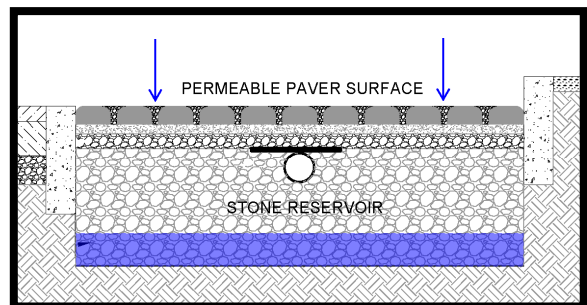


Figure 2: Typical permeable pavement detail.



Figure 3: Aerial image of the CoGB with the project site in red.



Figure 4: Project site with proposed porous pavement areas denoted by black rectangles.



Site Location:

12th to 15th Ave,
bounded by W Mason St & 5th St,
Green Bay, WI

Benefits of Captured Stormwater:

Total Phosphorus Reduction = 0.5041 (95.97%)

Total Suspended Solids Reduction = 96.32 lbs (99.15%)

Volume Captured = 282,839 gallons

GSI Description:

Four sections of greenway with native landscaping. The proposed greenway and native landscaping would replace existing mowed grass areas, reducing runoff and improving water quality.

Drainage Area = 3.441 acres (149,910 sq. ft.)

Proposed GSI Area = 2.464 acres (107,327 sq. ft.)

Approximate Cost = \$375,000 + \$5,000/year

Annualized Cost = \$241.38/ lb TSS reduction

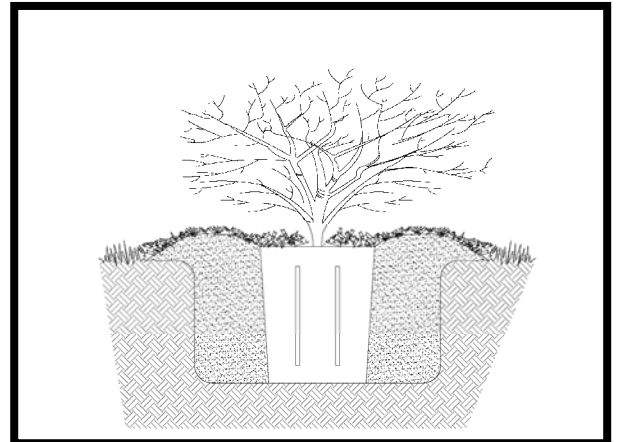


Figure 1: Typical native landscaping detail

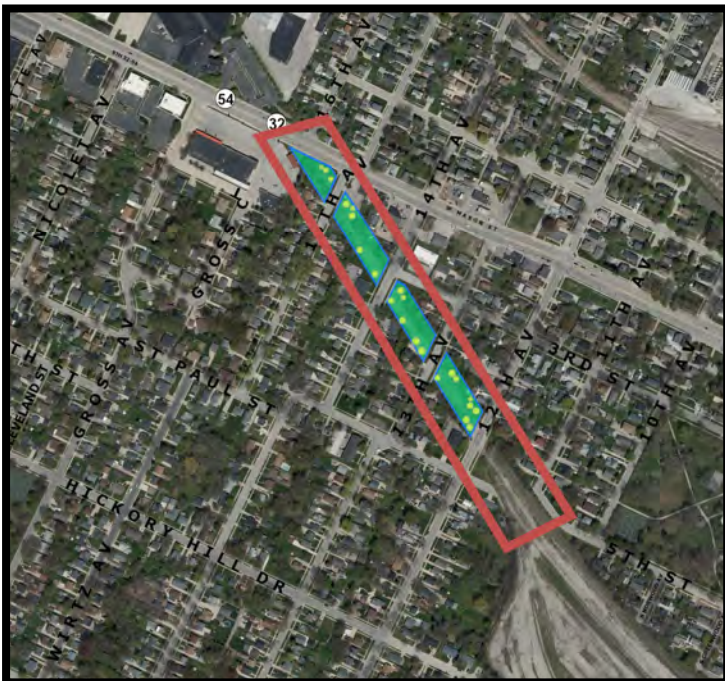


Figure 2: Aerial image of CoGB with the project site outlined.



Figure 3: Proposed site with greenway areas shown by green and blue outlined areas.



Site Location:

1350 N Military Ave, Green Bay, WI

Parcel ID #6-43, 6-42-D

GSI Description:

Two bioswales placed at across low points on the property. The proposed bioswale placements would capture runoff from the large landscaped area, resulting in better water quality.

Drainage Area = 26.879 acres (1,170,830 sq. ft.)

Proposed Bioswale Area = 4.454 acres (19,770 sq. ft.)

Approximate Cost = \$470,000 + \$15,000/year

Annualized Cost = \$18.08 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

7.755 lbs (49.18%)

Total Suspended Solids Reduction =

2129 (81.94%)

Volume Captured = 1,319,609 gallons

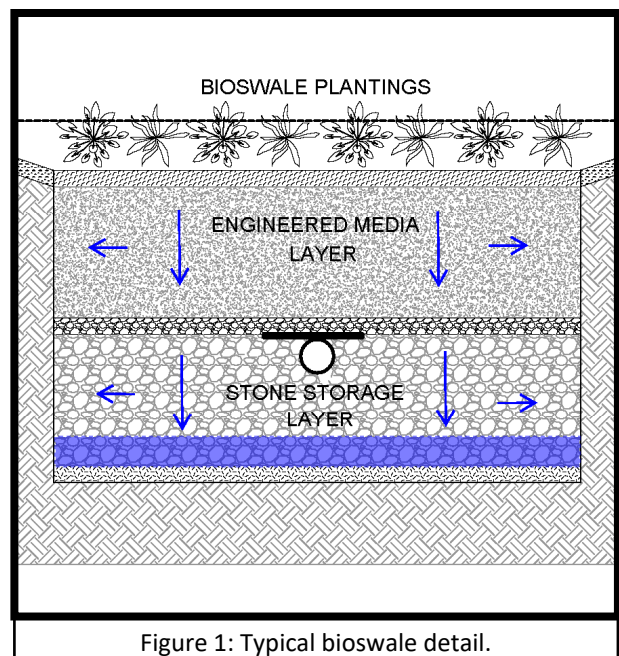


Figure 1: Typical bioswale detail.



Figure 2: Aerial image of CoGB with the project site outlined.

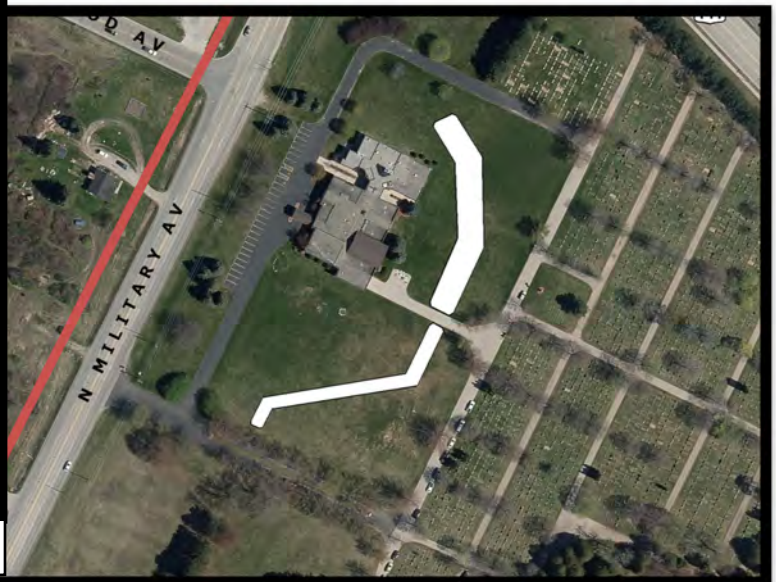


Figure 3: Proposed site with bioswale areas denoted by white rectangles.



Site Location:

2440 W Mason St, Green Bay, WI

Parcel # 6H-1763

GSI Description:

Permeable pavement (PP) with a 48" layer of stone storage. A 6" underdrain pipe will convey the stormwater to an existing manhole. The proposed PP placement would capture the heavily trafficked areas, resulting in better water quality.

Drainage Area = 1.63 acres (71,000 sq. ft.)

Proposed PP Area = 0.28 acres (12,000 sq. ft.)

Approximate Cost = \$575,000 + \$2,500/year

Annualized Cost = \$51.53 / lb TSS reduction

Benefits of Captured Stormwater:

Total Phosphorus Reduction =

0.862 lbs (39.31%)

Total Suspended Solids Reduction =

606.4 lbs (48.40%)

Volume Captured = 119,748 gallons

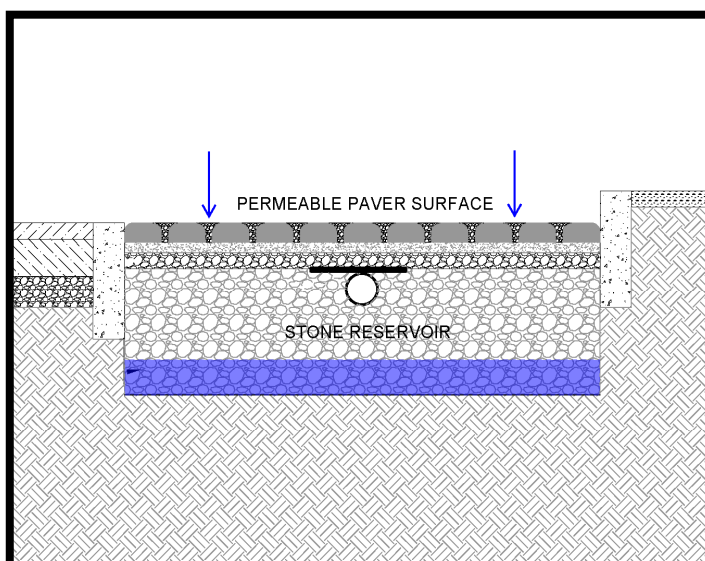


Figure 1: Typical permeable paver detail.



Figure 2: Aerial image of the CoGB with the project site outlined in red.



Figure 3: Proposed site with permeable pavement areas shown as a large green rectangle.



Site Location:

Walmart and Sam's Club

2440 W Mason St, Green Bay, WI

Parcel ID # 6H-2181, 2182, 2183, 2184, 2185, 2186

GSI Description:

Five sections of permeable pavement (PP) placed at intervals to capture parking lot runoff. Five bioswales placed to capture runoff and reduce runoff to the permeable pavement areas. This City of Green Bay subbasin ranks amongst the highest for poor water quality.

Drainage area = 6.067 ac. (264,290 sq. ft.)

Proposed PP area = 1.304 ac. (56,790 sq. ft.)

Proposed Bioswale area = 0.368 ac. (16,030 sq. ft.)

Approximate Cost = 2,700,000 + \$15,000/year

Annualized Cost = \$35.56/ lb TSS reduction

Benefits of Captured Stormwater:

Particulate Solids Reduction = 2644 lbs (93.50%)

Total Phosphorus Reduction = 4,218 lbs (90.19%)

Volume Captured = 603,581 gallons

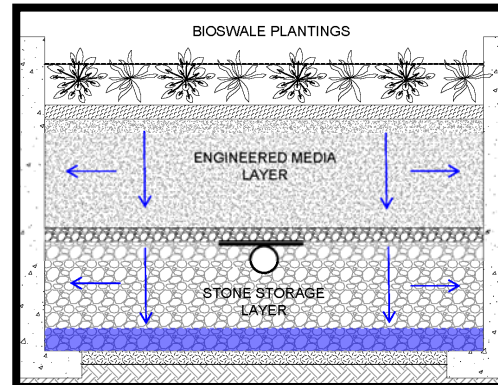


Figure 1: Typical bioswale detail.

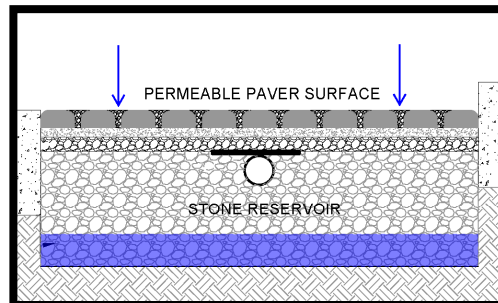


Figure 2: Typical permeable pavement de-

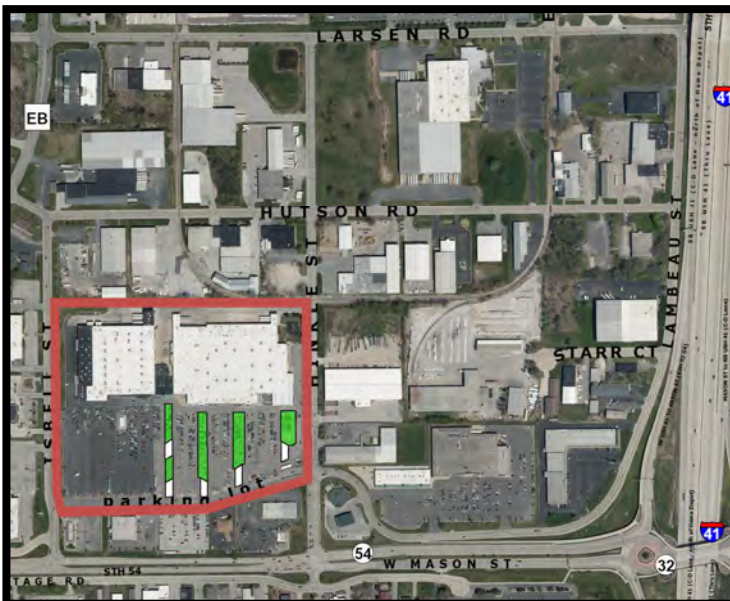


Figure 3: Aerial image of the CoGB with the project site outlined.



Figure 4: Proposed site with porous pavement areas shaded in green and bioswale area shown in white.



Site Location:

2250 W Mason St, Green Bay, WI

Parcel ID #6H-1096

GSI Description:

Permeable pavers (PP) in low point parking spaces. Two bioswale with trees placed to intercept runoff and reduce the amount of paved area. The proposed PP and bioswale placements would capture the runoff from large paved areas of parking.

Drainage Area = 3.374 ac. (146,960 sq. ft.)

Proposed Bioswale Area = 0.065 ac. (2850 sq. ft.)

Proposed PP Area = 0.368 ac. (16,020 sq. ft.)

Approximate Cost = \$760,000 + \$9,000/year

Annualized Cost = \$35.50 / lb TSS reduction

Benefits of Captured Parking Lot Water:

Total Phosphorus Reduction = 0.5578 lbs (78.55%)

Total Suspended Solids Reduction =

1324 lbs (84.23%)

Volume Captured = 277,610 gallons

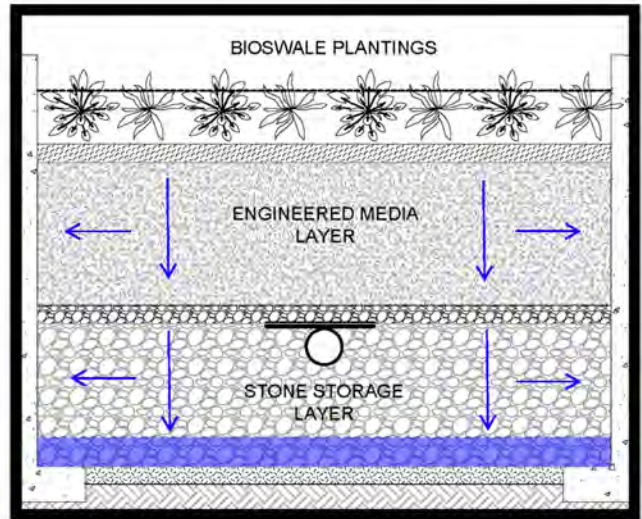


Figure 1: Typical bioswale detail.

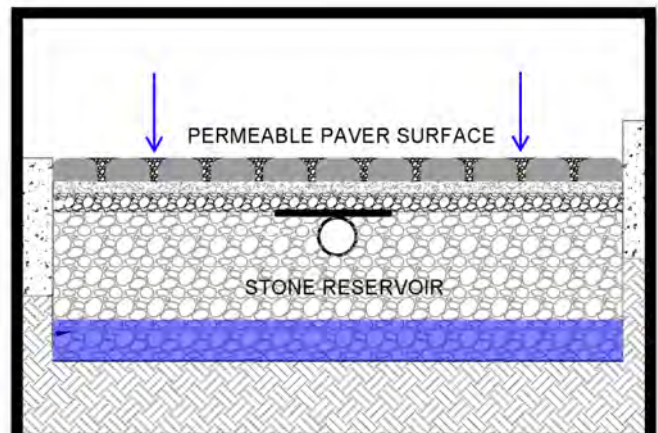


Figure 2: Typical permeable paver detail.



Figure 3: Aerial image of CoGB with the project site outlined.



Figure 4: Proposed site with permeable paver areas shaded in green and bioswale areas in white.



Site Location:

N Quincy St & Eastman Ave, Green Bay, WI

Parcel ID # 20-123

GSI Description:

Permeable pavers (PP) in parking spaces. The proposed PP and placements would capture the runoff from paved areas of parking, resulting in better water quality.

Drainage Area = 0.37 acres (16,219 sq. ft.)

Proposed PP Area = 0.19 acres (8,200 sq. ft.)

Approximate Cost = \$350,000 + \$4,000/year

Annualized Cost = \$72.68 / lb TSS reduction

Benefits of Captured Parking Lot Water:

Total Phosphorus Reduction =

0.3008 lbs (79.13%)

Total Suspended Solids Reduction =

295.8 lbs (88.49%)

Volume Captured = 25,845 gallons

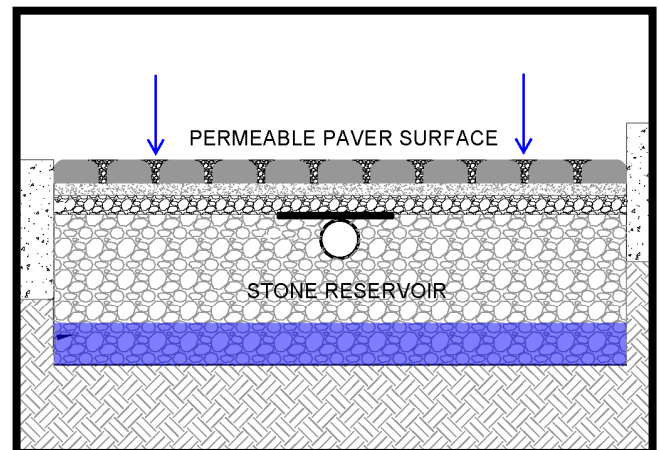


Figure 1: Typical permeable pavement detail.



Figure 2: Aerial image of CoGB with the project site outlined in red.



Figure 3: Proposed site with permeable pavement areas shown as green rectangles.

Legend

- Proposed GSI Locations
- Top Priority Basins
- Streets
- Lakes and Rivers
- Storm Basins

Priority Subbasins For GSI

The priority level of each subbasin was determined by the analysis of factors associated with Green Stormwater Infrastructure (GSI) best placement.

High
↑
Low

Determining Factors for Subbasin Ranking

- Percentage of Subbasin
 - Sandy Soils
 - Bedrock < 3 Feet
 - Depth to Groundwater < 3 Feet
 - Wetlands > 1 Acre
 - Below Median Home Value
 - Commercial or Industrial Zoning
 - Parks
- Total Number Within Subbasin
 - Wetlands < 1 Acre
 - Capital Improvement Projects
 - Poor PASER Ratings (1-4)
 - Schools
 - Flooding areas/concerns
- Value/Classification (Low-High)
 - Existing TSS (Lbs/Ac/Yr)
 - Existing TP (Lbs/Ac/Yr)

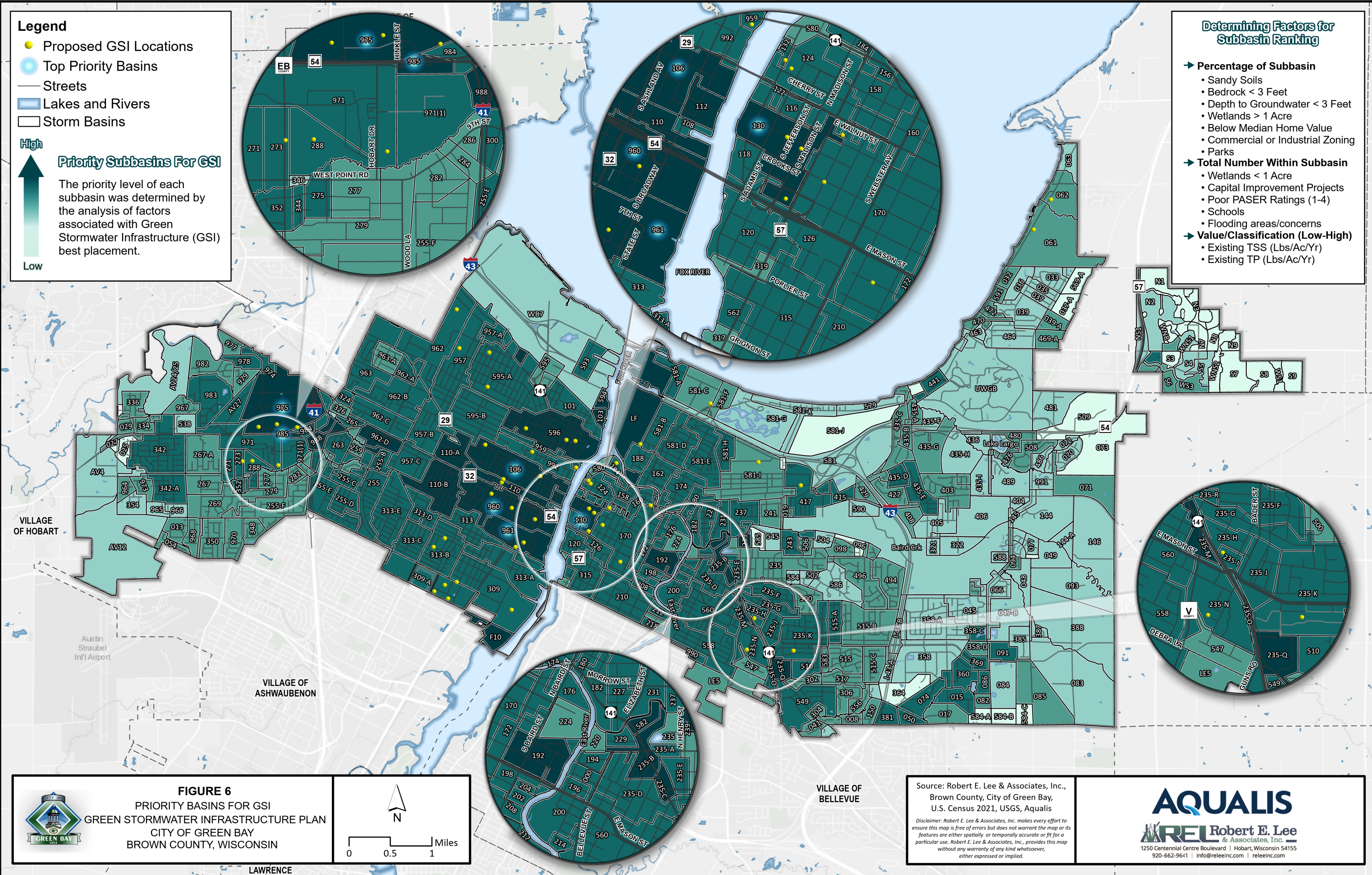
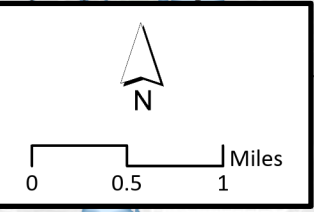


FIGURE 6
PRIORITY BASINS FOR GSI
GREEN STORMWATER INFRASTRUCTURE PLAN
CITY OF GREEN BAY
BROWN COUNTY, WISCONSIN



Source: Robert E. Lee & Associates, Inc., Brown County, City of Green Bay, U.S. Census 2021, USGS, Aqualis

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Legend
Opportunities

- Proposed GSI Locations
- Sandy Soils

Barriers

- Wetlands < 1 Acre
- Wetlands > 1 Acre
- Depth to Groundwater < 3 ft
- Depth to Bedrock < 3ft
- Lakes and Rivers
- Slope > 6%

Existing TSS & TP Load (lbs/yr/ac)

- Low
- Low Medium
- Medium
- Medium High
- High
- No Data

City of Green Bay
Other Municipal Boundaries
Streets

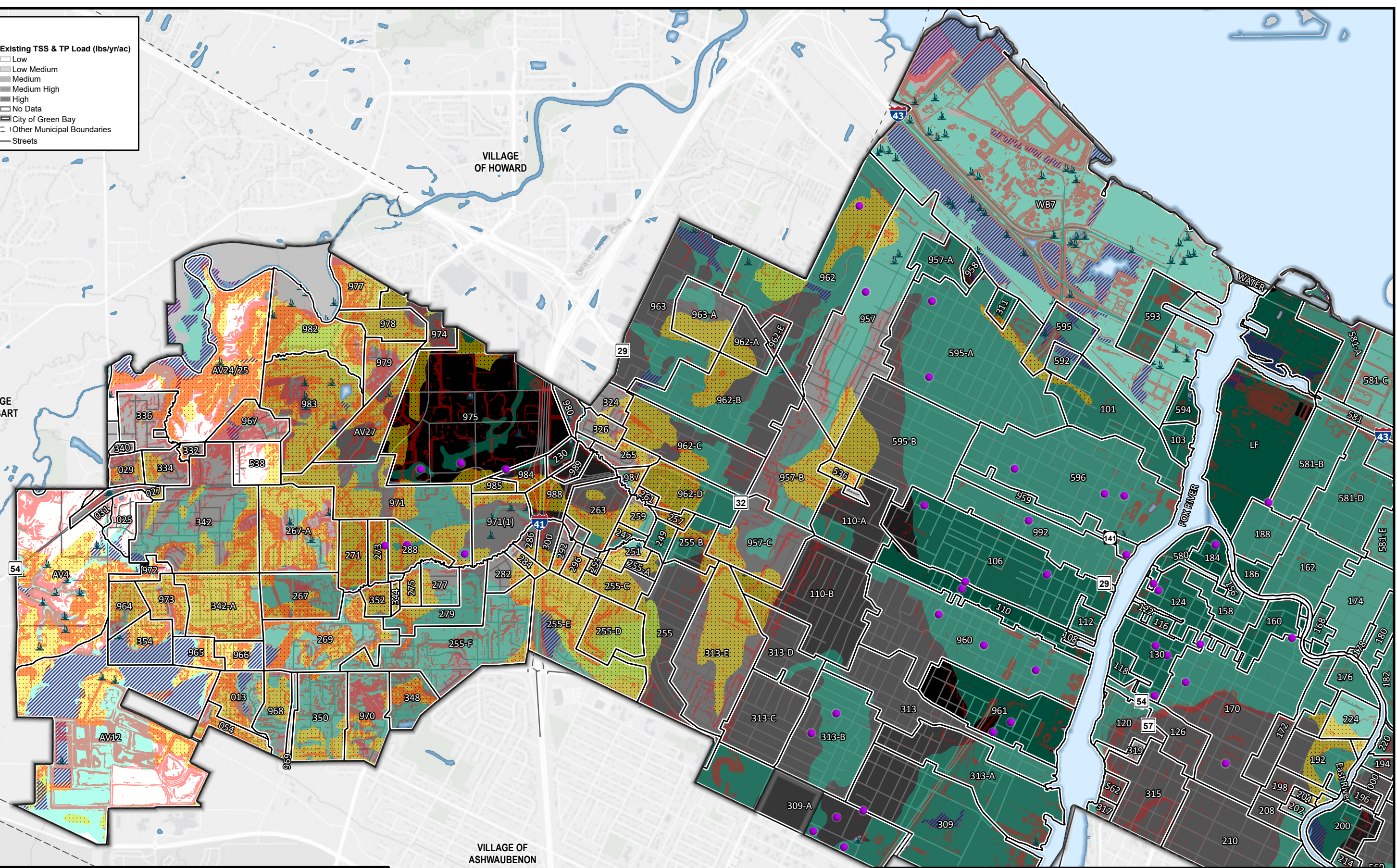


FIGURE 5

BARRIERS AND OPPORTUNITIES FOR GSI

GREEN STORMWATER INFRASTRUCTURE PLAN

CITY OF GREEN BAY

BROWN COUNTY, WISCONSIN

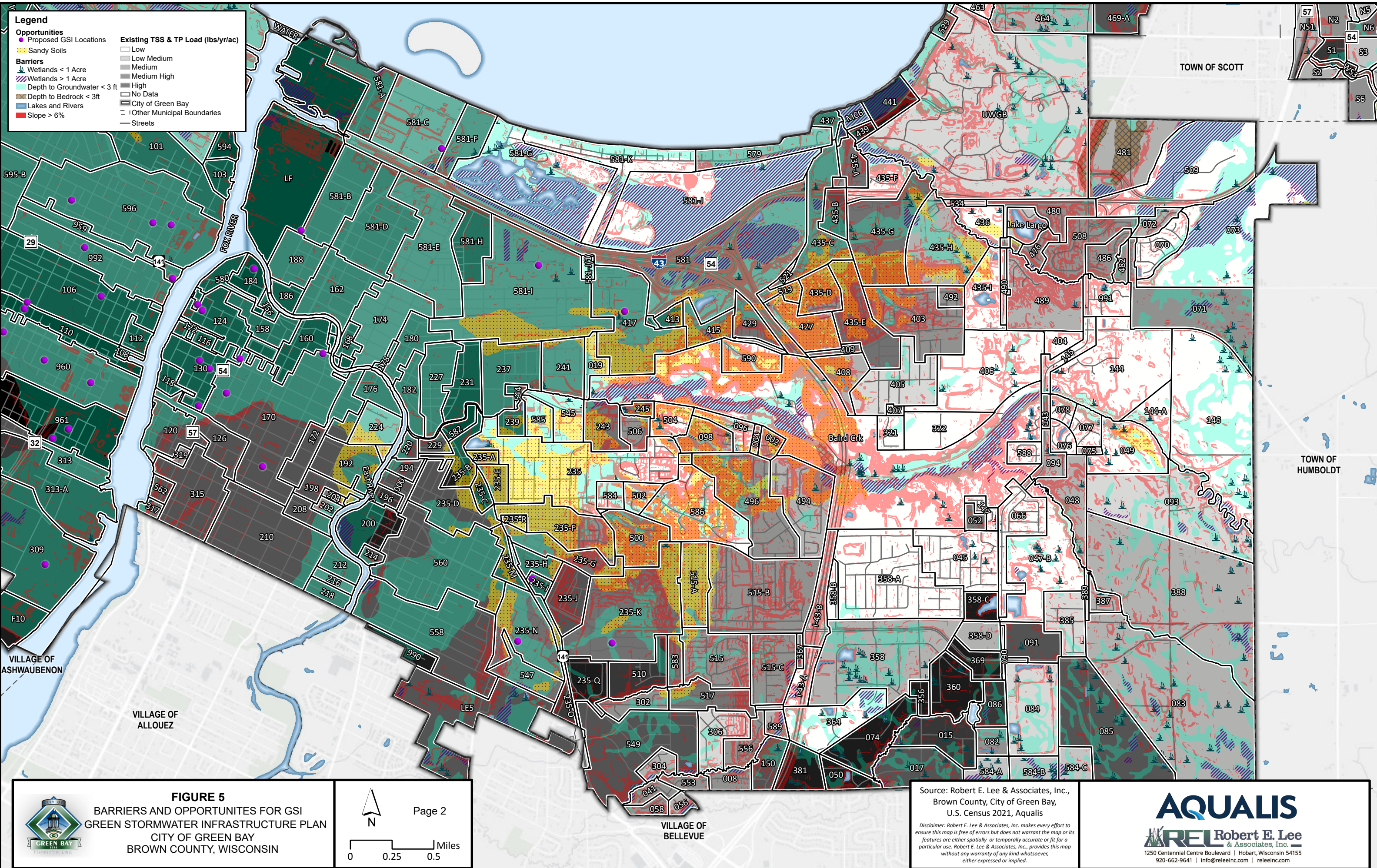
Page 1

0 0.25 0.5 Miles

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Legend

Opportunities

Proposed GSI Locations

Sandy Soils

Barriers

Wetlands < 1 Acre

Wetlands > 1 Acre

Depth to Groundwater < 3 ft

Depth to Bedrock < 3ft

Lakes and Rivers

Slope > 6%

Existing TSS & TP Load (lbs/yr/ac)

Low

Low Medium

Medium

Medium High

High

No Data

City of Green Bay

Other Municipal Boundaries

Streets



FIGURE 5

BARRIERS AND OPPORTUNITES FOR GSI

GREEN STORMWATER INFRASTRUCTURE PLAN

CITY OF GREEN BAY

BROWN COUNTY, WISCONSIN

N

0 0.25 0.5 Miles

Page 3

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Legend

- Wetlands < 1 Acre
- Concept Private Property GSI Locations
- Streets
- Wetlands > 1 Acre
- Storm Basins
- Lakes and Rivers
- Property Values Below City Median Value (\$151,000)

Commercial and Industrial Zoning

- C1 - Commercial One
- C2 - Commercial Two
- C3 - Commercial Three
- GI - General Industry
- S-RLI - Special District Light Industry
- LI - Light Industry
- City of Green Bay
- Other Municipal Boundaries

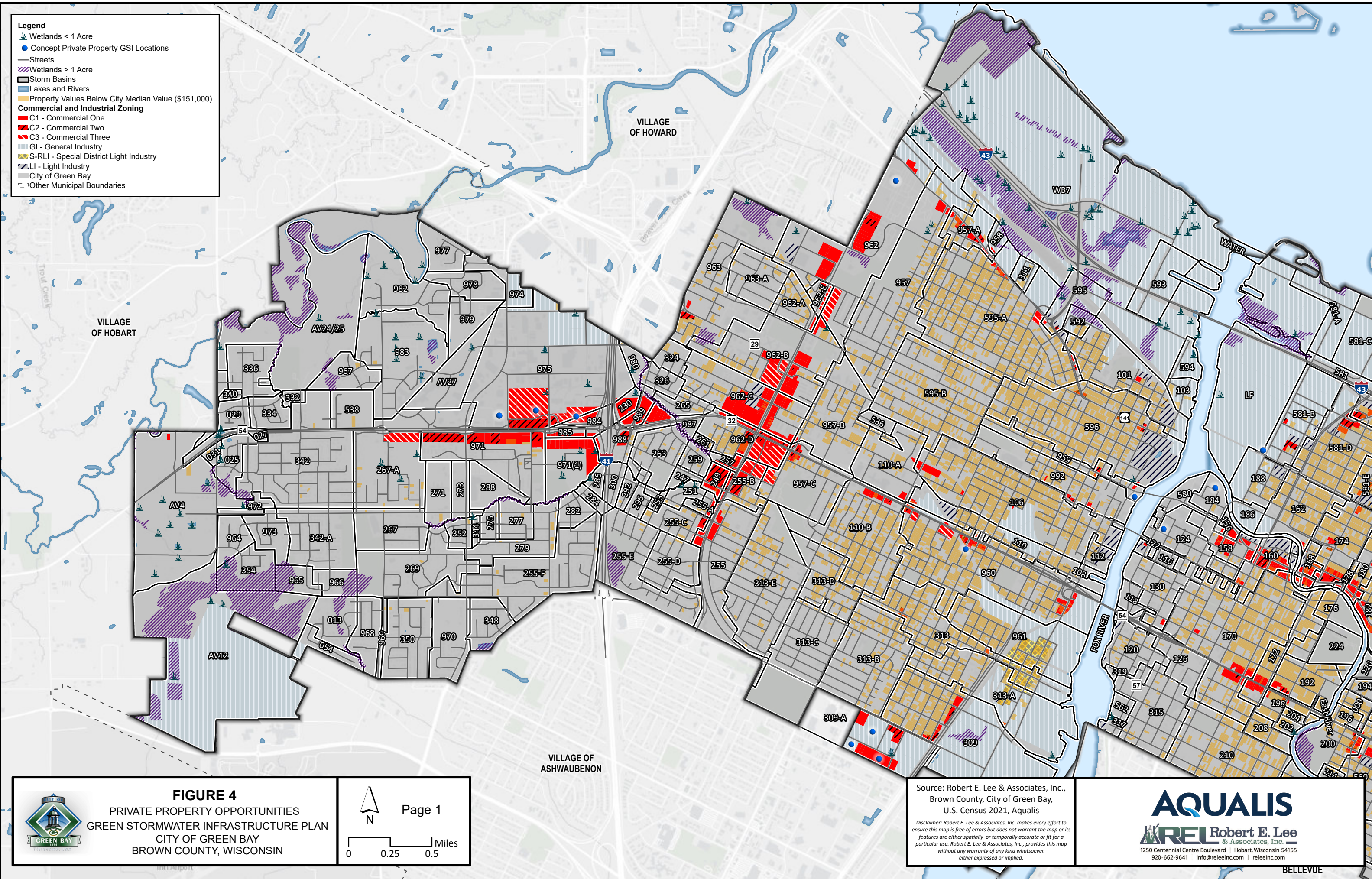


FIGURE 4
PRIVATE PROPERTY OPPORTUNITIES
GREEN STORMWATER INFRASTRUCTURE PLAN
CITY OF GREEN BAY
BROWN COUNTY, WISCONSIN

Page 1

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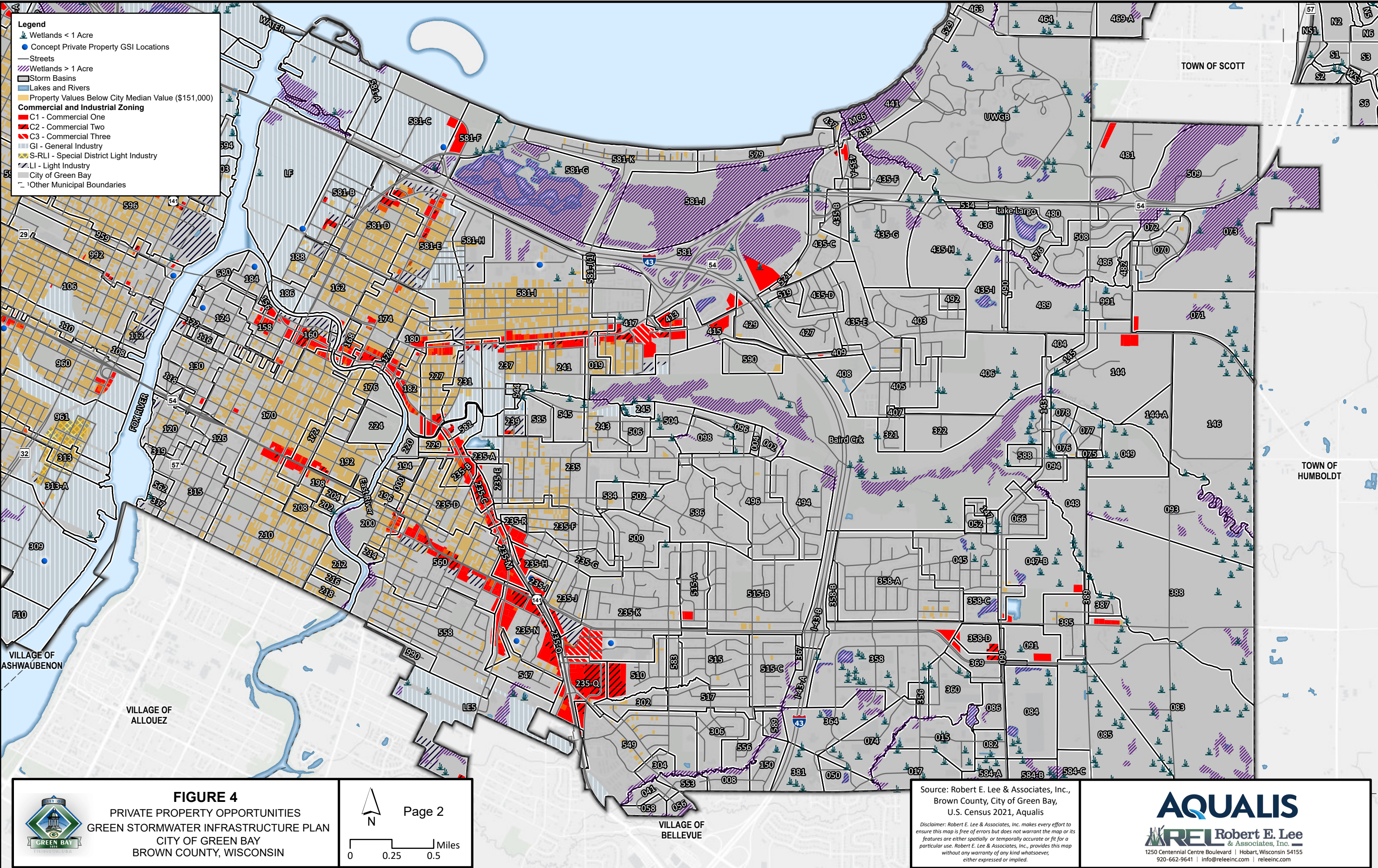
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Legend

- Wetlands < 1 Acre
- Concept Private Property GSI Locations
- Streets
- Wetlands > 1 Acre
- Storm Basins
- Lakes and Rivers
- Property Values Below City Median Value (\$151,000)

Commercial and Industrial Zoning

- C1 - Commercial One
- C2 - Commercial Two
- C3 - Commercial Three
- GI - General Industry
- S-RLI - Special District Light Industry
- LI - Light Industry
- City of Green Bay
- Other Municipal Boundaries

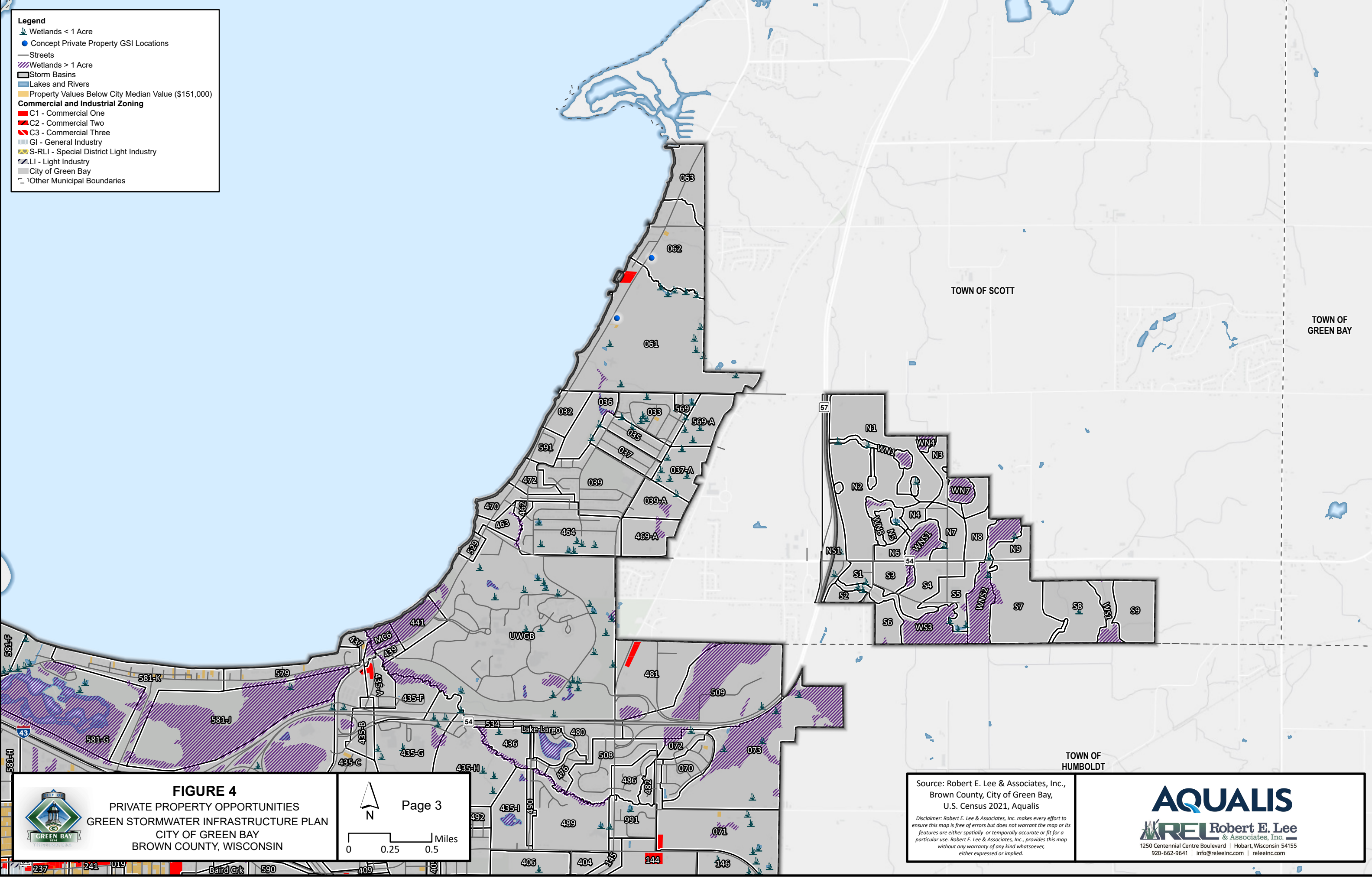


FIGURE 4
 PRIVATE PROPERTY OPPORTUNITIES
 GREEN STORMWATER INFRASTRUCTURE PLAN
 CITY OF GREEN BAY
 BROWN COUNTY, WISCONSIN

Page 3

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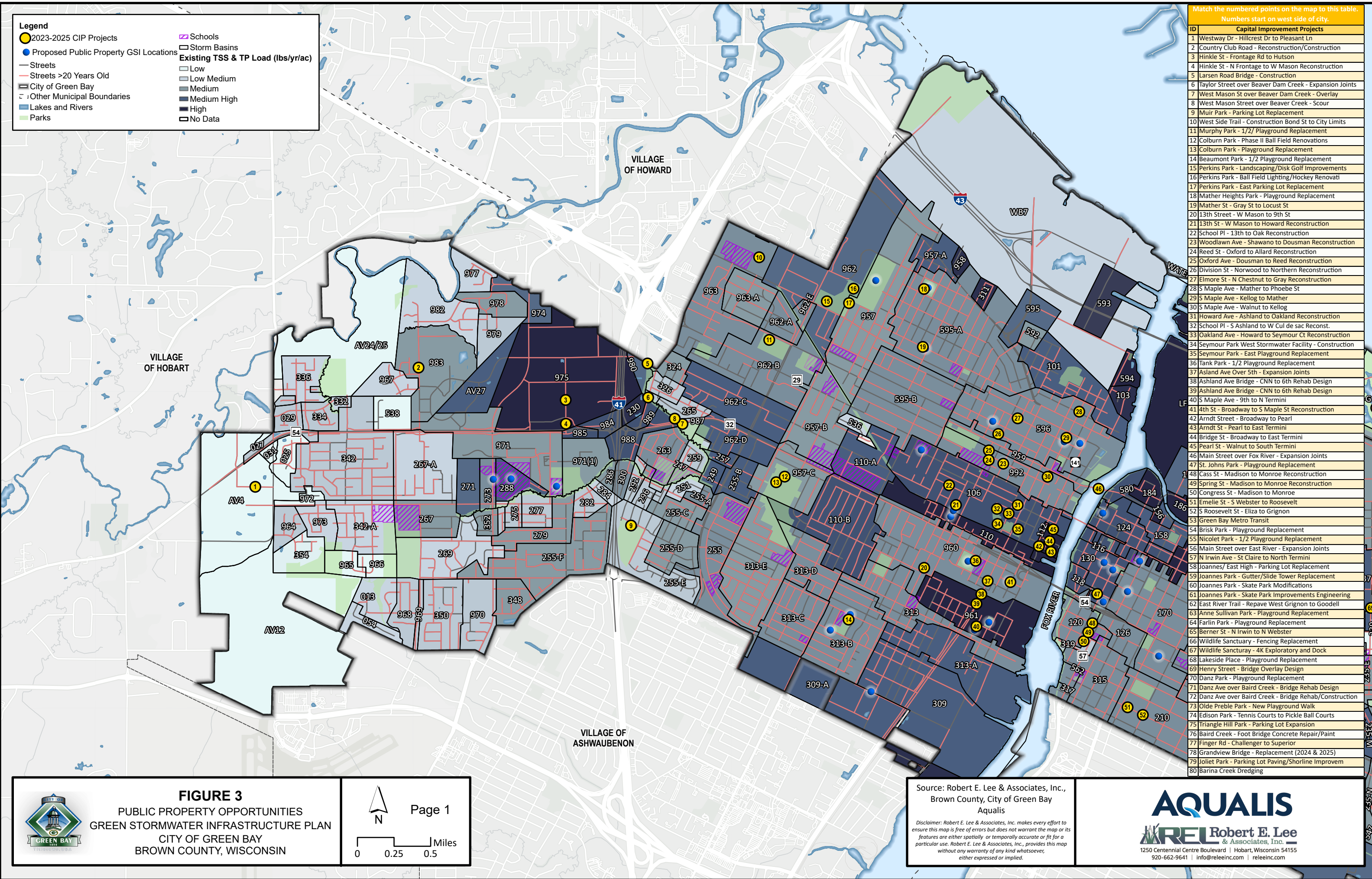
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Legend

● 2023-2025 CIP Projects

● Proposed Public Property GSI Locations

— Streets

— Streets >20 Years Old

City of Green Bay

Other Municipal Boundaries

Lakes and Rivers

Parks

Schools

Storm Basins

Existing TSS & TP Load (lbs/yr/ac)

Low

Low Medium

Medium

Medium High

High

No Data

Match the numbered points on the map to this table. Numbers start on west side of city.	
ID	Capital Improvement Projects
1	Westway Dr - Hillcrest Dr to Pleasant Ln
2	Country Club Road - Reconstruction/Construction
3	Hinkle St - Frontage Rd to Hutson
4	Hinkle St - N Frontage to W Mason Reconstruction
5	Larsen Road Bridge - Construction
6	Taylor Street over Beaver Dam Creek - Expansion Joints
7	West Mason St over Beaver Dam Creek - Overlay
8	West Mason Street over Beaver Creek - Scour
9	Muir Park - Parking Lot Replacement
10	West Side Trail - Construction Bond St to City Limits
11	Murphy Park - 1/2 Playground Replacement
12	Colburn Park - Phase II Ball Field Renovations
13	Colburn Park - Playground Replacement
14	Beaumont Park - 1/2 Playground Replacement
15	Perkins Park - Landscaping/Disk Golf Improvements
16	Perkins Park - Ball Field Lighting/Hockey Renovati
17	Perkins Park - East Parking Lot Replacement
18	Mather Heights Park - Playground Replacement
19	Mather St - Gray St to Locust St
20	13th Street - W Mason to 9th St
21	13th St - W Mason to Howard Reconstruction
22	School Pl - 13th to Oak Reconstruction
23	Woodlawn Ave - Shawano to Dousman Reconstruction
24	Reed St - Oxford to Allard Reconstruction
25	Oxford Ave - Dousman to Reed Reconstruction
26	Division St - Norwood to Northern Reconstruction
27	Elmore St - N Chestnut to Gray Reconstruction
28	S Maple Ave - Mather to Phoebe St
29	S Maple Ave - Kellogg to Mather
30	S Maple Ave - Walnut to Kellogg
31	Howard Ave - Ashland to Oakland Reconstruction
32	School Pl - S Ashland to W Cul de sac Reconst.
33	Oakland Ave - Howard to Seymour Ct Reconstruction
34	Seymour Park West Stormwater Facility - Construction
35	Seymour Park - East Playground Replacement
36	Tank Park - 1/2 Playground Replacement
37	Ashland Ave Over 5th - Expansion Joints
38	Ashland Ave Bridge - CNN to 6th Rehab Design
39	Ashland Ave Bridge - CNN to 6th Rehab Design
40	S Maple Ave - 9th to N Termini
41	4th St - Broadway to S Maple St Reconstruction
42	Arndt Street - Broadway to Pearl
43	Arndt St - Pearl to East Termini
44	Bridge St - Broadway to East Termini
45	Pearl St - Walnut to South Termini
46	Main Street over Fox River - Expansion Joints
47	St. Johns Park - Playground Replacement
48	Cass St - Madison to Monroe Reconstruction
49	Spring St - Madison to Monroe Reconstruction
50	Congress St - Madison to Monroe
51	Emelie St - S Webster to Roosevelt
52	S Roosevelt St - Eliza to Grignon
53	Green Bay Metro Transit
54	Brisk Park - Playground Replacement
55	Nicolet Park - 1/2 Playground Replacement
56	Main Street over East River - Expansion Joints
57	N Irwin Ave - St Claire to North Termini
58	Joannes/ East High - Parking Lot Replacement
59	Joannes Park - Gutter/Slide Tower Replacement
60	Joannes Park - Skate Park Modifications
61	Joannes Park - Skate Park Improvements Engineering
62	East River Trail - Repave West Grignon to Goodell
63	Anne Sullivan Park - Playground Replacement
64	Farlin Park - Playground Replacement
65	Berner St - N Irwin to N Webster
66	Wildlife Sanctuary - Fencing Replacement
67	Wildlife Sancturay - 4K Exploratory and Dock
68	Lakeside Place - Playground Replacement
69	Henry Street - Bridge Overlay Design
70	Danz Park - Playground Replacement
71	Danz Ave over Baird Creek - Bridge Rehab Design
72	Danz Ave over Baird Creek - Bridge Rehab/Construction
73	Olde Preble Park - New Playground Walk
74	Edison Park - Tennis Courts to Pickle Ball Courts
75	Triangle Hill Park - Parking Lot Expansion
76	Baird Creek - Foot Bridge Concrete Repair/Paint
77	Finger Rd - Challenger to Superior
78	Grandview Bridge - Replacement (2024 & 2025)
79	Joliet Park - Parking Lot Paving/Shorline Improvem
80	Barina Creek Dredging

FIGURE 3

PUBLIC PROPERTY OPPORTUNITIES

GREEN STORMWATER INFRASTRUCTURE PLAN

CITY OF GREEN BAY

BROWN COUNTY, WISCONSIN

0

0.25

0.5

Miles

Page 1

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Legend

- Major and Minor Outfalls
- Common Points of Flooding
- Wetlands < 1 Acre
- Storm Sewers
- Streets
- Private Storm Sewers
- Storm Water Ponds
- Lakes and Rivers
- Wetlands > 1 Acre
- Common Flooding Areas

- City of Green Bay
- Other Municipal Boundaries

Flooding Areas Per Storm Basin

- No Recorded Flooding Area
- 1 Area
- 2 Areas
- 3 Areas
- 5 Areas
- Storm Basins
- Neighborhood Associations

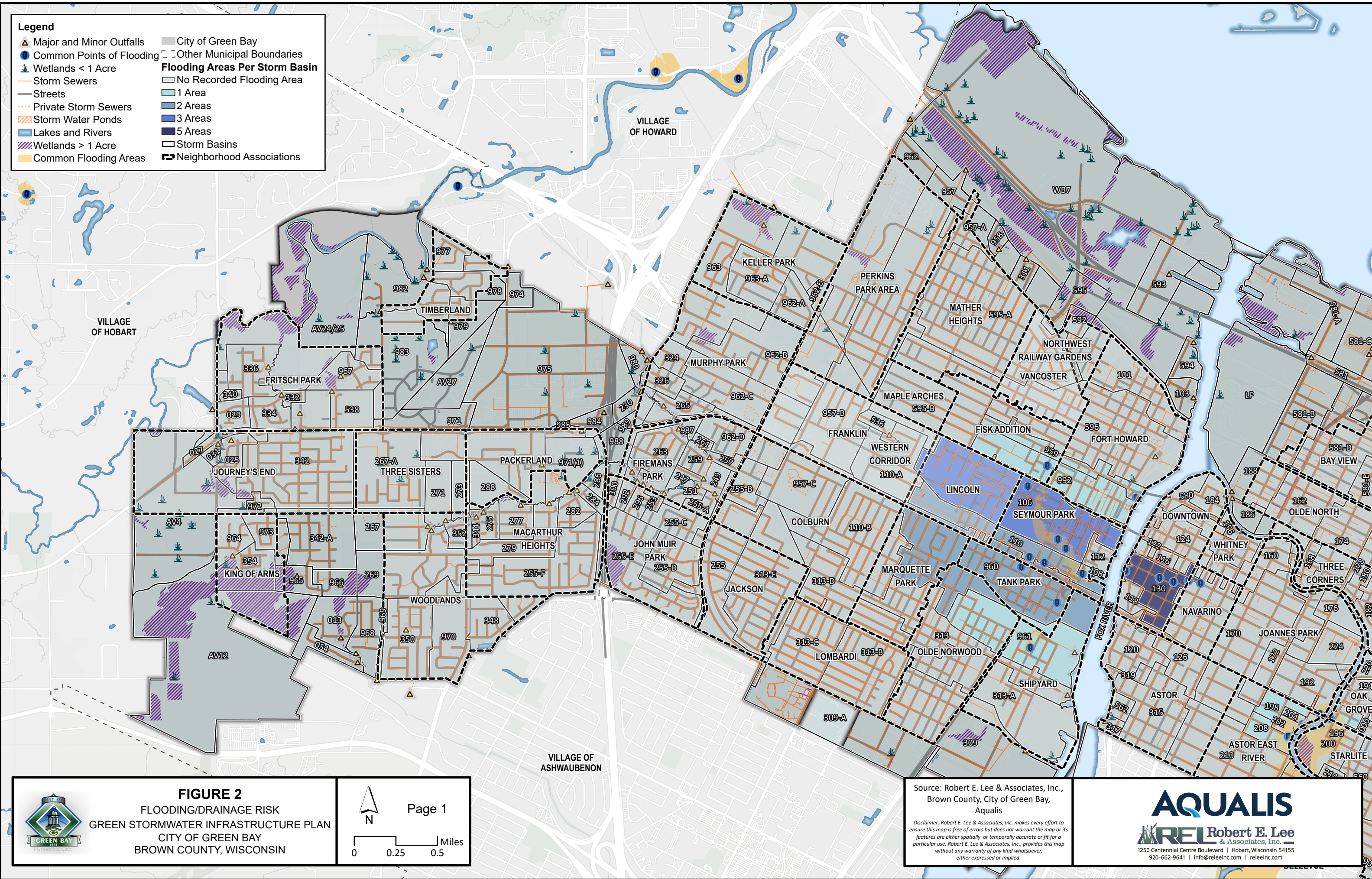




FIGURE 2
 FLOODING/DRAINAGE RISK
 GREEN STORMWATER INFRASTRUCTURE PLAN
 CITY OF GREEN BAY
 BROWN COUNTY, WISCONSIN



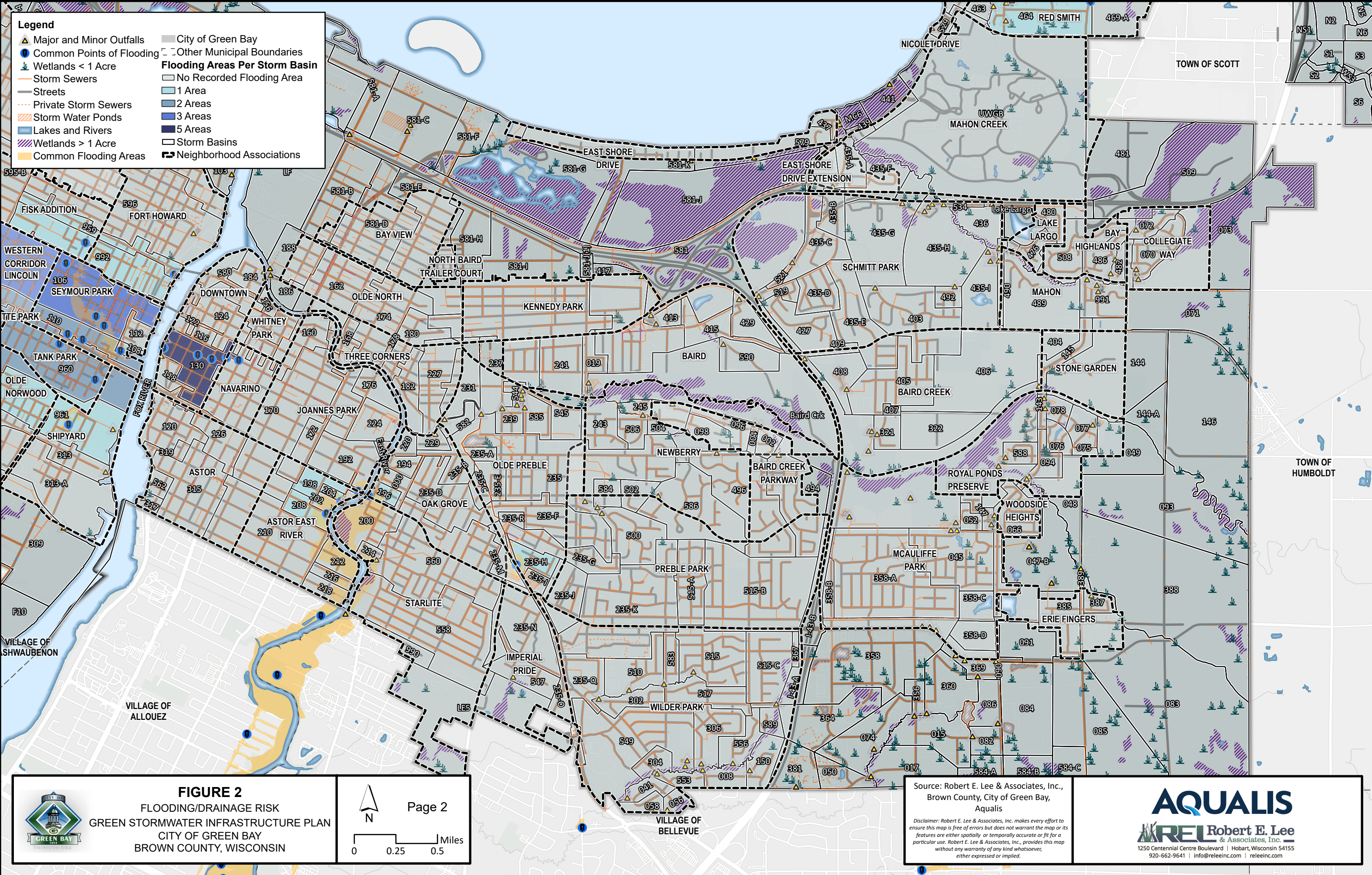
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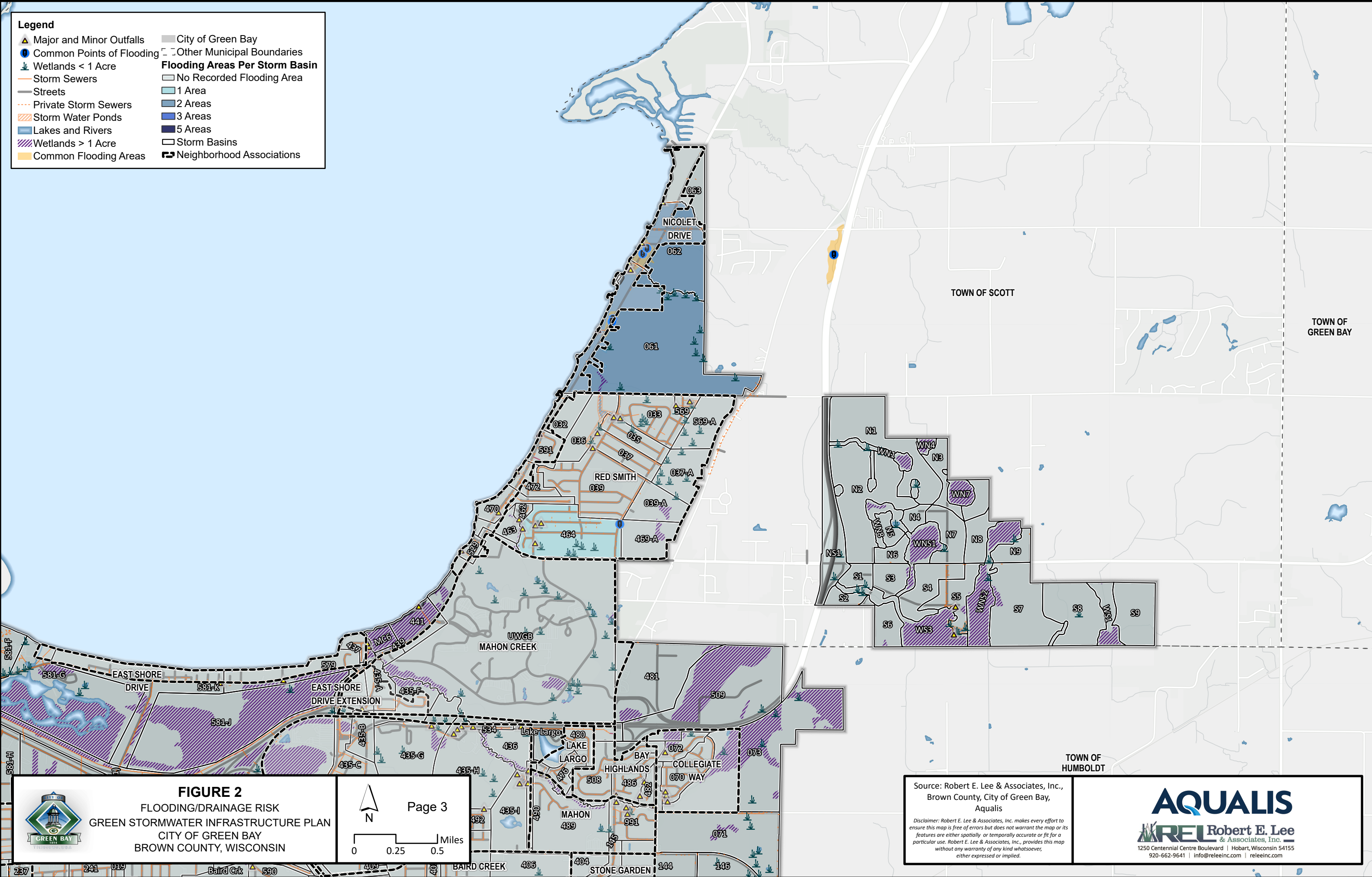
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Major and Minor Outfalls

Common Points of Flooding

Wetlands < 1 Acre

Storm Sewers

Streets

Private Storm Sewers

Storm Water Ponds

Lakes and Rivers

Wetlands > 1 Acre

Common Flooding Areas

City of Green Bay

Other Municipal Boundaries

Flooding Areas Per Storm Basin

No Recorded Flooding Area

1 Area

2 Areas

3 Areas

5 Areas

Storm Basins

Neighborhood Associations



FIGURE 2

FLOODING/DRAINAGE RISK

GREEN STORMWATER INFRASTRUCTURE PLAN

CITY OF GREEN BAY

BROWN COUNTY, WISCONSIN

N

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Page 3

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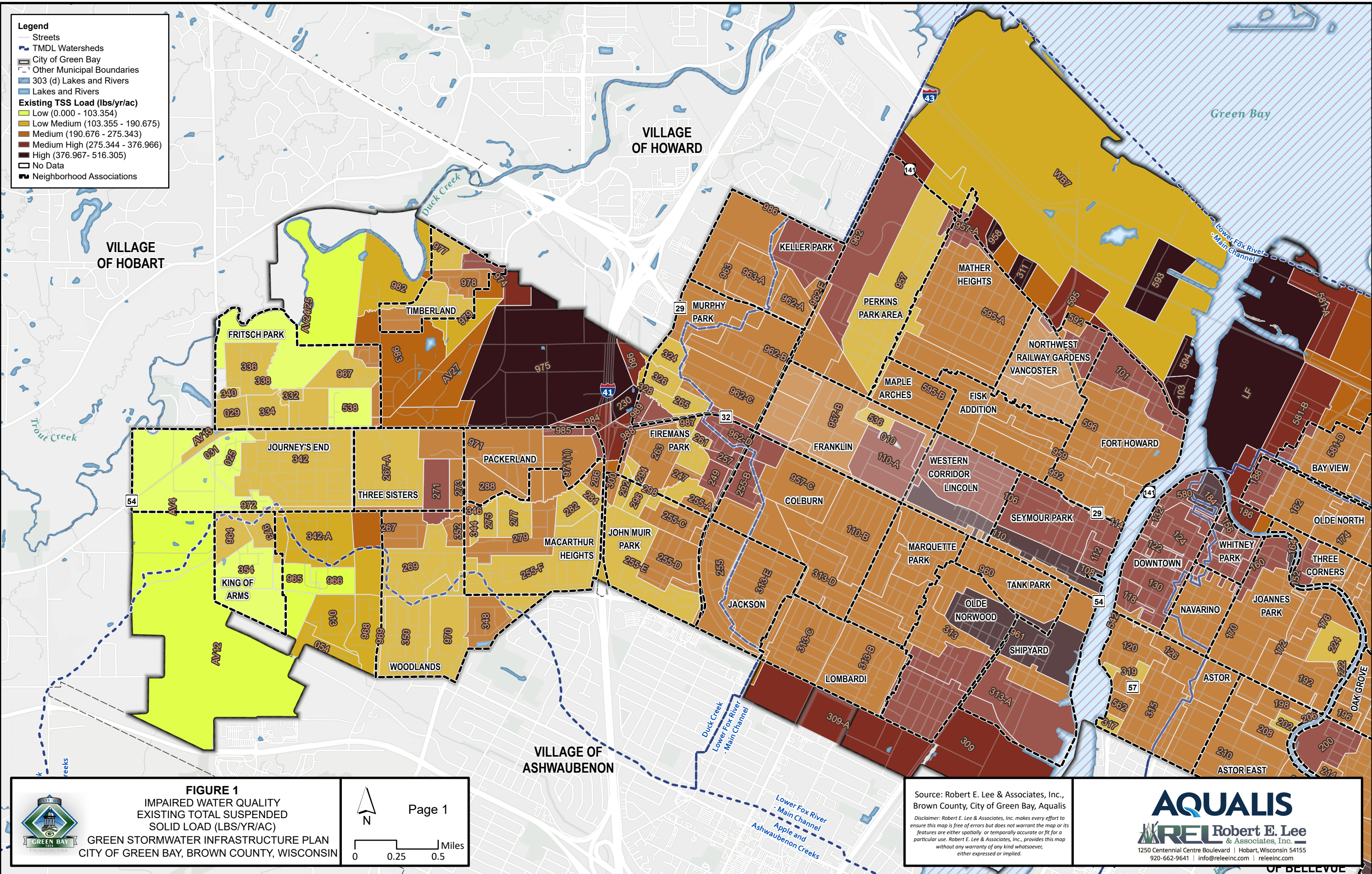
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Legend

- Streets
- TMDL Watersheds
- City of Green Bay
- Other Municipal Boundaries
- 303 (d) Lakes and Rivers
- Lakes and Rivers
- Existing TSS Load (lbs/yr/ac)**
- Low (0.000 - 103.354)
- Low Medium (103.355 - 190.675)
- Medium (190.676 - 275.343)
- Medium High (275.344 - 376.966)
- High (376.967 - 516.305)
- No Data
- Neighborhood Associations



FIGURE 1
IMPAIRED WATER QUALITY
EXISTING TOTAL SUSPENDED
SOLID LOAD (LBS/YR/AC)
GREEN STORMWATER INFRASTRUCTURE PLAN
CITY OF GREEN BAY, BROWN COUNTY, WISCONSIN

Page 1

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0 0.25 0.5 Miles

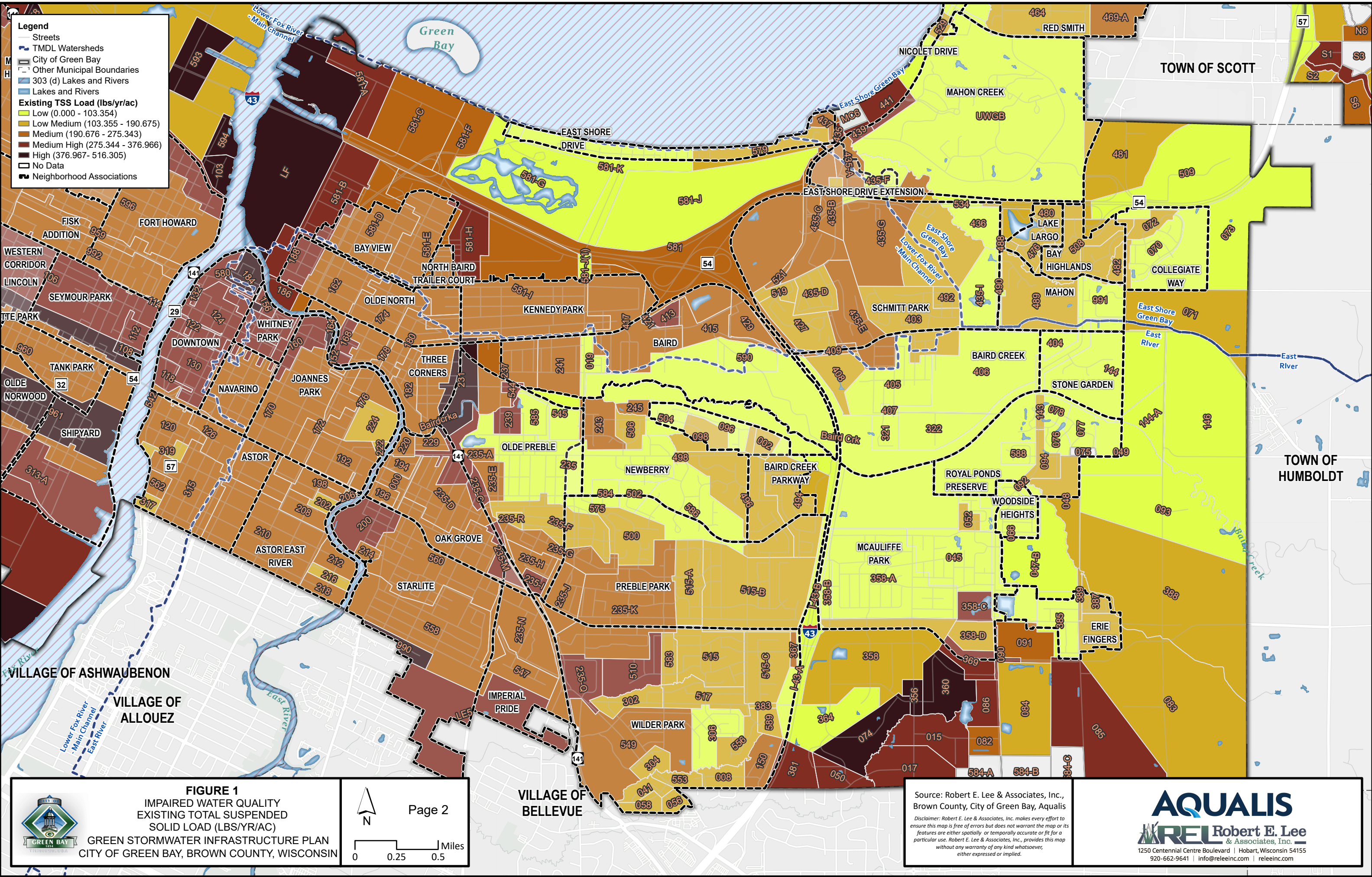
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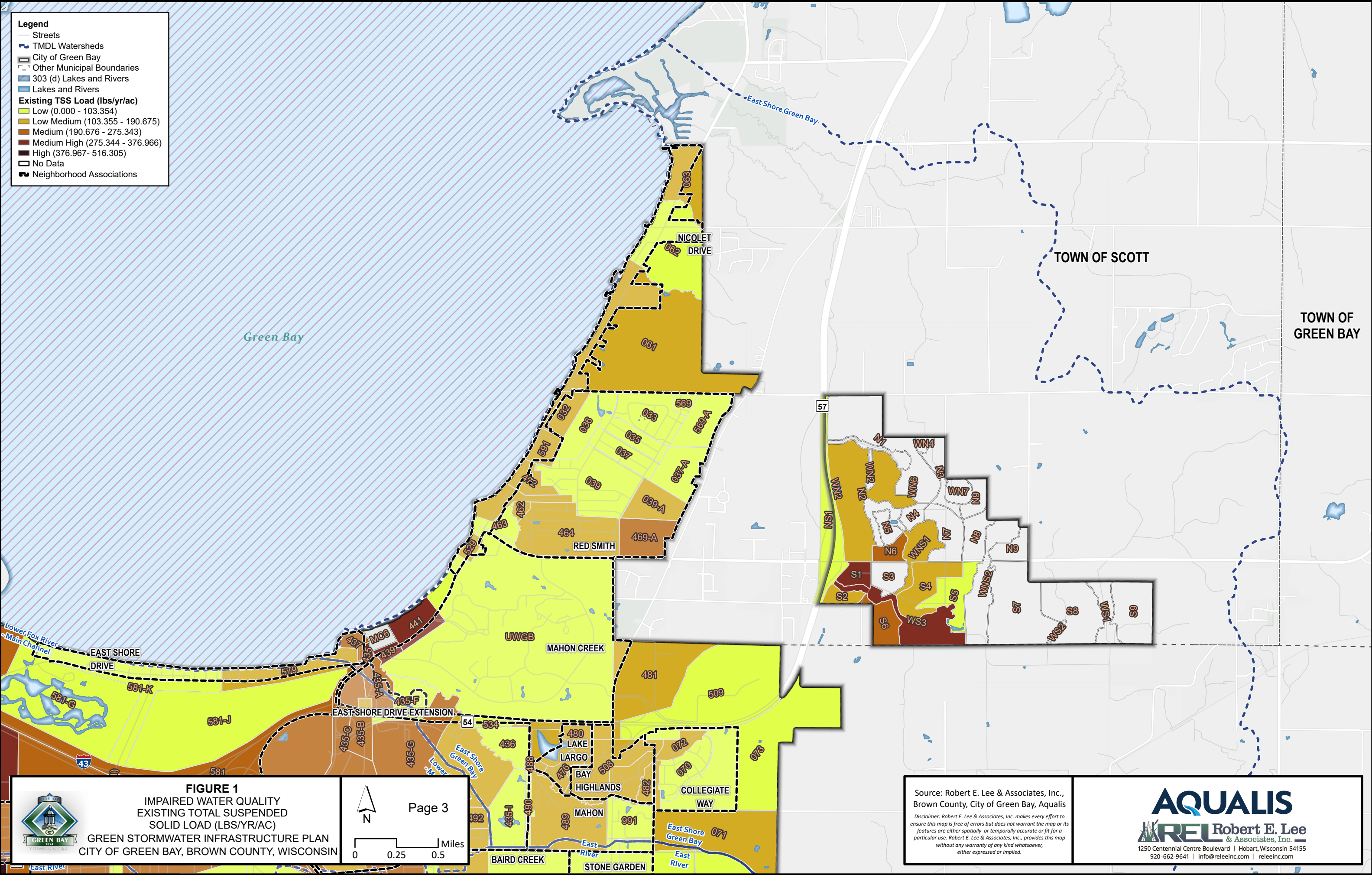
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Legend

- Streets
- TMDL Watersheds
- City of Green Bay
- Other Municipal Boundaries
- 303 (d) Lakes and Rivers
- Lakes and Rivers

Existing TSS Load (lbs/yr/ac)

- Low (0.000 - 103.354)
- Low Medium (103.355 - 190.675)
- Medium (190.676 - 275.343)
- Medium High (275.344 - 376.966)
- High (376.967 - 516.305)
- No Data

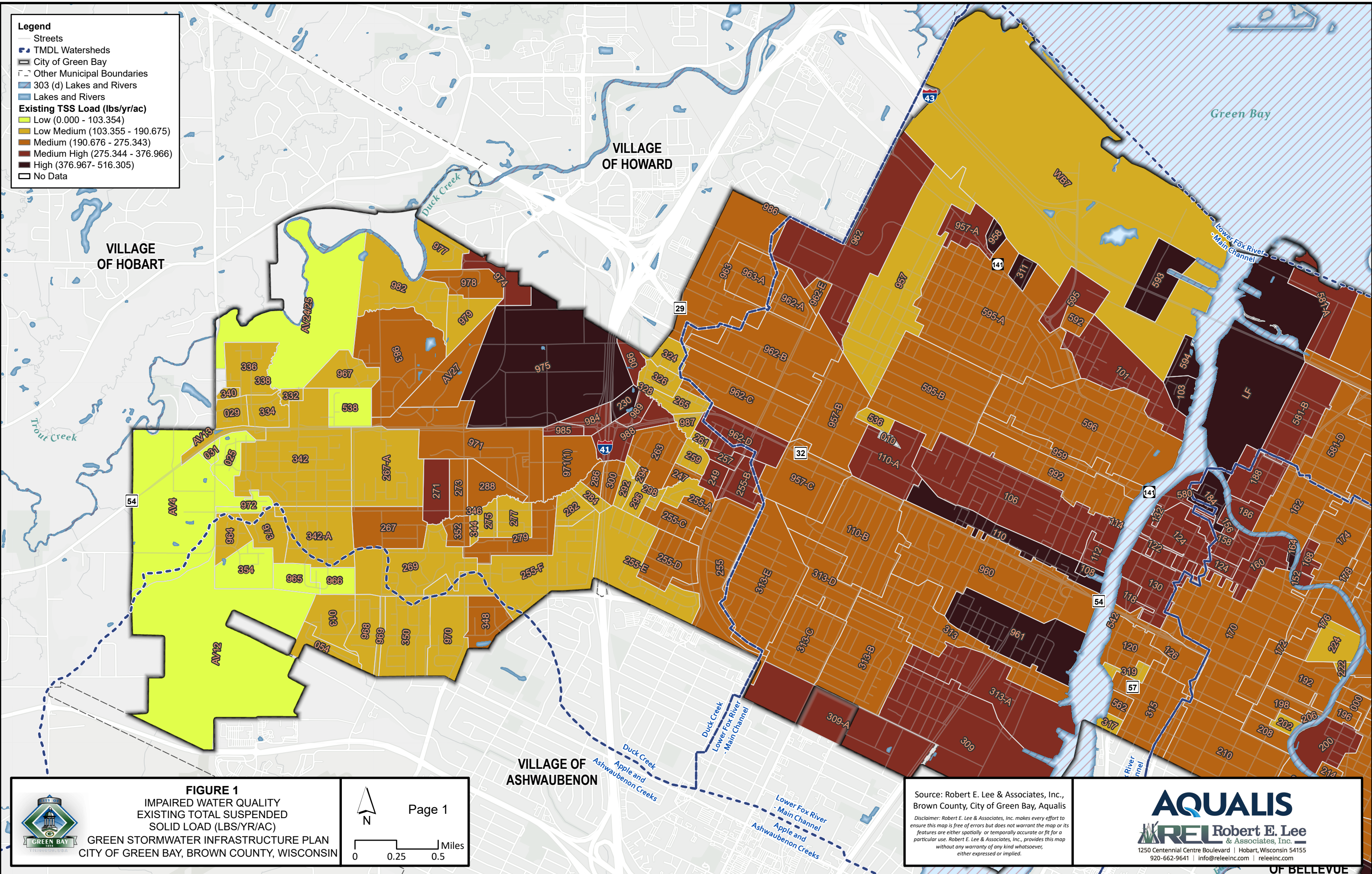


FIGURE 1
IMPAIRED WATER QUALITY
EXISTING TOTAL SUSPENDED
SOLID LOAD (LBS/YR/AC)
GREEN STORMWATER INFRASTRUCTURE PLAN
CITY OF GREEN BAY, BROWN COUNTY, WISCONSIN

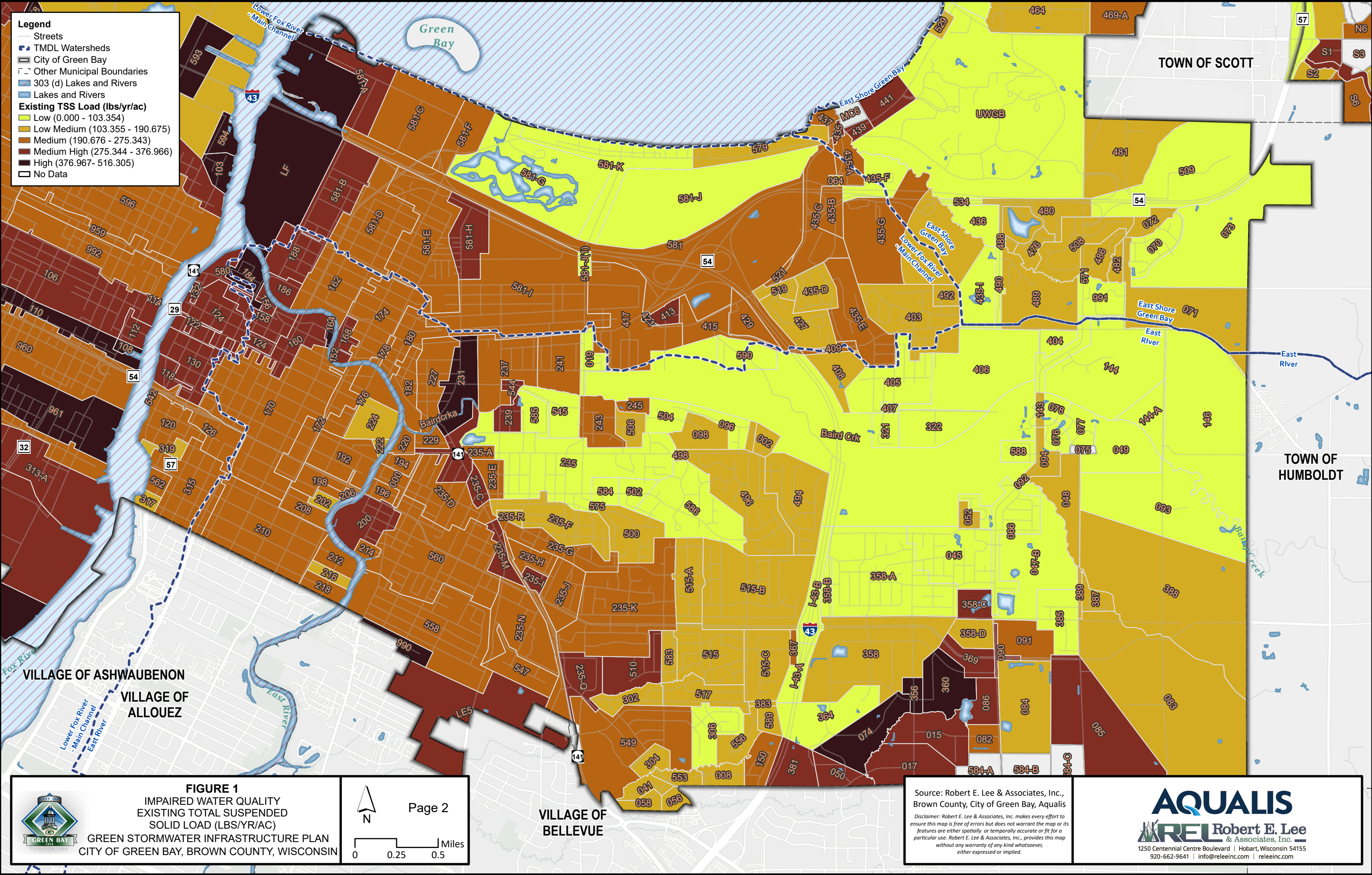
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0 0.25 0.5 Miles

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Legend

- Streets
- TMDL Watersheds
- City of Green Bay
- Other Municipal Boundaries
- 303 (d) Lakes and Rivers
- Lakes and Rivers

Existing TP Load (lbs/yr/ac)

- Low (0.000 - 0.373)
- Low Medium (0.373 - 0.556)
- Medium (0.556 - 0.694)
- Medium High (0.694 - 0.813)
- High (0.813 - 1.017)
- No Data
- Neighborhood Associations

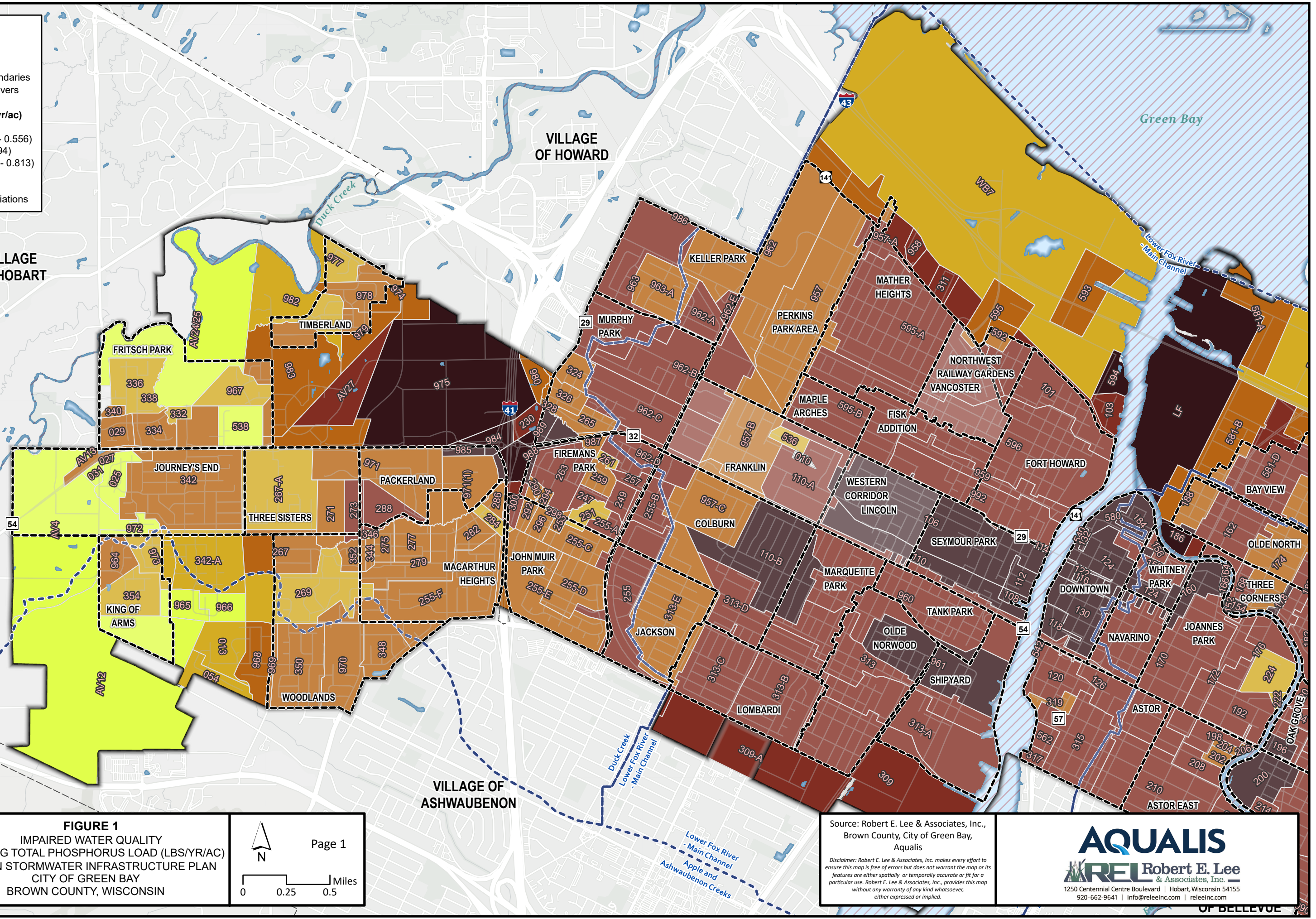


FIGURE 1

IMPAIRED WATER QUALITY

EXISTING TOTAL PHOSPHORUS LOAD (LBS/YR/AC)

GREEN STORMWATER INFRASTRUCTURE PLAN

CITY OF GREEN BAY

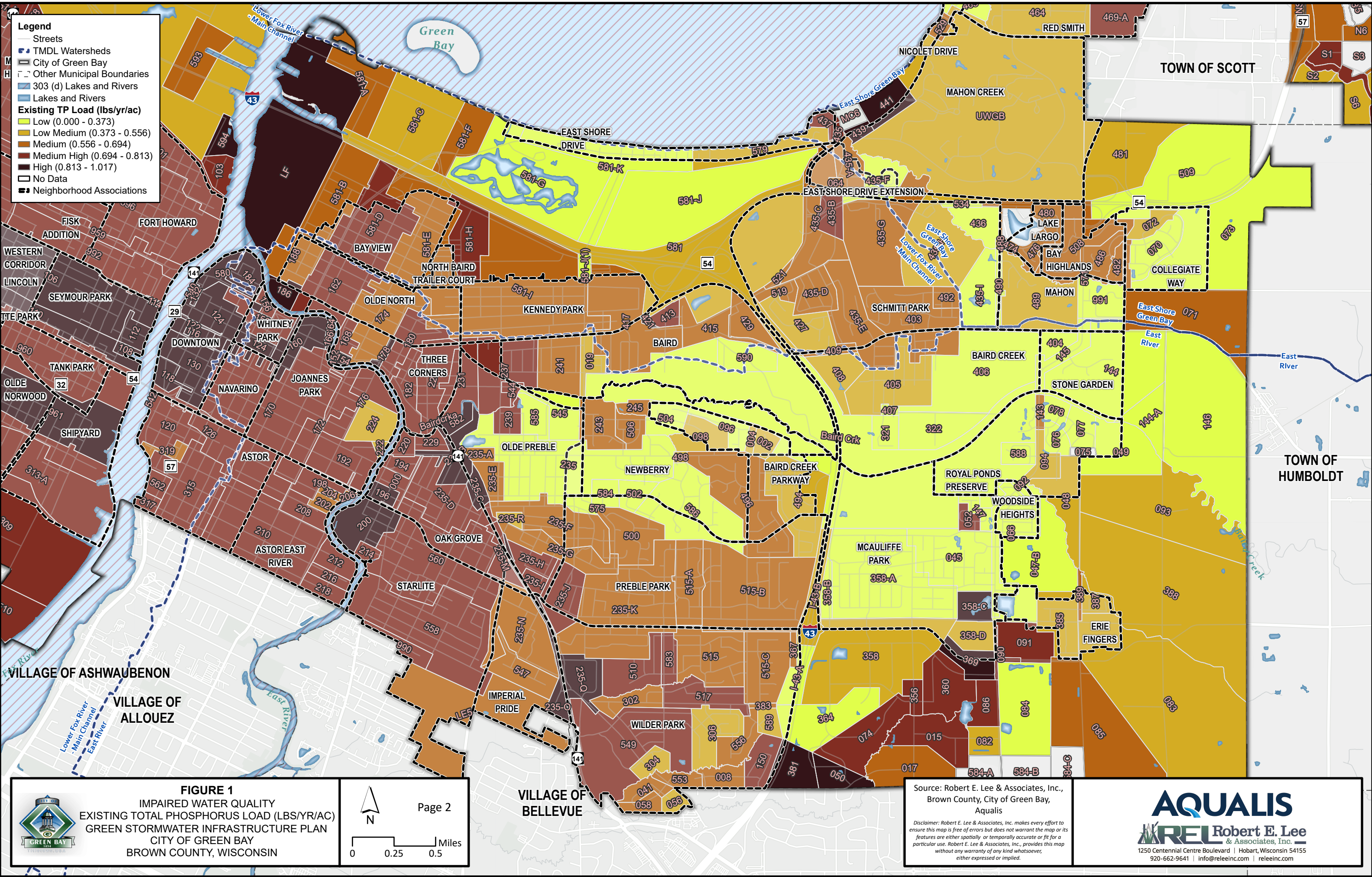
BROWN COUNTY, WISCONSIN

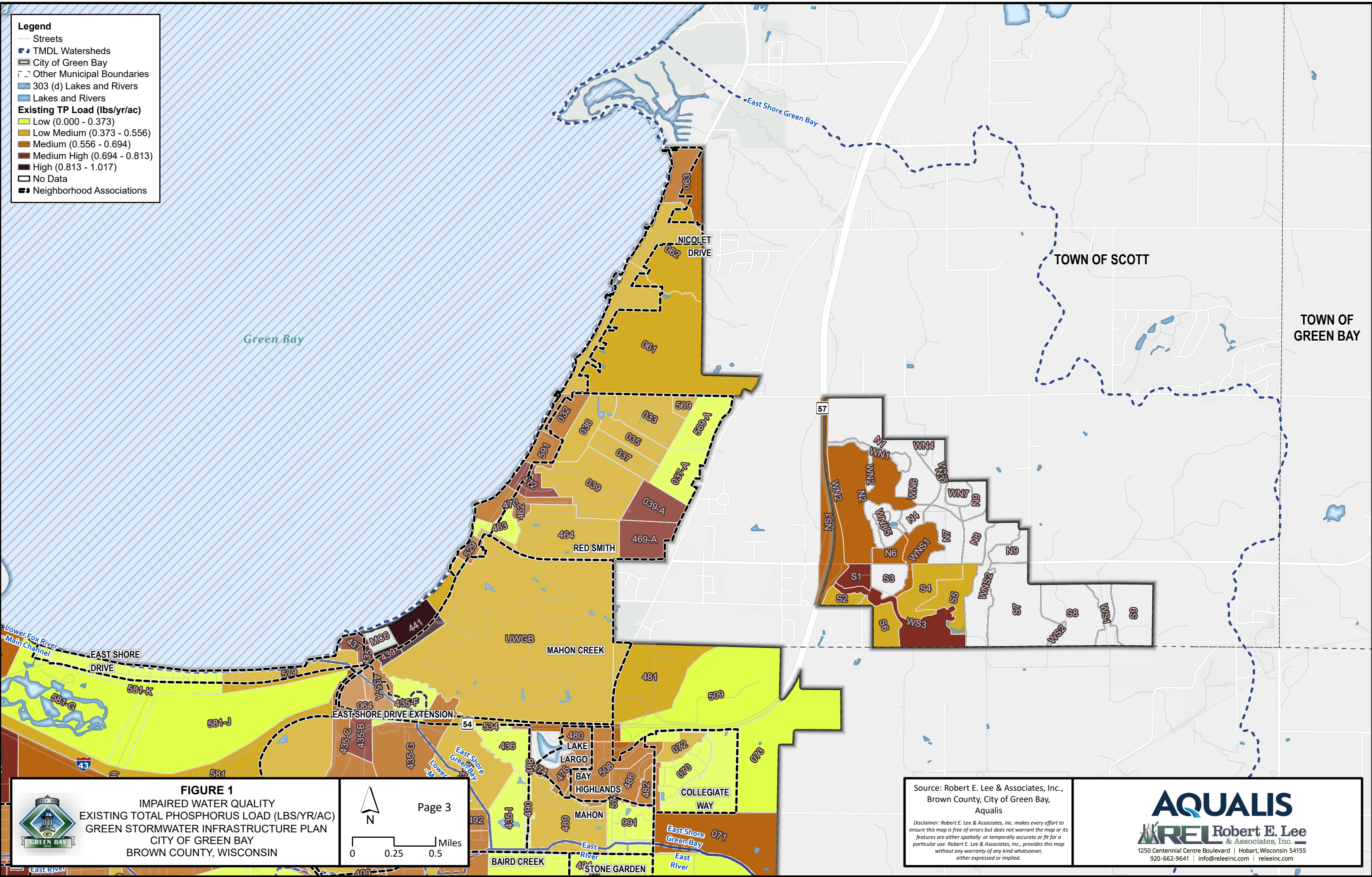
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Legend

Streets

TMDL Watersheds

City of Green Bay

Other Municipal Boundaries

303 (d) Lakes and Rivers

Lakes and Rivers

Existing TP Load (lbs/yr/ac)

Low (0.000 - 0.373)

Low Medium (0.373 - 0.556)

Medium (0.556 - 0.694)

Medium High (0.694 - 0.813)

High (0.813 - 1.017)

No Data

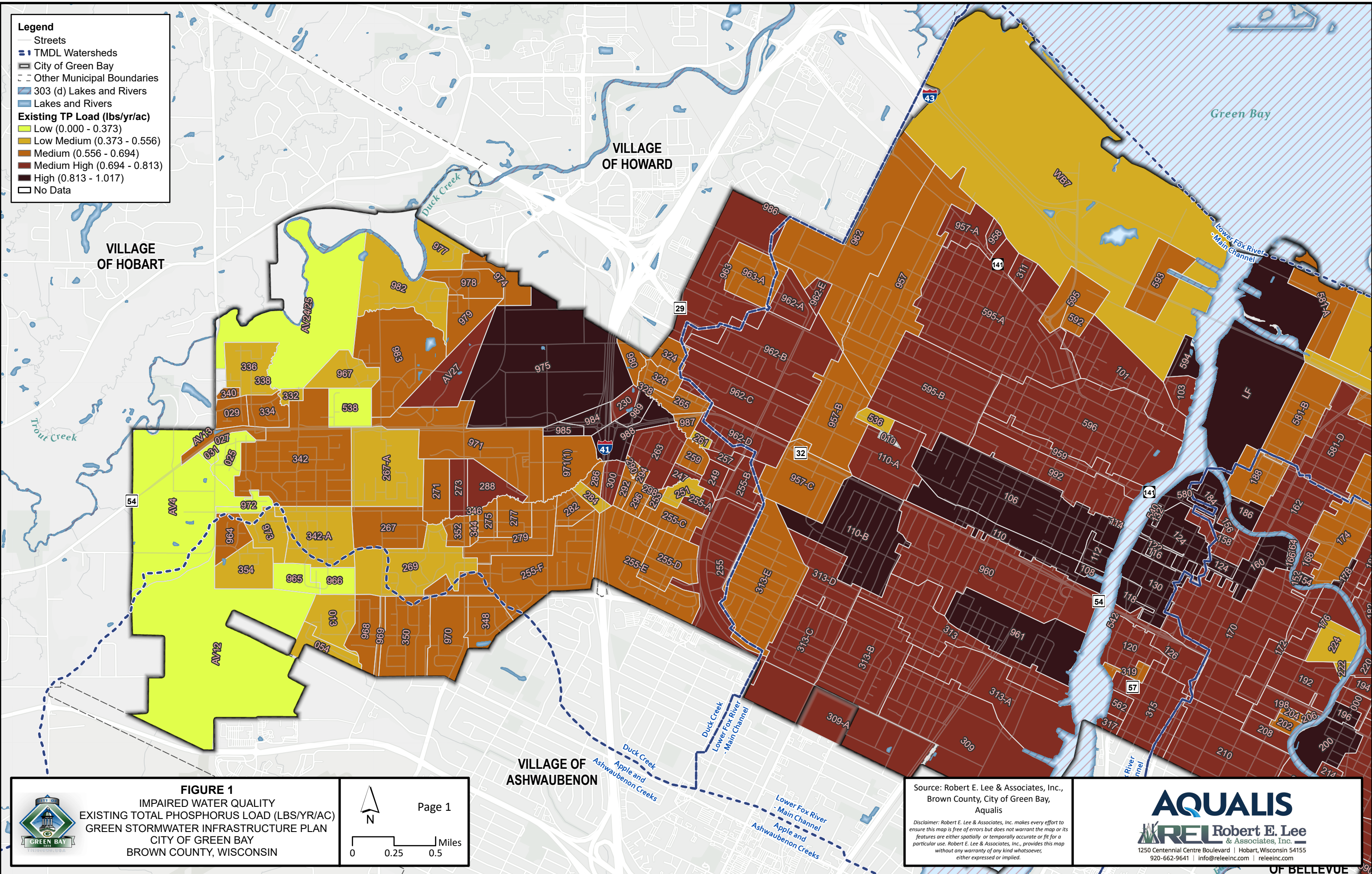


FIGURE 1

IMPAIRED WATER QUALITY

EXISTING TOTAL PHOSPHORUS LOAD (LBS/YR/AC)

GREEN STORMWATER INFRASTRUCTURE PLAN

CITY OF GREEN BAY

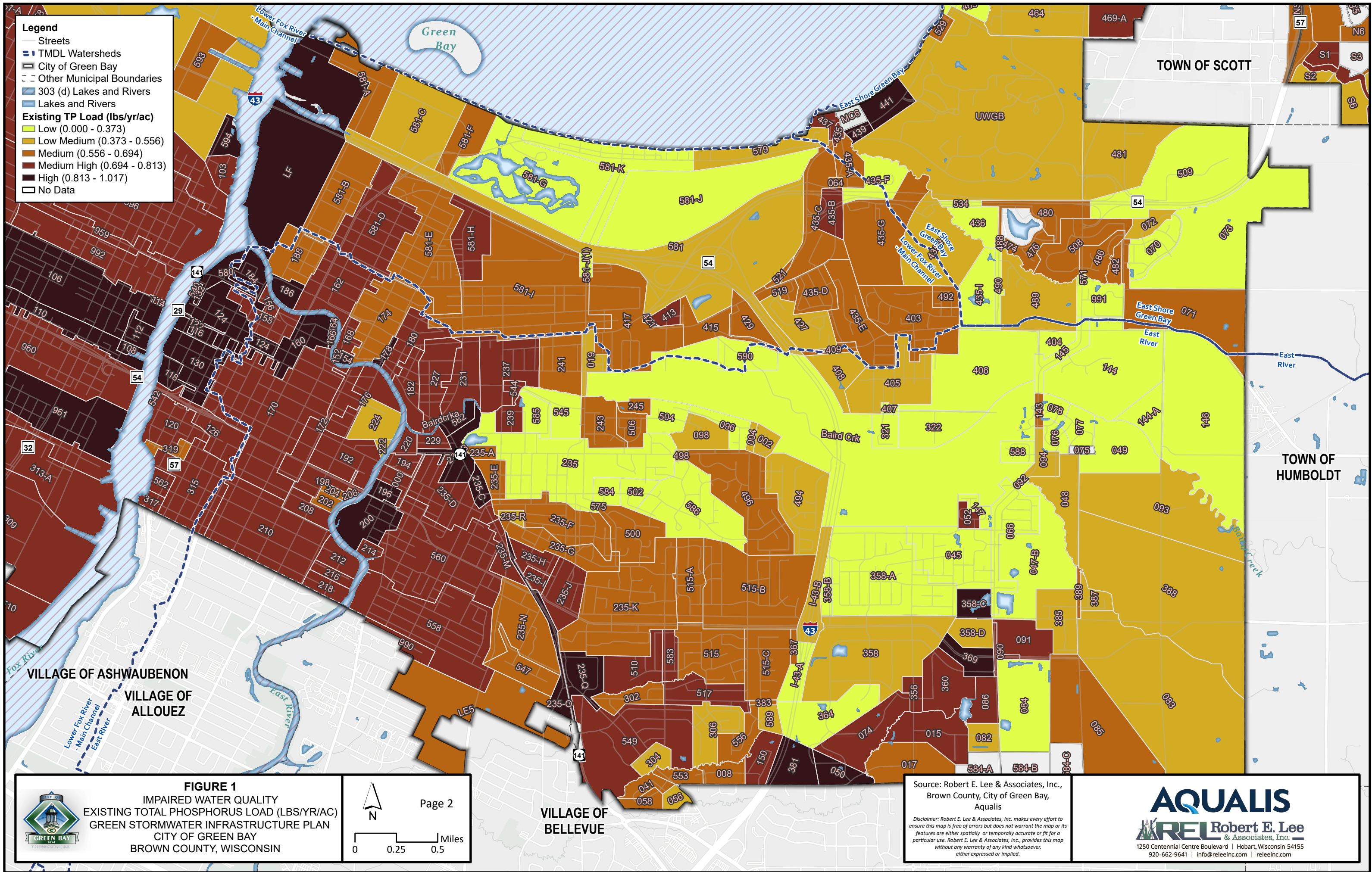
BROWN COUNTY, WISCONSIN

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Using the Evaluation Process for ROW Projects: This tool guides the designer to whether Green Stormwater Infrastructure (GSI) strategies are feasible for your project, which GSI are the best fit, and a step-by-step process for achieving a successful product. Please follow each tab in this spreadsheet tool (Eval Step 1, Pavement, Building, Green Space, and lastly Design Process Steps). For more information, or with questions, please contact Carrie Bristoll-Groll, PE, ENV SP at AQUALIS: 414.810.1245.

Right of Way Project GSI Evaluation Tool

CIP Project Name:	
Streets:	
Project Schedule/CIP Year	
Roadway/ROW Designer:	
Design Delivery Department:	
GSI Design Evaluation Performed by:	

Place an "x" in the box that most fits your response

Project Selection Questions	Rating					Weight
	Yes	Probably	Maybe	Unlikely	No	
Project Schedule and Budget						
Is the project construction scheduled for more than 6 months from today			x			3
Is sufficient budget or grant funding available to allow a GSI device?			x			3
Is the roadway/right-of-way designer on board with adding GSI?			x			3
Do you have the necessary staff available to design GSI for this project?		x				4
Project Area Needs						
Is the project area highly rated for water quality needs according to GSI Map 1?	x					5
Is the project area highly rated to be flood prone according to the GSI Map 2?					x	1
Does the project appear in the City's GSI Plan?					x	1
Is there interest for GSI here for other reasons not yet listed?			x			3
Project Area Constraints						
Does the area have high bedrock or high water table (see Map 5)			x			3
Does the area have sandy soils?	x		x			5
Are buried or overhead utilities buried constraints to the project area?*		x				2
Do residents or abutting property owners in favor of GSI?		x				4
Likelihood of Moving Project Forward	Yes				No	
TOTAL (RECOMMENDED SCORES OVER 60% TO PROCEED)						62%

Scores over 70% have a good likelihood of success and the designer should proceed to the next step. Scores between 60%-70%, project is possible with some added effort. Scores less than 60% need additional assistance, champions for the project, or funding. See tabs below to continue evaluation depending on your project area. If pavement project, see the Pavement Tab. If a building project, see the Building Tab, if a Parks, School or other greenspace project, see Green Space Tab

Green Stormwater Infrastructure for Pavement

Does your Project Area Have	Regenerative Stormwater Conveyance	Bioswale	Native Landscaping	Porous Pavement	Remove Pavement	Stormwater Trees
↓ Best GSI Options →						
Unused/Underused Pavement						
Roadways						
Min. of 10' between curb and bldg						
With vegetated islands						
With Rural Cross-section/ditches						
Has inverted crown (alley pavement)						
Scheduled to be repaved only						
Parking Areas						
With vegetated islands						
Sloped towards vegetated perimeter						
Does not drain towards vegetated perimeter						
Scheduled to be repaved only						
Paths and Sidewalks						

Green Stormwater Infrastructure for Buildings

Does your Project Area Have



Best GSI Options



	Removal of Structure	Rain barrel/Cistern/StormGUARDer	Blue Roof	Green Roof
Existing Land Use				
Flat/Shallow Roof				
No Vegetation Desired				
Garden or Courtyard				
External Drainage*				
Steep Roof				
External Drainage*				
Access to Internal Drainage				
Outbuilding				
Structure Not Used				
Structure function can be provided elsewhere				
External Drainage				

Now that you have determined that your public right of way space could be a good candidate for GSI, and you have decided, using the tabs in this tool, what type of GSI would be a good fit, the following information is needed to proceed.

Right of Way Project GSI Design Process

	Assigned to	Completed date	Reviewed by
Project Area - Concept Plan			
Request site survey including all utilities, property lines, and easements			
Review WDNR Brrts for soil contamination concerns			
If concerns from Brrts review, discuss Environmental Phase 1 Evaluation with Project Team			
Perform hydrology and hydraulic (H&H) calculations for sizing GSI based on chosen design storm			
Perform initial WinSLAMM model to determine potential TSS and TP removals			
Prepare Conceptual Engineer's Estimate for Construction Cost and confirm budget			
Perform initial layout and create Concept Plan. Route to Roadway Design team for review			
Preliminary Design			
Review roadway design team comments and address			
Confirm GSI is located at least 3' horizontally from any other utility			
Discuss proximity to existing trees with City Arborist or Forestry Dept			
Determine if GSI needs a liner based upon depth to groundwater, contaminated soils, other			
Perform prelim H&H			
Review layout to Preliminary Design Plan. Use GSI standard details			
Perform preliminary WinSLAMM model			
Determine if project still qualifies for grants, captures the anticipated gallons			
Review standard specifications to ID which are needed for project			
Prepare Prelim Engineer's Estimate for Construction Cost and confirm budget			
Prepare Preliminary Plans and route to Roadway Design Team for review			
Final Design			
Review roadway design team comments and address			
Prepare final Plans, Details, Specifications, and Engineer's Construction Estimate			
Prepare permit documents as needed			
Prepare public information meeting documents to discuss benefits of GSI			
Inform City's street maintenance crews of future GSI O&M manual sections			
Construction Management			
Assist in pre-bid and pre-construction meetings with information on GSI			
Review questions from field and perform site inspections as needed			
Prepare as-built information and upload to City's ArcMAP for GSI			
Futute O&M and DNR reporting			
Inspect GSI at minimum quarterly as directed by GSI O&M Manual			
Document maintenance needs and costs as appropriate and upload to City' ArcMAP for GSI			
Update city's DNR TMDL permit compliance with WinSLAMM model updates of GSI			
Congratulations! You have been an instrumental part in protecting the health of our valued water resources for the future!			



City of Green Bay

Green Stormwater Infrastructure (GSI)

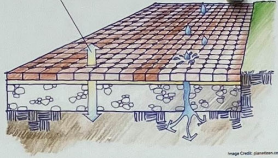
Operations and Maintenance Plan



GREEN STORMWATER INFRASTRUCTURE
PERMEABLE PAVEMENT
FOR A CLEAN BAY

PROTECTING THE FOX RIVER & BAY OF GREEN BAY
This permeable paver street allows water to soak through the street, and will clean and manage over 83,000 gallons of stormwater runoff annually.

Permeable pavement allows for infiltration of water and air movement through the void spaces.



WHAT ARE THE BENEFITS OF PERMEABLE PAVEMENT?

- Protect local waterways and the Bay by reducing stormwater runoff
- Lessens the risk of flooding and drainage problems
- Less salt needed for deicing in the winter
- Manages a lot of urban runoff in a small space
- Increases storm sewer capacity during heavy rains
- Suitable for parking, sidewalks, driveways, bike trails, or other low-traffic areas

Check us out!



SCAN THIS CODE FOR MORE INFORMATION ON GREEN STORMWATER INFRASTRUCTURE

Brought to you by:



Permeable interlocking concrete blocks are effective for managing stormwater and a durable pavement surface.



AQUALIS
Formerly Stormwater Solutions Engineering

Prepared 10-11-2023 by:
Aqualis, Engineering Department
247 Freshwater Way, Suite 410
Milwaukee, WI 53204

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1 Introduction and Background

Throughout Wisconsin, communities use a combination of traditional and green stormwater infrastructure (GSI) strategies to manage stormwater runoff, mitigate flooding, and protect water quality. GSI strategies such as engineered bioswales (bioretention basins), stormwater trees in structural soils, and permeable pavement provide benefits over and above those of traditional ponds and underground storage systems. GSI strategies can reduce the urban heat island effect, return water to the natural hydrologic cycle, create urban habitats, and beautify urban spaces.

Consistent and effective maintenance is critical to unlocking the full potential of GSI to benefit our communities. GSI involves a broad range of practices and materials whose maintenance needs differ from season to season and place to place. As more GSI measures are being built in public and private spaces, there is a need to develop a stronger base of knowledge and practice around GSI operation and maintenance in the region. This document is intended to support building that base of knowledge and practice in the City of Green Bay by breaking down the operation and maintenance components — labor, materials, equipment and practices — to ensure the long-term success of GSI strategies.

This document offers detailed guidance for the standard maintenance and inspection of the primary GSI strategies used in the City of Green Bay, as defined by the City of Green Bay. Since each GSI strategy has very distinct requirements, this guide is organized by GSI type to ensure that clear standards and practices are outlined for municipal staff and Green Bay Conservation Corps, maintenance contractors, property managers, and the many volunteers who are involved in Green Bay's Garden clubs, conservancies, and watershed groups. The guide supports pre-planning for maintenance activities by outlining recommended tasks, frequencies, equipment and material needs, safety steps, and weather considerations that need to be taken into account for effective GSI maintenance.

This guide is intended to consider maintenance during GSI design to achieve better long-term outcomes for installed GSI strategies. Up-front consideration of the visibility of a GSI strategy on a site, the type of owner and property manager who will be responsible for upkeep, aesthetic needs, and surrounding land uses can prompt different plan or material selections and other design approaches. By assessing the maintenance needs of different practices up-front, using this guide, designers will become important partners in ensuring maintenance success.

With the ever-changing environmental conditions and many stresses affecting the region's urban environments, developing strong, well-informed GSI maintenance practices is one step that can help ensure that investments in GSI are well spent and continue to benefit our city over time. Users of this guide are encouraged to add their own notes and experiences to help the City of Green Bay GSI network become a success story for climate resiliency and water quality.

2 Use of This Document

Successful GSI maintenance begins with good design and carries through construction, inspection, and ongoing maintenance phases. This document was developed to advance seven goals:

- 1 Ensure the ongoing stormwater management (i.e. volume capture and pollutant removal) function of GSI strategies installed.
- 2 Maintain the intended aesthetic appearance of plants, planting beds, surfacing, and other components of GSI installations.
- 3 Ensure that GSI is designed for ease of maintenance, and that the design reflects the level of maintenance that can be reasonably provided after construction. For example, for spaces where regular maintenance is less likely, designers can use this guide to identify low maintenance features to incorporate into designs.
- 4 Ensure that GSI strategies include appropriate levels and types of pretreatments based on the surrounding land use, runoff patterns, and trash and debris loadings.
- 5 Ensure staff who are charged with O&M have the necessary information and tools to evaluate the condition and function of different GSI installations, and accurately identify O&M issues.
- 6 Provide metrics and methods for tracking maintenance activities, both to ensure permit compliance and to assess long-term functionality.
- 7 Enable managers of multiple GSI strategies or sites to plan and optimize maintenance efforts and resources.

2.1 Intended Users

The document is intended to help many different user groups work effectively with GSI:

- **Regulators/Plan Review Staff:** Understanding the maintenance needs of different practices to inform the development of permit criteria, technical standards for GSI strategies, and compliance assessments.
- **Municipal Engineering and Operations Staff:** Supporting capital project and system maintenance planning, contractor selection, and training field staff to maintain GSI effectively.
- **Maintenance Contractors:** Giving maintenance and landscape contractors the specific information and planning tools needed to provide high-quality service for GSI strategies.
- **General Contractors:** Identifying crucial elements for construction that can make maintenance easier and more effective, especially during the warranty period.

- Property Owners and Managers: Provide clear, concise outlines of maintenance needs that facilitate good planning and lead to a high-quality product.
- Engineers and Landscape Architects: Point to design approaches, considerations, and features that can be incorporated into project development to facilitate better maintenance outcomes.
- Volunteers: Promote effective planning and strong understanding of the methods, materials, and practices that go into healthy landscapes and working GSI strategies.

3 Green Stormwater Infrastructure (GSI) Operations and Maintenance Overview

3.1 GSI Strategies

Operation and Maintenance Standards were created for the following 10 green stormwater infrastructure strategies.

- | | |
|-----------------------------|------------------------------------|
| 1) BIORETENTION / BIOSWALES | 6) RAIN GARDENS |
| 2) CONSTRUCTED WETLANDS | 7) TREE INLET/ CELLS |
| 3) GREEN ROOFS | 8) RAINWATER HARVESTING (CISTERNS) |
| 4) NATIVE LANDSCAPING | 9) SOIL AMENDMENTS |
| 5) PERMEABLE PAVEMENT | 10) STORMWATER TREES |

Each green stormwater infrastructure strategy listed above has an individual maintenance standard that includes the following information.

TITLE OF STRATEGY

The title of the individual strategy.

DESCRIPTION

A description of the individual strategy.

COMMON PRACTICES AND APPLICATIONS

Common locations and applications of where individual strategies are installed.

TYPICAL SECTION

A visual representation of the specific GSI strategy that lists the common components, including what is located under the surface.

INSPECTION AND MAINTENANCE

A summary of the expected inspection, operations and maintenance of the individual strategy.

MAINTENANCE TASKS

A table that lists each individual maintenance task that may be provided for when performing operations and maintenance on a specific strategy. The table also includes a brief description of the maintenance tasks, indications of when the task is necessary, and the recommended minimum frequency of the task.

EXPECTED ANNUAL MAINTENANCE SCHEDULE

A table that lists the specific maintenance tasks that are expected to be performed on an annual basis. It lists the task, season (spring, summer, fall, winter, post 2-inch rain event}, and frequency each task is expected to be performed during each season or event.

3.2 GSI Maintenance Tasks

Each green stormwater infrastructure strategy has an individual maintenance standard for the specific activities that are involved in maintenance. Many of these activities, such as water or sediment removal, are common to multiple GSI strategies. The tasks described are:

- | | |
|----------------------------------|---------------------------------------|
| 1) CONCRETE REPAIR | 11) PIPE JETTING |
| 2) DEICING | 12) PLOWING |
| 3) EROSION REPAIR | 13) PRUNING (STRUCTURAL) |
| 4) GRAFFITI REMOVAL | 14) SANITIZING |
| 5) GRAVEL JOINT FILLING | 15) SEDIMENT REMOVAL |
| 6) INVASIVE SPECIES CONTROL | 16) SEEDING |
| 7) MANUAL WEED CONTROL | 17) SETTLING REPAIR |
| 8) MOWING | 18) SOIL AMENDMENT |
| 9) MULCH AMENDMENT & REPLACEMENT | 19) STRUCTURAL CLEARING & MAINTENANCE |
| 10) ORGANIC DEBRIS REMOVAL | 20) SURFACE MEDIA RENOVATION |

21) TRASH REMOVAL

24) WATERING

22) VACUUM CLEANING

25) WOODY VEGETATION REMOVAL

23) VEGETATION MAINTENANCE

Each maintenance task listed above includes the following information.

TITLE OF MAINTENANCE TASK

The title of the individual maintenance task.

DESCRIPTION

A description of the individual maintenance task.

EQUIPMENT & MATERIALS

A list of equipment and materials needed to perform the individual maintenance task.

INSTRUCTIONS

Step-by-step instructions on how to perform the individual maintenance task.

SPECIAL CONSIDERATIONS

Any special considerations for the individual maintenance task. This is where manufacturer recommendations are included, as well as priority or specialty items. It also includes any other general considerations, observations, and actions that may be needed while performing the individual task.

3.3 General Maintenance Notes

For all GSI installation, inspection, and maintenance activities, there are a number of practices that can facilitate good planning, record-keeping, and facility performance. The list below, while not exhaustive, is a general reference list of recommended practices for anyone installing, inspecting, or maintaining GSI installations.

PLANS, PERMITS & BASELINE PHOTOGRAPHS

It is strongly recommended that for each GSI strategy or suite of strategies, the owner develops a binder, folder, or digital location with key baseline information about the strategy or strategies. This should include planting plans for any vegetated strategies, baseline photos, recommended plant heights, mow/no mow areas, and related stormwater permits, stormwater management plans, and other information supporting operation and maintenance.

O&M FORMS & INSPECTION LOGS

All facility operators should keep inspection and maintenance logs. Operators should record date, description and contractor (if applicable) for all repairs, landscape maintenance, and facility cleanout activities.

SITE INSPECTION

Sites should be inspected at the beginning of every maintenance season (i.e. after snow melt) to assess maintenance needs, especially for any facilities with unusual conditions or needs. Sites should also be inspected after every 2-inch (or greater) rainfall, with special attention to areas where debris may collect.

PHOTO DOCUMENTATION

Photo documentation is especially valuable for GSI strategies. Photos should always be taken prior to starting maintenance activities and at their conclusion to document how the facility is performing, what maintenance activities have been completed, and how the strategy looks before and after maintenance.

FERTILIZERS/PESTICIDES/HERBICIDES

The use of fertilizers, pesticides, and herbicides are discouraged for GSI strategies because of the potential for damage to downstream aquatic systems and wildlife. If pesticides and herbicides are required, use the services of licensed applicator, and only use products approved for aquatic use, where required. It is essential to ensure any application is confined to affected plants or areas. Note, the use of chemical herbicides in waters of the state, including stormwater treatment facilities, is regulated by the Wisconsin Department of Natural Resources (WDNR) — Aquatic Plant Management Program under NR 107, Wisconsin Administrative Code. Contact the WDNR prior to using herbicides and/or algaecides.

ACCESS

Maintain ingress/egress per design standards.

INFILTRATION/FLOW CONTROL

All bioretention/bioswale and rain gardens are to be fully drained (i.e. free from standing water) within 48 hours of a 1-inch rainfall. If ponding is observed in a GSI strategy, photograph the ponding and record the time/date, current and antecedent (i.e. last two days) weather conditions, and any other relevant site conditions observed. Water should always be ponded in constructed wetland and no duration of surface ponding is acceptable for permeable pavements and green roofs.

POLLUTION PREVENTION

All sites must implement best management practices to prevent contamination of stormwater. *Never wash spills into a stormwater facility.* If contamination occurs, document the circumstances and the corrective action taken; include the time, date, weather and site conditions.

VECTORS (MOSQUITOS AND RODENTS)

Stormwater facilities must not harbor mosquito larvae or rodents that pose a threat to public health or that undermine the facility structure. Record the time/date, weather, and site conditions when any vector activity is observed, and record the dates when any vector abatement starts and ends.

4 Green Stormwater Infrastructure (GSI) Operations and Maintenance Standards

4.1 Bioretention / Bioswales (also referred to as biofilters, biofiltration, and bioinfiltration)

DESCRIPTION



A stormwater management practice that allows water to pool in a depressed vegetated area and then infiltrate through engineered soils and into a gravel layer where water collects and is stored. The infiltrating or engineered soil layer is a special mix that typically includes sand mixed with compost. This layer is typically 18 to 24 inches deep to prevent disturbance of the gravel layer during maintenance activities. Both bioretention and rain gardens include an engineered soil layer. Unlike a rain garden, the bioretention includes a gravel storage layer and sewer systems. These sewer systems often include a section of perforated underdrain located within the gravel

layer that carries stormwater to a discharge point. They also typically include cleanouts and a series of overflow structures that control the ponding depth. Bioretention can capture stormwater runoff where it infiltrates through the engineering soil to remove pollutants. Bioretention can also retain the stormwater, slowly discharging to downstream storm sewer systems and waterways.

COMMON PRACTICES & APPLICATIONS

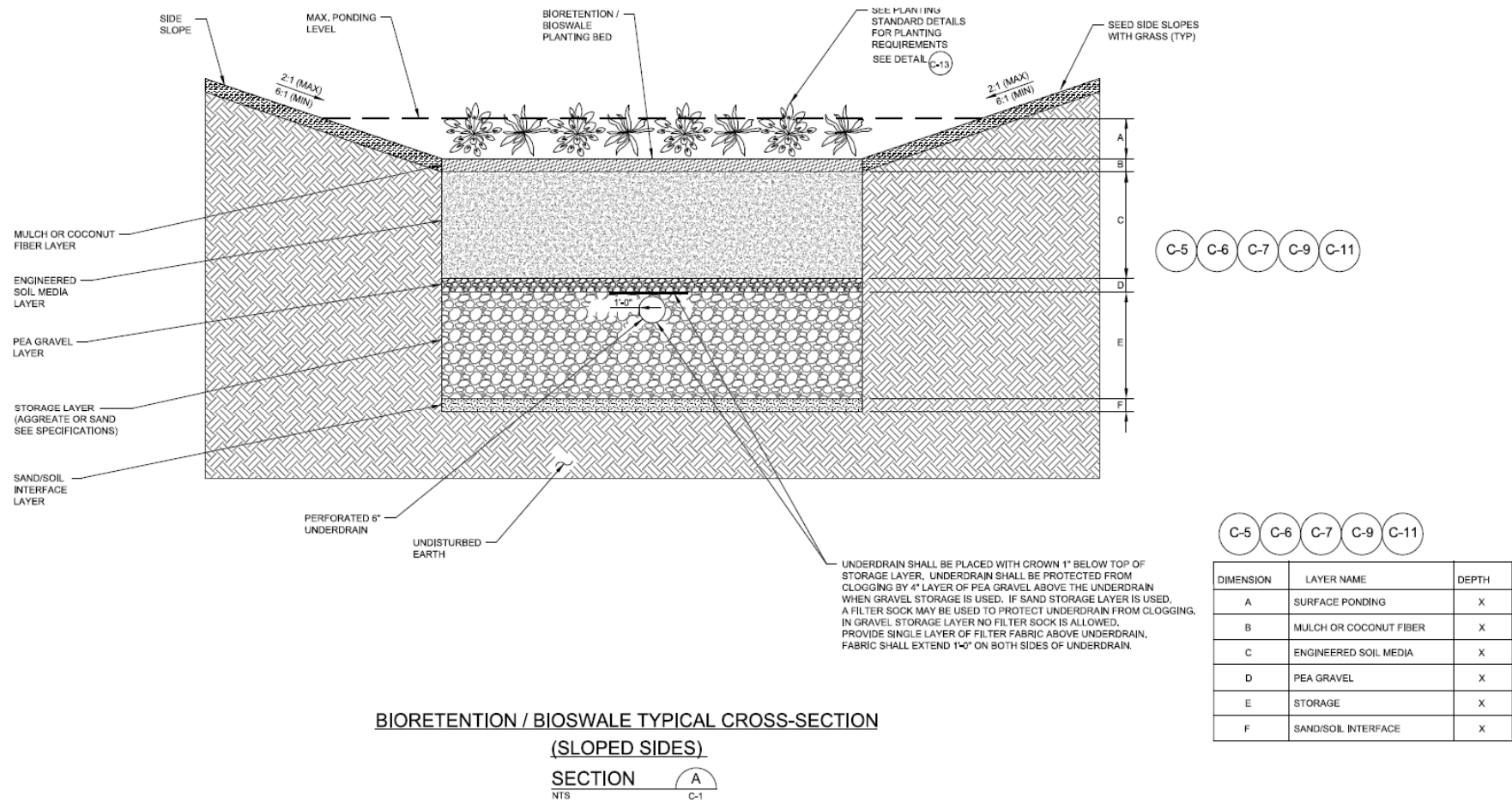
Bioretention can be constructed in a wide range of previously disturbed or developed areas, including areas with insufficient soils. Bioretention/Bioswales can be lined on the bottom, preventing stormwater from infiltrating, or can be purposely constructed in native soils with positive drainage to allow for infiltration of the treated stormwater. The engineered soils are used



to provide infiltration and pollutant removal, and the gravel layer is used for collection and storage. Because of their filtration and storage layers, bioswales are well suited for applications with runoff from large impervious surfaces such as parking lots and roadway medians and can be incorporated or retrofitted into these designs.

BIORETENTION / BIOSWALE TYPICAL SECTIONS AND COMPONENTS

(Taken from MMSD’s Bioretention-Bioswale GSI Strategy Typical Details which can be found in MMSD’s GSI Calculator download. Check the link for the most up-to-date sections: https://www.freshcoastguardians.com/static/GI_calc.zip)



BIORETENTION / BIOSWALE INSPECTION & MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and the upstream land use. Site-specific maintenance plans should always be consulted, as the successful functionality of the bioswale may have specific maintenance requirements that were considered during design.

Referring to Planting Plans & Photos: It is especially important to refer to planting plans and photos that show what types of vegetation should be present, and where maintenance crews should or should not mow.

Timing of Inspections: Bioretention should be inspected in the spring after snow melt, and after the end of the growing season to ensure the system will function as intended. In addition, because inflows from large storm events can damage vegetation, cause erosion, and clog inlets and outfall structures, bioswales should be inspected after any rain event of 2 inches in 24 hours or more. Inspection during the time of weed growth is also especially critical, as it is usually the top maintenance activity associated with these systems. For the City of Green Bay, this will begin in late-May through mid-July.

Inspection Focus: Inspections should focus on the growth and condition of vegetation, including all weeds or invasives; soil conditions (especially sediment build-up or clogging); structural integrity; and stormwater flow paths and erosion. Maintenance of any items identified in the inspections should be completed within seven days of the inspection.

Initial Site Inspection: A site inspection should be performed after snow melt (mid-April) to identify any items that would not be covered in the expected annual maintenance visits. This would include:

- Identifying any bare areas in the bioswales
- Identifying any low or eroded areas in the engineered soil
- Identifying any structural component issues

Manual Weed Control: Depending on establishment and condition of planting bed, as many as 12 weeding visits could occur during the typical six-month growing season of mid-April through mid-October. The weeds grow most aggressively from early May through mid-July (before native warm season grasses have filled out). During this period, visits may need to be weekly. Ornamental landscapes will typically require more visits than naturalized ones, but to begin with, naturalized landscapes will require more visits. As naturalized landscapes are established, the frequency of manual weed control will taper off.

BIORETENTION / BIOSWALE MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, sign, or bioswale surfaces.	If graffiti is present on bioswale sign, or adjacent to bioswale area.	As needed
Structural Components			
Concrete Repair	Repair cracks on concrete structures.	If cracks or fractures are present on concrete structures located in bioswale.	As needed
Structural Clearing & Maintenance	Clear trash, debris, sediment, etc. from inlet and outlet structures, including catch basins and curb inlets, to clear and restore to function.	Clogged inlets, outlets, or outfall structures.	Biannually
Pipe Jetting	Jet pipes clogged with trash debris, sediment, etc. to clear and restore to function; maintain at least 50% function.	Clogged inlets, outlets, or outfall structures.	As needed
Vacuum Cleaning	Vacuum out trash, debris, sediment, etc. from clogged structures.	Clogged inlets, outlets, or outfall structures.	As needed
Vegetation Components			

Invasive Species Control	Control invasive species impacting desired plant species in bioswale. Refer to Appendix of Invasive Species for list of the most common invasive species found in GSI strategies in Northeastern WI.	Invasive plants are present in bioswale.	Biannually, or as needed
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Task	Description	Maintenance Indicator	Minimum Frequency
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present in bioswale area.	Monthly (spring through fall – more frequently May through July)
Mowing	Mow plants if height of vegetation exceeds recommended heights. Mow perimeter edge of bioswales within vegetated grassy areas.	If height of vegetation exceeds recommended heights.	Annually
Pest Management*	Inspect plants for signs of disease or predation.	Presence of pests or diseased plants.	Biannually
Plant Replacement	Remove and replace dead plants.	If at least 10% of the plants have died.	As needed
Pruning	Remove damaged, diseased or dead branches or woody plants, small trees, or shrubs	If damaged, diseased, or dead branches are present, or if safe line of sight is obstructed.	Annually
Vegetation Maintenance	Trimming and/or transplanting annual herbaceous vegetation.	Presence of decayed material.	Annually

Watering	Water plants as necessary to ensure survival during extended dry periods.	Yellow or brown tips of leaves, dying plants, or wilted/dehydrated leaves or stalks. Note, yellow leaves can also be an indicator that plants are receiving too much water.	As needed, depending on weather
Woody Vegetation Removal	Remove of woody vegetation or saplings.	If unplanned woody vegetation or saplings are present in bioswale.	Annually

Task	Description	Maintenance Indicator	Minimum Frequency
Growing Medium/Planting Bed Components			
Erosion Repair	Stabilize any disturbed areas with seed or live plantings and biodegradable erosion matting.	If minor (<20 sf), nonrecurring erosion is present within the bioswale, or if erosion is deeper than 2 inches.	As needed
Mulch Amendment/ Replacement	Amend (i.e. rake, aerate, and add material) or replace mulch in bioswale.	If visible mulch is observed to have bare spots, depth is less than 2 inches or appears compacted or disarrayed in or around bioswale.	Annually, or as needed
Organic Debris Removal	Remove excess organic debris (e.g., leaves, plant decay, etc.) from bioswale.	If present in bioswale.	Biannually
Sediment Removal	Remove sediment from bioswale basin and surrounding areas, including gutters and sidewalks.	If sediment is present or visible in or around the bioswale, and if sediment is more than 1-inch deep.	Biannually or as needed
Settling Repair	Repair areas of bioswale that have settled.	Area is observed to be lower than surrounding areas of designed elevation of bioswale.	As needed
Surface Media Renovation	Remove top inches of filter media and cultivating the surface.	Bioswale is clogged or not draining properly or within 48 hours of a rainfall.	As needed
Trash Removal	Remove trash from bioswale planting beds and surrounding areas. Report any evidence of dumping.	If present in or around the bioswale.	Monthly (Spring through Fall)
*Integrated Pest Management (IPM) routines are encouraged. This involves inspecting the plants for signs of disease or predation. The IPM approach encourages non-chemical methods for treated diseases or pests as a first resort.			

BIORETENTION / BIOSWALE EXPECTED ANNUAL MAINTENANCE VISITS

It is recommended to complete twelve (12) site visits annually for bioswale maintenance. The timing and the tasks related to each of these site visits is detailed in the table below.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall ¹
Site Inspection	1 ²				2
Mowing			1 ³		
Manual Weed Control	3	3	3		
Pest Management		1	1		
Invasive Species Control		1	1		
Vegetation Maintenance	1				
Trash Removal	2	2	2		2
Organic Debris Removal	1		1		2
Pruning			1		
Structural Clearing & Maintenance	1				2
Woody Vegetation Removal			1		
Sediment Removal	1		1		2
Mulch Amendment/Replacement	1				2
Total Minimum Annual Expected Maintenance	4	3	3		2

¹ A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

² Initial site inspection shall be completed mid-April after snowmelt. The site inspection should be the focus and other maintenance tasks **should not be considered** at this time. Site inspections conducted after 2-inch rainfalls can be combined with other maintenance tasks as needed.

³ Mowing frequency is based on an established, native landscape. Mowing may take place in late-fall or early-spring depending on plant species.

If the native landscaping is recently established, the mowing is usually conducted in decreasing frequencies from the date of planting. Often five mowings the first full growing season, four the second, three the third, and so on. This allows the native seed to germinated and prevent annual weeds from flowering and setting seed.

If ornamental grasses are used, they are not mown, but usually trimmed back in early spring of each year.

4.2 Constructed Wetlands

DESCRIPTION

A stormwater management practice designed and constructed to simulate the pollutant removal, stormwater storage and other environmental benefits of natural wetlands. Constructed wetlands are often comprised of multiple inter- connected shallow pools, vegetation and microorganisms that remove pollutants through settling, biological uptake and biodegradation. Constructed wetland islands can be added to enhance pollutant control and improve habitat in constructed wetland systems or existing storm water ponds. Planted vegetation in constructed and natural wetlands are often adaptable to both dry and wet periods during the year. Constructed wetlands are managed and maintained to provide water quality benefits to downstream waterways while providing aquatic and wetland habitat for various species.



COMMON PRACTICES & APPLICATIONS

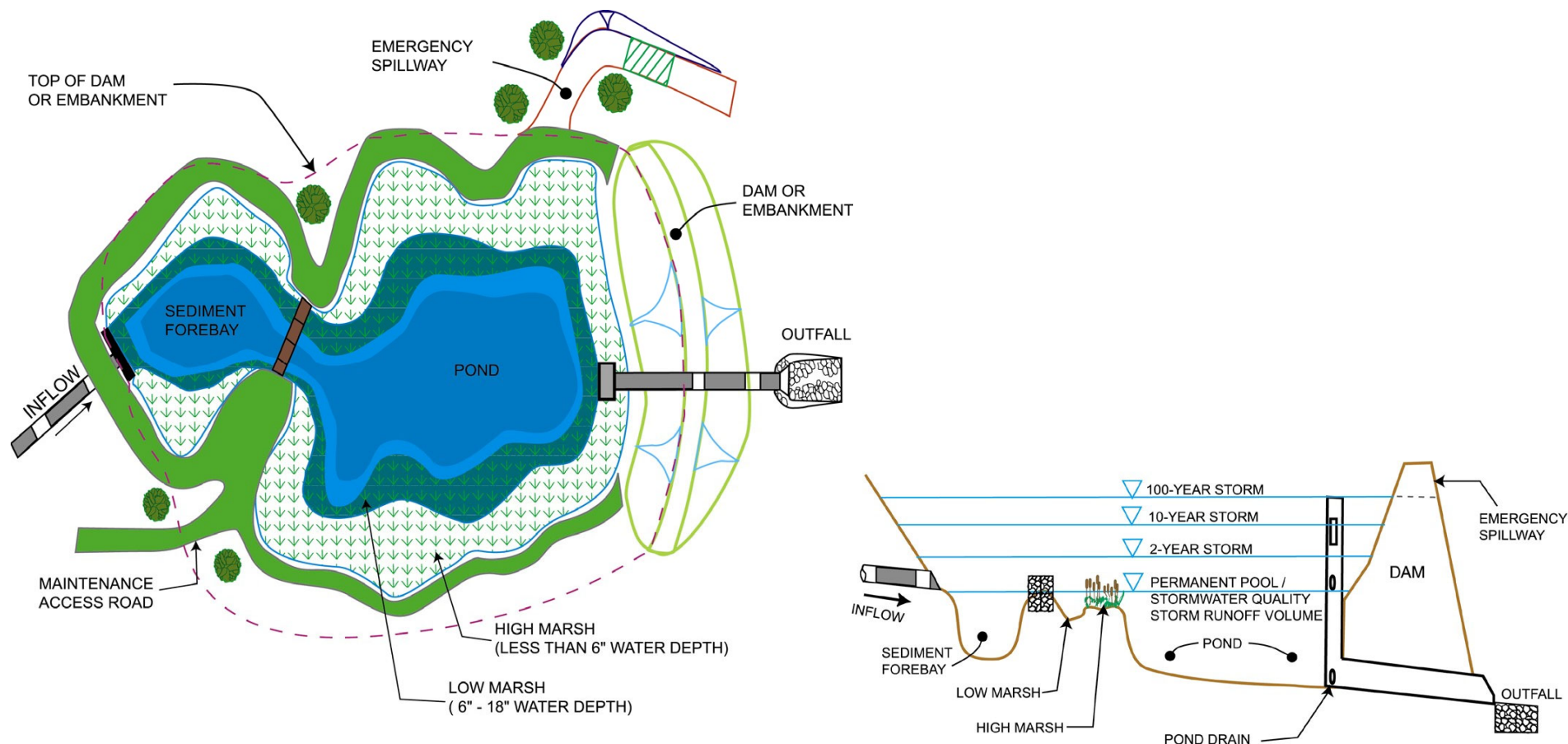
The various features of constructed wetlands can be designed to offer habitat for a variety of species. Common site conditions that are favorable to the development of a constructed wetland



include surface area equaling approximately 3-5% of the contributing drainage area to mitigate pollutants, minimal species on neighboring properties, and dedicated resources to conduct maintenance over the lifetime of the facility. Public trails and educational displays and signs can be incorporated into constructed wetlands which are often suitable for public spaces.

CONSTRUCTED WETLAND TYPICAL SECTION AND COMPONENTS

(this example was taken from New Jersey Stormwater Best Management Practices Manual – Chapter 9.2: Standard for Constructed Stormwater Wetlands – February 2004 <http://www.state.nj.us/dep/watershedmgt/bmpmanualfeb2004.htm>)



CONSTRUCTED WETLAND INSPECTION AND MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less-frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and upstream land use. Site-specific maintenance plans should always be consulted as the successful functionality of the constructed wetland may have specific maintenance requirements that were considered during design.

Maintenance Plans: Maintenance of constructed wetlands is a critical component to the success of this type of designed facility. A detailed maintenance plan should be implemented to ensure plant matter is harvested at the appropriate times of year (typically fall), and to ensure the designated water areas do not become clogged with excess vegetative growth.

Burning: Intentionally burning plant growth is a measure sometimes used to control invasives and promote regrowth of desired plant species. Many prairie species flourish in the months following a control burn. This document does not outline burning as a specific maintenance task but recognizes that there are instances where burning may be the most effective method to control invasive species, especially in or around wetlands.

- A burn plan should be developed for the specific best management practice if controlled burns are necessary. The burn plan should include information such as emergency contacts, specific area to be burned, desired/required weather conditions, time-of-year considerations, required equipment, and more.
- Controlled burns are typically conducted in mid-spring. Too much rain in preceding days will make it difficult to maintain the fire, while dry conditions will make it difficult to control the fire and keep the burn in the designated area.
- Burning vegetation in GSI strategies in urban areas should be conducted carefully, as public safety, private property and infrastructure are the primary concerns and considerations when choosing to use this type of control. Burn permits or approvals from the local fire department may be required.
- Controlled burns should not be conducted on windy days to minimize the potential for unintentional impacts or spreading.
- All controlled burned areas should be carefully monitored during and after the burn, to prevent unintentional impacts from spreading and to ensure the fire will not restart.

Referring to Planting Plans & Photos: It is important to refer to planting plans and past photos that show what types of vegetation should be present, and where maintenance crews should or should not remove vegetation. Designed and constructed pools of water or flowing water areas.

should particularly be evaluated per the planting plan, to prevent these areas from becoming clogged over time with excess plant growth.

Timing of Inspections: Regular inspections and maintenance are critical to the effective operation of constructed wetlands as the vegetation needs to be monitored and harvested instead of naturally dying off. The many shallow pools, channels and upland areas need to be inspected and maintained to ensure they remain clear of leaves and debris that could back up water or divert flows. Inspection during the time of weed growth is also critical. For the City of Green Bay, this is late-May through mid-July.

Inspection Focus: Inspections should focus on the growth and condition of vegetation, including any weeds or invasives; wet pool or flowing water areas and specifically plant growth in these areas that was not called for in the planting plans; structural integrity of the inlets/outlets and other artificial structures throughout the constructed wetland; and storm water paths and erosion. Maintenance of any items identified in the inspections should be completed within 30 days of inspection.

Initial Site Inspection: A site inspection should be performed after snow melt (mid-April) to identify any items that would not be covered in the expected annual maintenance visits. This would include:

- Identifying any bare areas in or around the constructed wetland.
- Identifying any low or eroded areas in the embankment or berm.
- Identifying any structural component issues.

Manual Weed Control: Depending on establishment and condition of planting bed, as many as 12 weeding visits could occur during the typical 6 month growing season of mid-April through mid-October. The weeds are growing most aggressively from early May through mid-July (before native warm season grasses have filled out). During this period, visits may need to be weekly. Ornamental landscapes will typically require more visits than naturalized ones, but to begin with, naturalized landscapes will require more visits. As naturalized landscapes are established, the frequency of manual weed control will taper off.

CONSTRUCTED WETLAND MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Signage Care	Wipe down signage.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, signage, or GSI surfaces.	If graffiti is present on GSI signage, or adjacent to GSI area.	As needed
Structural Components			
Concrete Repair	Repair cracks on concrete structures.	If cracks or fractures are present on concrete structures located in wetland area.	As needed
Pipe Jetting	Jet pipes clogged with trash debris, sediment, etc. to clear and restore to functioning.	Clogged inlets, outlets, or outfall Structures.	As needed
Structural Clearing & Maintenance	Clearing trash, debris, sediments from inlet or outlet structures that may be hindering function.	Clogged inlets, outlets, or outfall structures.	Annually or as needed
Vegetation Components			
Invasive Species Control	Controlling invasive species impacting desired plant species in constructed wetland. Refer to Appendix of Invasive Species for list of the most common invasive species found in GSI strategies in Northeastern WI.	Invasive plants or animals are present in constructed wetland.	Biannually, or as needed

Manual Weed Control	Remove weeds by hand weeding.	If weeds are present in wetland area.	Monthly (Spring through Fall – more frequently May through July)
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4.3 Green Roof

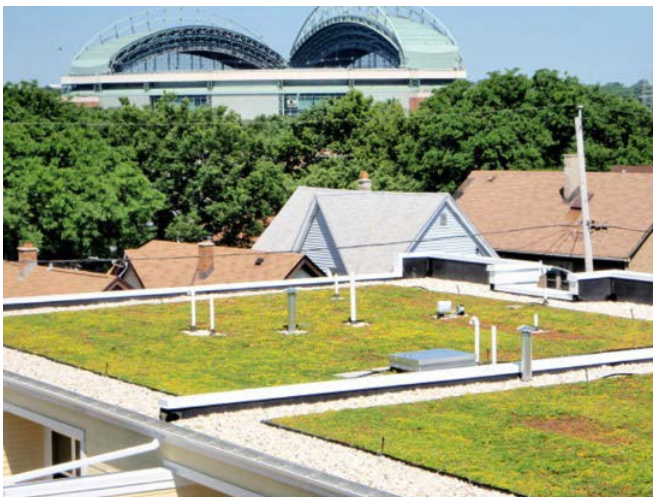
DESCRIPTION

A green roof refers to a roof structure, often a building, that is either partially or completely planted with vegetation growing in soil or soil medium to absorb rainwater. Green roofs can be planted in waterproof trays or on top of a waterproof barrier. There are two types of green roofs: intensive, and extensive. Intensive are thicker, with a minimum depth of 12.8 cm (5.0 in), and extensive roofs, which are shallower, ranging in depth from 2 cm (0.79 in) to 12.7 cm (5.0 in).



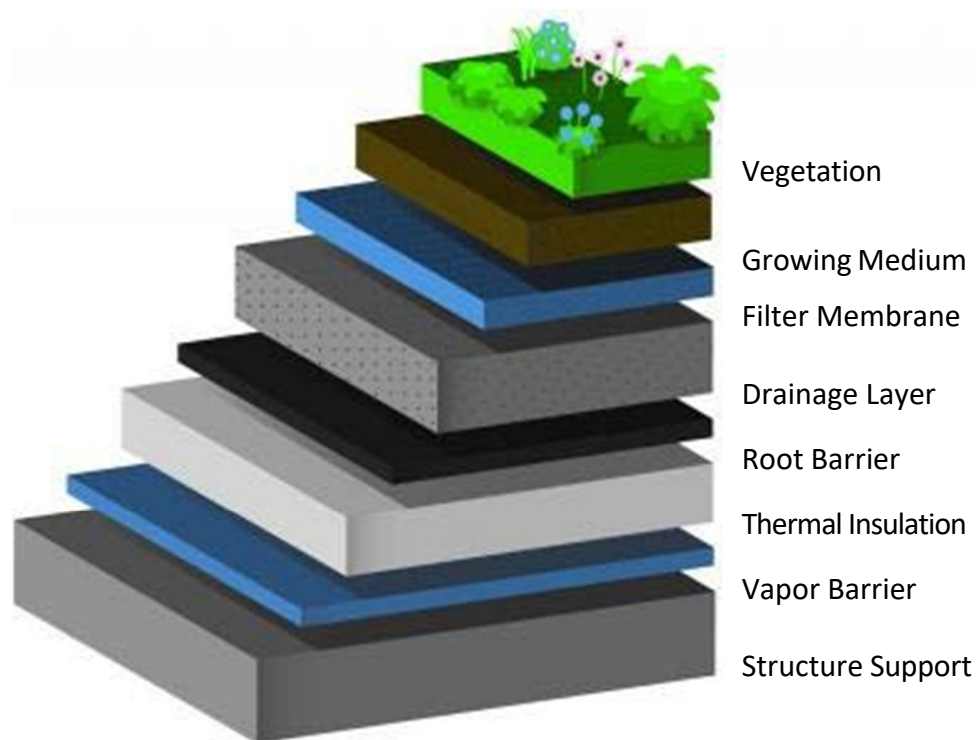
COMMON PRACTICES & APPLICATIONS

Green roofs (also known as eco-roofs) act as stormwater management systems by collecting and managing the stormwater that falls on them. They can be retrofitted on existing buildings or redevelopments, or installed on new buildings, and are especially valuable in urban areas, where green space or pervious area is limited. The type of green roof is dependent on the roof structure and what it can support based on weight. This dictates the design, and ultimately the specific type of maintenance needed for each individual roof.



GREEN ROOF TYPICAL SECTION AND COMPONENTS

(Taken from EPA's Common Green Roof Layers: <https://www.epa.gov/heat-islands/using-green-roofs-reduce-heat-islands#types>)



Note the figure above represents the most common design of green roof and not all layers shown will be found on every green roof. Extensive green roofs may be simpler than intensive green roofs, and all types of roof will vary by manufacturer.

GREEN ROOF INSPECTION AND MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the number and timing of large storm events, overly wet or dry (i.e. drought), irrigation and access. Site-specific maintenance plans should always be consulted, as the successful functionality of the green roof may have specific maintenance requirements that were considered during design.

Referring to Planting Plan, Design Plans, & Manufacturer Recommendations: It is especially important to refer to planting plans and photos that show what types of vegetation, soil mixture, roof membrane, and drainage structures that should be present. It is also important to refer to design plans and manufacturer recommendations, as green roof components and maintenance are specific to the design and type. Intensive roofs are heavier and tend to require more maintenance, where extensive tend to be lighter and require less (or even) minimal maintenance.

Timing of Inspections: Green roof maintenance is especially important during the first 3-5 years of installation, to ensure proper vegetation establishment. Green roofs should be inspected in the spring after snow melt, and after the end of the growing season to ensure the system will function as intended. In addition, because inflows from large storm events can damage vegetation, cause erosion, and clog inlets and outfall structures, green roofs should be inspected after any rain event of 2 inches in 24 hours or more. It is also important to check to make sure the roof is draining, and that there are no leaks in the membrane of the roof. Inspection during the time of weed growth is also critical. For the City of Green Bay, this is late-May through mid-July.

Inspection Focus: Because of the nature of green roofs and the location of maintenance activities, be sure to consult with the facilities manager and review design plans and manufacturer maintenance recommendations prior to performing any maintenance activities on a green roof. The following are general green roof maintenance considerations.

- **Personal Safety:** Maintenance crews must be trained to work on rooftop environments and must always utilize safety measures, including lines, harnesses, etc. Also, beware of potential nesting birds when approaching the roof.
- **Materials:** Never leave materials out that could blow off the roof and pose a hazard to people on the ground.
- **Roof Membrane:** The roof membrane must always be protected. It prevents water from entering the buildings and/or structures and can be easily damaged by foot traffic and maintenance tools (such as shovels). Anyone working on the roof needs to know what the membrane is, what it looks like, where it occurs in the profile of the roof, and ultimately how it should be protected. Roofs with organic membranes should be protected with a

root barrier, which is usually a sheet of polyethylene, because plants will eat organic membranes (like bitumen). This sheet also needs to be maintained, and if it is damaged, it should be repaired.

- **Weight:** Green roofs are designed to a specific saturated weight, which is the weight of all the material when it is completely wet, this includes soil, drainage components, and plants. It is critical that maintenance workers do not add soil, change plantings, or store materials that would increase the weight of the roof system. This could cause damage to the roof structure, and potentially result in collapse. Rooftop soils are usually specially blended lightweight soils, and therefore planting soil should never be added to a roof without first consulting a design professional (engineer, landscape architect, architect).
- **Wind Scour:** One of the greatest threats to rooftop plantings is wind scour. Wind can desiccate plantings when it rolls over a parapet wall, or around rooftop mechanical equipment. The higher the roof, the more wind scour tends to increase, ultimately creating a bigger problem. Unvegetated soil will quickly blow away, and if the soil was necessary to weigh down a non-adhered roof membrane, then the membrane can become damaged as well.
- **Firebreaks:** A firebreak is a gap in vegetation or other combustible material that acts as a barrier to slow or stop the progress of a fire. Note that many insurers require that firebreaks are established and maintained on large roofs. Consult the facilities manager or design plans to ensure that if necessary, this is properly maintained.
- **Drainage Structures:** In general, pitched roofs have external gutters and downspouts, while flat roofs have internal roof drains. It is important for maintenance to know where the roof is actually draining, since the green roof components can disguise this. Internal drains are often protected in an enclosed metal box that can be accessed by opening a lid. It is important that these features be inspected frequently to make sure they are not clogged.

Site Inspections: A site inspection should be performed once after snow melt (mid-April), once in summer, and once in fall to identify any items that might occur during expected annual maintenance, but also need special attention to, specific to green roofs:

- Identifying any bare or eroded areas caused by wind scour and/or wind desiccation, especially at roof edges and next to rooftop objects. Note, that some areas may end up being completely inhospitable to vegetation. In those cases, the plantings and planting soil should be replaced with an inorganic ballast (typically rock), that has the same saturated weight as the planned soil and vegetation.
- Identifying any structural component issues, including but not limited to leaks, tears, perforations, or deficiencies in membranes, root barriers, and drains.

- Monitoring weed control, especially if weed growth occurs in gravel beds that might be used to separate vegetation from mechanical features or adjacent building walls. Vegetation can climb behind and/or under flashing and impair the roof seal. This may also include inspecting and maintain firebreaks by removing weedy vegetation in a gravel break or restoring gravel paths that serve as firebreaks.

GREEN ROOF MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Structural Components			
Membrane and Root Barrier Inspection ¹	Repair any leaks, tears, perforations, or structural deficiencies.	Noticeable leaks, and/or tears or perforations of the membrane, root barrier, or structural components.	Annually, or as needed
Structural Clearing & Maintenance	Clear trash, debris, sediment from conveyance structures, including gutters and/or roof drains draining to and from the green roof.	Clogged gutters, drains, pipes, or structures.	Monthly (spring through Fall) or as needed
Vegetation Components			
Invasive Species Control	Control invasive species impacting desired plant species on green roof. Refer to Appendix of Invasive Species for list of the most common invasive species found in GSI strategies in Northeastern WI.	Invasive plants are present on the green roof.	Biannually
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present on or around green roof, adjacent structures or gravel breaks.	Monthly (spring through Fall – more frequently May through July)
Pest Management*	Inspect plants for signs of disease or predation.	Presence of pests or diseased plants.	Biannually

Plant Replacement	Remove and replace dead plants or sedums.	If at least 10% of the plants have died.	As needed
Vegetation Maintenance	Trimming and/or transplanting annual herbaceous vegetation.	Presence of decayed material.	Annually
Watering	Water plants as necessary to ensure survival during extended dry periods.	Yellow or brown tips of leaves, dying plants, or wilted/dehydrated leaves or stalks. Note, yellow leaves can also be an indicator that plants are receiving too much water.	As needed, depending on weather
Woody Vegetation Removal	Remove of woody vegetation or saplings.	If unplanned woody vegetation or saplings are present on green roof.	Annually
Growing Medium/Planting Bed Components			
Erosion Repair	Stabilize any disturbed areas with seed or an inorganic ballast (typically rock) that has the same saturated weight as the planned soil and vegetation.	If minor (<20 sf), nonrecurring erosion is present within the green roof.	As needed
Organic Debris Removal	Remove excess organic debris (e.g., leaves, plant decay, etc.) from roof system.	If present on green roof.	Biannually
Sediment Removal	Remove sediment from green roof and surrounding areas, including gutters and roof.	If sediment is present/visible in or around the green roof.	Biannually or as needed.
Surface Media Renovation	Remove top inches of filter media and cultivate the surface. Check product type, structure, vegetation depth, and manufacturer recommendations prior to performing renovation.	Green roof is clogged or not draining properly within 48 hours of a rainfall (provided outlets are cleared).	As needed

Trash Removal	Remove trash from green roof planting beds and surrounding areas. Report any observed evidence of dumping.	If present on or around the green roof.	Biannually
¹ Membrane and Root Barrier Maintenance is not included as a maintenance task because membranes, barriers, and structural components of green roofs tend to be specific to manufacturer. Contact manufacturer for repair or replacement of parts. * Integrated Pest Management (IPM) routines are encouraged. This involves inspecting the plants for signs of disease or predation. The IPM approach encourages non-chemical methods for treated diseases or pests as a first resort.			

GREEN ROOF EXPECTED ANNUAL MAINTENANCE

It is recommended to complete eight (8) site visits annually for green roof maintenance. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall ¹
Site Inspection	1	1	1		2
Manual Weed Control	2	2	2		
Pest Management		1	1		
Invasive Species Control		1	1		
Vegetation Maintenance	1				
Trash Removal	1		1		2
Organic Debris Removal	1		1		2
Structural Clearing & Maintenance	1	1	1		2
Woody Vegetation Removal			1		
Sediment Removal	1	1	1		2
Total Minimum Annual Expected Maintenance	2	2	2		2
¹ A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.					

Task	Description	Maintenance Indicator	Minimum Frequency
Mowing	Mowing plants if height of vegetation exceeds recommended heights. Mow perimeter edge of constructed wetland within vegetated grassy areas.	If height of vegetation exceeds recommended heights.	Annually
Pest Management*	Inspect plants for signs of disease or predation.	Presence of pests or diseased plants.	Biannually
Plant Replacement	Remove and replace dead plants.	If at least 10% of the plants have died.	As needed
Pruning	Remove damaged, diseased or dead branches or woody plants, small trees, or shrubs	If damaged, diseased, or dead branches are present, or if safe line of sight is obstructed.	Annually
Vegetation Maintenance	Trimming and/or transplanting annual herbaceous vegetation.	Presence of decayed material.	Annually
Woody Vegetation Removal	Removal of woody vegetation or saplings.	If unplanned woody vegetation or saplings are present in constructed wetland.	Annually
Growing Medium/Constructed Wetland Components			
Erosion Repair	Stabilize any disturbed areas with seed and biodegradable erosion matting.	If minor (<20 sf), nonrecurring erosion is present within the wetland, or if erosion is deeper than 2 inches.	As needed
Organic Debris Removal	Remove excess organic debris (e.g., leaves, plant decay, etc.) from constructed wetland.	If present in constructed wetland.	Biannually
Sediment Removal	Remove sediment from constructed wetland and surrounding areas, including forebay.	If sediment is present or visible in or around the constructed wetland.	Biannually

Settling Repair	Repairing areas of constructed wetland that have settled.	Area is observed to be lower than surrounding areas of designed elevation of constructed wetland.	As needed
Trash Removal	Remove trash from constructed wetland and surrounding areas. Report large dumping.	If present in or around the constructed wetland.	Monthly (Spring through Fall)
* Integrated Pest Management (IPM) routines are encouraged. This involves inspecting the plants for signs of disease or predation. The IPM approach encourages non-chemical methods for treated diseases or pests as a first resort.			

CONSTRUCTED WETLAND EXPECTED ANNUAL MAINTENANCE

It is recommended to complete twelve (12) site visits annually for constructed wetland maintenance. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall ¹
Site Inspection	1 ²				2
Mowing			1 ³		
Manual Weed Control	3	3	3		
Pest Management		1	1		
Invasive Species Control		1	1		
Vegetation Maintenance	1				
Trash Removal	2	2	2		2
Organic Debris Removal	1		1		2
Inlet Clearing & Maintenance	1				2
Pruning			1		
Woody Vegetation Removal			1		
Sediment Removal	1		1		2
Total Minimum Annual Expected Maintenance	4	3	3		2

¹ A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

² Initial site inspection shall be completed mid-April after snowmelt. The site inspection should be the focus and other maintenance tasks **should not be considered** at this time. Site inspections conducted after 2-inch rainfalls can be combined with other maintenance tasks as needed.

³ Mowing frequency is based on an established, native landscape. Mowing may take place in late-fall or early-spring depending on plant species.

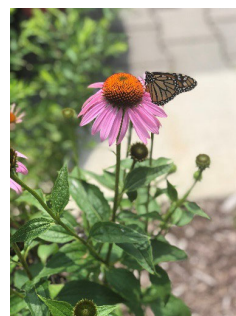
If the native landscaping is recently established, the mowing is usually conducted in decreasing frequencies from the date of planting. Often five mowings the first full growing season, four the second, three the third, and so on. This allows the native seed to germinated and prevent annual weeds from flowering and setting seed.

If ornamental grasses are used, they are not mown, but usually trimmed back in early spring of each year.

4.4 Native Landscaping

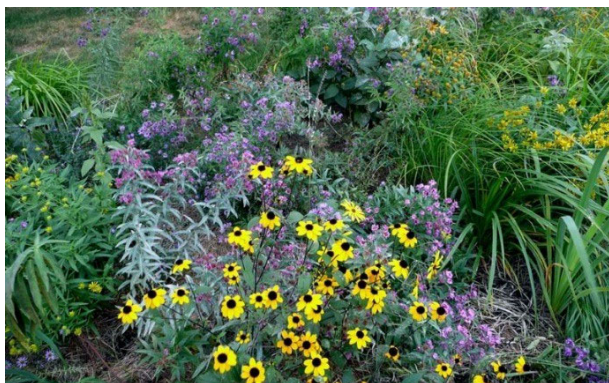
DESCRIPTION

Native landscapes in Northeastern (NE) Wisconsin include a wide variety of plant communities, including forests, grasslands, and wetlands. Native landscaping with grass or sedge dominated plant communities refers to plants with deep growing root systems that increase the infiltration capacity of soils by breaking up hardening soil structures and introducing macropores and organic matter. Native landscaping uses colorful native plants, non-invasive ornamentals, or a combination of the two to create a prairie-type setting. In addition, many native plants and grasses provide important habitat functions for birds, butterflies, and bees. As such, native landscaping can be used as a habitat enhancement feature of stormwater projects to achieve biodiversity goals.



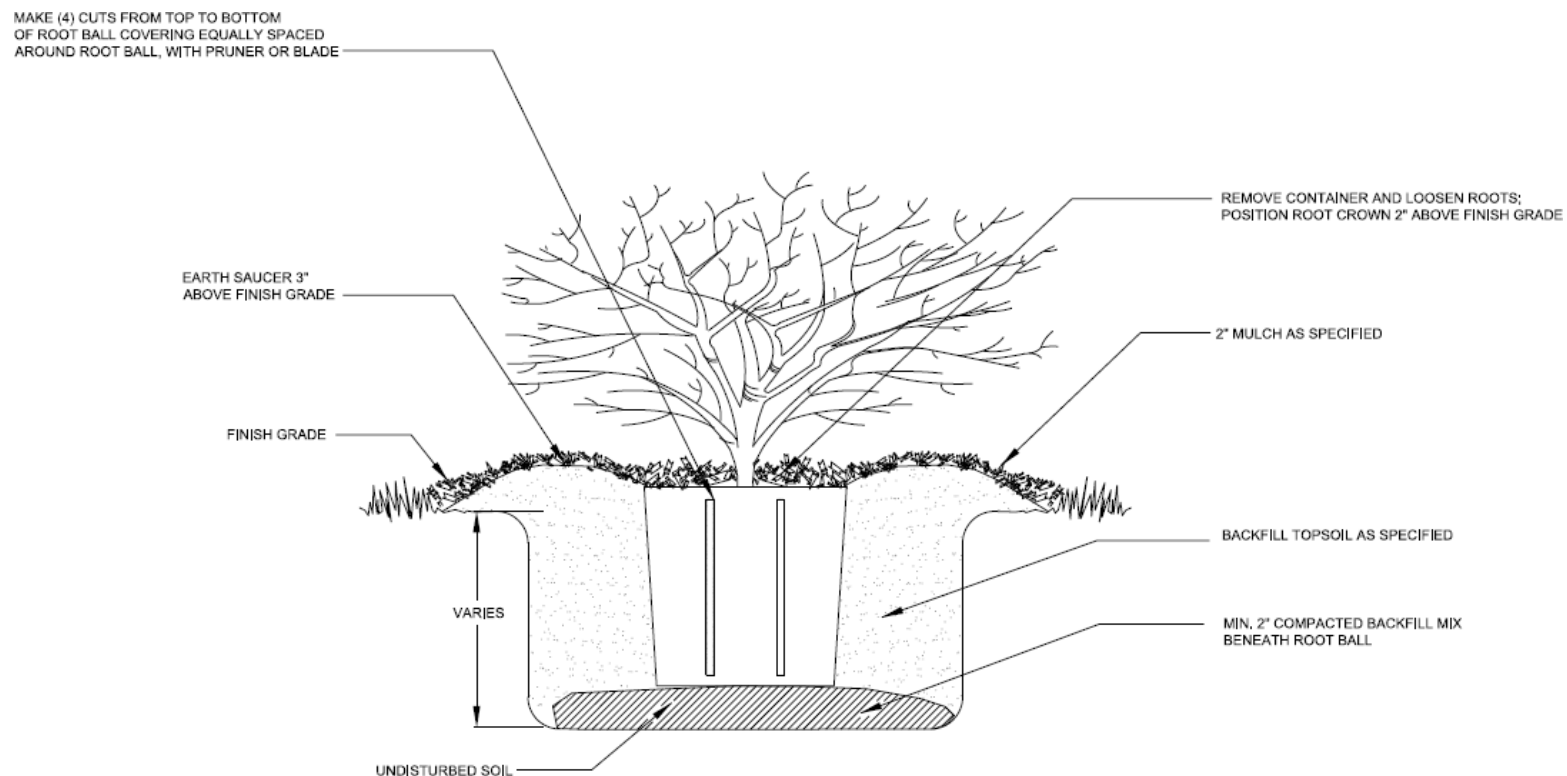
COMMON PRACTICES & APPLICATIONS

Native plant species can tolerate the drought and flooding cycles of an area, have evolved in a particular area, and are adapted to local climate conditions.



NATIVE LANDSCAPING (SHRUB) TYPICAL SECTION AND COMPONENTS

There are other native landscaping details considering the wide variety of plant communities, but the detail shown below is specific to a container grown shrub. (taken from MMSD's Native Landscaping GSI Strategy Typical Details which can be found in MMSD's GSI Calculator download. Check the link for the most up-to-date sections: https://www.freshcoastguardians.com/static/GI_calc.zip)



NATIVE LANDSCAPING DETAIL

NTS

NATIVE LANDSCAPING INSPECTION & MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and upstream land use. Site-specific maintenance plans should always be consulted, as the successful functionality of the plants may have specific maintenance requirements that were considered during design.

Referring to Planting Plans, Photos and Plant Identification: One of the greatest challenges for native landscaping maintenance is plant identification. Maintenance professionals must distinguish healthy desirable plants from weeds and invasive plants. It is especially important to refer to planting plans and photos that show what types of vegetation should be present. There are numerous electronic applications for plant identification that can identify plants at various stages of growth.

Timing of Inspections: Maintenance tasks for native landscaping vary by season. Conducting the right tasks at the right point in the growing season will improve plant survival, aesthetics, and infiltration capacity.

Inspection Focus: It is also important to identify when areas are in the installment and establishment phase, when plant loss is expected, and plant identification may be the most challenging. Maintenance teams should expect approximately 10% of plant material to fail during the first year after planting, and plan accordingly for replacements. Warranties may cover part or all the replacement and are important tools to reduce replacement costs for the expected failure of some plants.

Initial Site Inspection: A site inspection should be performed after snow melt (mid-April) to identify any items that would not be covered in the expected annual maintenance visits. This would include:

- Identifying any bare areas in the landscaping.
- Identifying any low or eroded areas in the landscaped areas.

Manual Weed Control: Depending on establishment and condition of planting bed, as many as 12 weeding visits could occur during the typical six-month growing season of mid-April through mid-October. The weeds are growing most aggressively from early May through mid-July (before native warm season grasses have filled out). During this period, visits may need to be weekly. Ornamental landscapes will typically require more visits than naturalized ones, but to begin with, naturalized landscapes will require more visits. As naturalized landscapes are established, the frequency of manual weed control will taper off.

NATIVE LANDSCAPING MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, sign, or GI surfaces.	If graffiti is present on signage, or adjacent to area.	As needed
Vegetation Components			
Invasive Species Control	Remove any invasive species affecting desired plant species in landscaped area. Refer to Appendix of Invasive Species for list of the most common invasive species found in GSI strategies in Northeastern WI.	Invasive plants are present in landscaped area.	Biannually, or as needed
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present in landscaped areas.	Monthly (Spring through Fall – more frequently May through July)
Mowing	If directed by landscape plan, mow plants if height of vegetation exceed recommended heights. Mow perimeter edge of naturalized landscape within vegetated grassy areas.	If height of vegetation exceeds recommended heights.	Annually

Pest Management*	Inspect plants for signs of disease or predation.	Presence of pests or diseased plants.	Biannually
Plant Replacement	Remove and replace dead plants.	If at least 10% of the plants have died.	As needed
Pruning	Remove damaged, diseased or dead branches or woody plants, small trees, or shrubs	If damaged, diseased, or dead branches are present, or if safe line of sight is obstructed.	Annually
Vegetation Maintenance	Trimming and/or transplanting annual herbaceous vegetation.	Presence of decayed material.	Annually
Watering	Water plants as necessary to ensure survival during extended dry periods	Yellow or brown tips of leaves, dying plants, or wilted/dehydrated leaves or stalks. Note, yellow leaves can also be an indicator that plants are receiving too much water.	As needed, depending on weather
Woody Vegetation Removal	Remove woody vegetation or saplings.	If unplanned woody vegetation or saplings are present in landscaped area.	Annually
Growing Medium/Planting Bed Components			
Erosion Repair	Stabilize any disturbed areas with seed or live plants and biodegradable erosion matting.	If minor (<20 sf), nonrecurring erosion is present within the landscaped area, or if erosion is deeper than 2 inches.	As needed
Mulch Amendment/Replacement	Amend (i.e. rake, aerate, and add material) or replace mulch in landscaped areas, if planting plan calls for mulch.	If visible mulch is observed to have bare spots, depth is less than 2 inches or appears compacted or disarrayed in or around landscaped area.	Annually or as needed

Organic Debris Removal	Remove excess organic debris (e.g., leaves, plant decay, etc.) from landscaped surfaces.	If present in landscaped area.	Biannually
Sediment Removal	Remove sediment from landscaping and surrounding areas, including gutters and sidewalks.	If sediment is present or visible in or around the landscaped area, and if sediment is more than 1 inch deep.	Biannually or as needed
Settling Repair	Repair areas of landscaping that have settled.	Area is observed to be lower than surrounding areas of designed elevation of landscaping.	As needed
Trash Removal	Remove trash from landscaped planting beds and surrounding areas. Report any evidence of dumping.	If present in or around the landscaped area.	Monthly (through Spring and Fall)
* Integrated Pest Management (IPM) routines are encouraged. This involves inspecting the plants for signs of disease or predation. The IPM approach encourages non-chemical methods for treated diseases or pests as a first resort.			

NATIVE LANDSCAPING EXPECTED ANNUAL MAINTENANCE

It is recommended to complete twelve (12) site visits annually for native landscaping maintenance.

The timing and the tasks related to each of these site visits is detailed in the below table.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall ¹
Site Inspection	1 ²				2
Mowing			1 ³		
Manual Weed Control	3	3	3		
Pest Management		1	1		
Invasive Species Control		1	1		
Vegetation Maintenance	1				
Trash Removal	2	2	2		2
Organic Debris Removal	1		1		2
Pruning			1		
Woody Vegetation Removal			1		
Sediment Removal	1		1		2
Mulch Amendment/Replacement	1				2
Total Minimum Annual Expected Maintenance	4	3	3		2

¹ A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

² Initial site inspection shall be completed mid-April after snowmelt. The site inspection should be the focus and other maintenance tasks **should not be considered** at this time. Site inspections conducted after 2-inch rainfalls can be combined with other maintenance tasks as needed.

³ Mowing frequency is based on an established, native landscape. Mowing may take place in late-fall or early-spring depending on plant species.

If the native landscaping is recently established, the mowing is usually conducted in decreasing frequencies from the date of planting. Often five mowings the first full growing season, four the second, three the third, and so on. This allows the native seed to germinate and prevent annual weeds from flowering and setting seed.

If ornamental grasses are used, they are not mown, but usually trimmed back in early spring of each year.

4.5 Permeable Interlocking Concrete Pavement

DESCRIPTION

Permeable Interlocking Concrete Pavement (PICP) consists of concrete pavement units or bricks that when assembled into a pattern, creates open joints. These joint openings are typically filled with an open-graded chip stone that allow water to run through. The overall ratio of void space to the paver surface is approximately 13%. The paving units are placed on a bedding layer of permeable aggregates, which is laid over a base and subbase layer of open-graded aggregates. Perforated underdrains are typically placed in bottom storage layer to collect and convey water out of the system if it does not infiltrate within the design period, which is typically 48 to 72 hours.



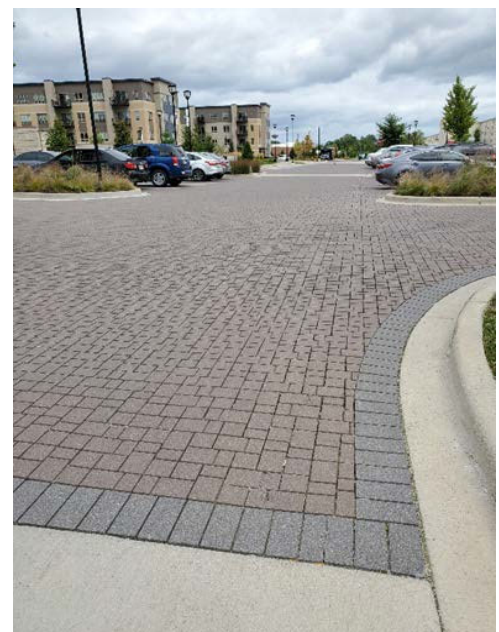
effects.

These systems provide infiltration and groundwater recharge and are capable of tremendous amounts of storage. Of equal importance is the structural functionality of the pavement. PICP is designed as a flexible pavement for structural load, desired storage, and frost depth requirements. The concrete blocks that form the pavers have the added benefit of being a cooler surface than dark pavements and reduce heat island effects.

COMMON PRACTICES & APPLICATIONS

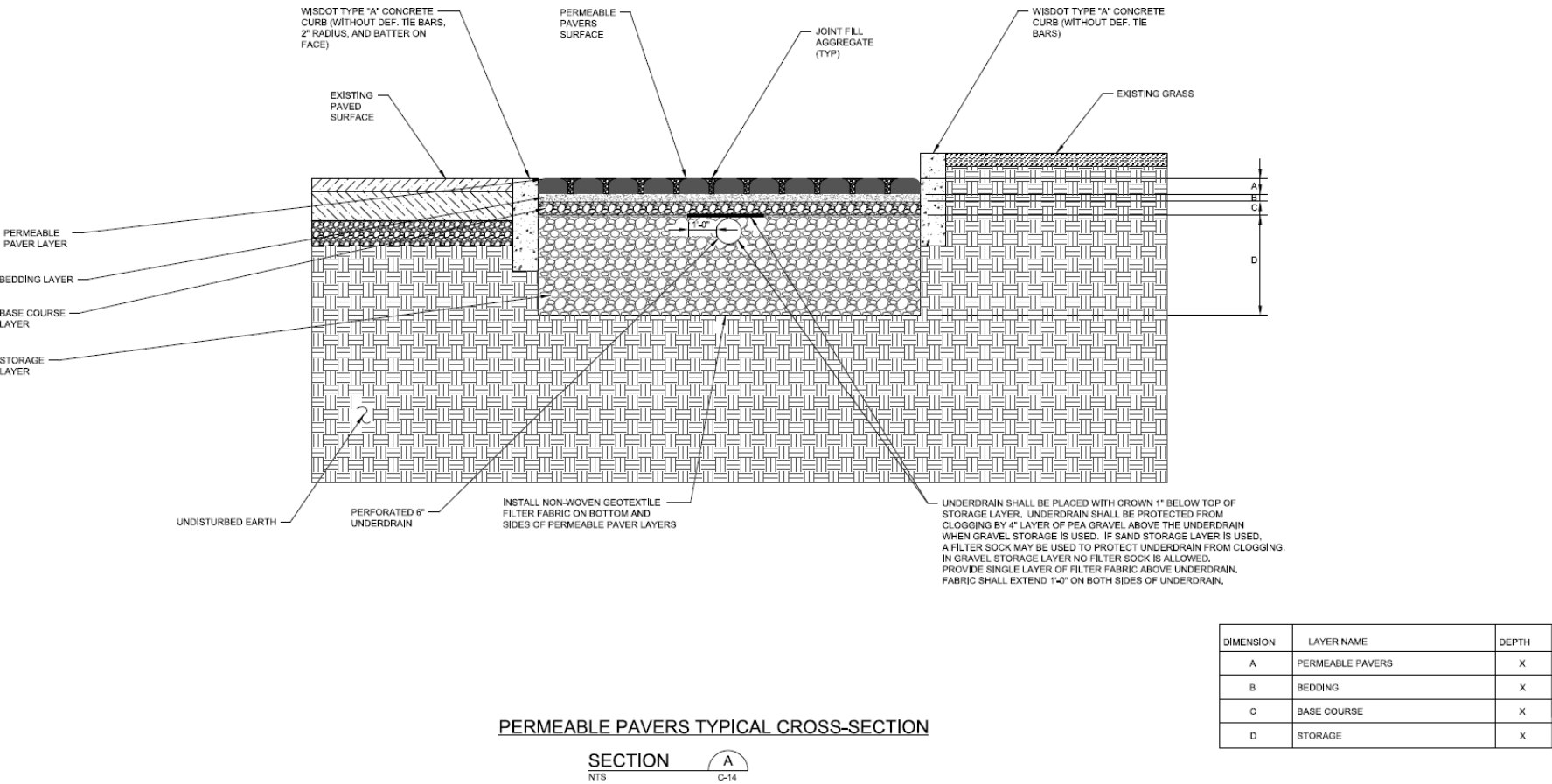
PICP is well-suited for parking areas, sidewalks, recreational areas, driveways, and roadway parking lanes with proper design considerations. PICP has been used in heavy duty applications such as shipping container storage because of its tremendous durability. Heavy duty volume applications require a commitment to proper design, construction quality assurance, and long-term operations and maintenance.

PaveDrain product has been used by the City of Green Bay. Information on maintenance recommendations from PaveDrain can be found at: <https://www.pavedrain.com/maintenance>



PERMEABLE INTERLOCKING CONCRETE PAVEMENT TYPICAL SECTION AND COMPONENTS

(taken from MMSD’s Porous Pavement GSI Strategy Typical Details which can be found in MMSD’s GSI Calculator download Check the link for the most up-to-date sections: https://www.freshcoastguardians.com/static/GI_calc.zip)



PERMEABLE INTERLOCKING CONCRETE PAVEMENT INSPECTION & MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and upstream land use. Site-specific maintenance plans should always be consulted, as the successful functionality of the pavement may have specific maintenance requirements that were considered during design.

There are a number of important principles for PICP inspection and maintenance that will extend the life and function of these systems.

Reducing run-on of sediment and debris: Controlling run-on and preventing tracking or transport of debris onto PICP surfaces is key to extending the life of PICP systems. Approaches to this include:

- Practice strict erosion and sediment control on upstream or contributing areas.
- Vacuuming or sweeping of upstream areas that contribute sediment or debris can be effective in minimizing run-on.
- Mow surrounding grass away from the PICP surface. Consider collecting grass clippings to prevent debris from collecting in joints.
- Do not store materials such as sand, salt, mulch, soil, yard waste, and other stockpiles on permeable surfaces.
- Stockpiling snow on PICPs is not recommended and will lead to premature clogging. Stockpiled snow areas on PICPs will require additional maintenance and vacuuming to prevent clogging and deterioration.

Repairing cuts for utilities: Repairs may be needed for cuts made for utilities. Repairs can typically be made by removal and reuse of the existing paver blocks. Subbase repair may be required to match the initial construction standards.

Informational Signs: Posting signs that alert people to the use of PICPs for surfacing are helpful and recommended. Signage should indicate any limitations on design load (i.e. passenger vehicles only, light truck traffic, etc.) as well as, applicable warnings regarding plowing, use of salt, snow stockpiling, and avoiding debris run-on.

Routine PICP Maintenance:

Routine preventative cleaning of PICP is more effective than corrective cleaning, but both practices are feasible and will be needed at some point in the life of the PICP system. At a minimum, if the recommendations above regarding stockpiling and run-on prevention are

followed, 3x yearly vacuum cleaning of the interlocking concrete pavers will remove sediments and contaminants to prevent clogging. All sweepings from routine vacuuming must be disposed of according to appropriate standards. Preventative sweeping is recommended during high-use periods, or if sediment and debris has washed onto PICP areas.

Gravel Joint Filling: The gravel joint fill in PICP tends to settle substantially during the first 3 to 6 months after its initial installation. Construction specifications should require that the contractor revisit the site 6 months after construction to refill the joints with gravel.

Power-washing of PICP should be used for cleaning acutely clogged areas.

- Power-washing activity should only be done in conjunction with use of a high velocity vacuum head so that debris is removed, and not just displaced. A power vacuum, such as Elgin Whirlwind or Tymco 500X is recommended.
- Power-washing may be required prior to vacuum sweeping to dislodge trapped particles in acutely clogged areas.
- Power-washing should occur at mid-pressure, typically less than 500 pounds per square inch, and at a low angle less than 45 degrees, to drive sediment and material out of the void spaces, instead of deeper clogging.
- Replacement of the PICP gap stone may be necessary if vacuum pressure has removed stones.

Additional Standards: This list provides a quick reference for PICP maintenance.

- Never replace permeable pavers with impermeable materials.
- Never use any type of seal coating on PICPs.
- Inspect PICPs annually for pavement deterioration or spalling and replace pavers as needed where these occur.
- Monitor periodically to ensure that the pavement surfaces are draining effectively after storm. Ponding on PICP surfaces should not routinely occur.
- Major clogging may necessitate restoration of PICP by removal of pavers, cleaning of subbase, and reuse of existing pavers.

Winter PICP Maintenance Guidance

Regular winter maintenance is critical to effective and safe operation of PICP.

- Plow after every storm. Special plow blades may be used to prevent scarring but are not necessary. Raised blade plowing is not recommended.
- Salt of any type can damage concrete surfaces and should be used sparingly.

- Apply deicing treatment before plowing to facilitate plowing and break the bond between compacted snow and pavement. Magnesium chloride should not be used, nor should deicers that contain ammonium nitrate or ammonium sulfate. Similar to all types of concrete pavement, pervious concrete has the concern in northern climates for damage from chloride deicing.

Site Inspections: A site inspection should be performed once after snow melt (mid-April) to identify any items that might occur during expected annual maintenance, but also need special attention to, specific to PICP including:

- Identifying any damaged pavement.
- Identifying any structural component issues, including cleanouts and outfalls.
- Identifying need for gravel joint replacement.
- After rainfall, ensure that system is draining and there is no standing water on the pavement system.

PERMEABLE INTERLOCKING CONCRETE PAVEMENT MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, sign, or GI strategy surfaces.	If graffiti is present on GSI sign, or adjacent to GSI area.	As needed
Trash Removal	Remove trash from surface and surrounding areas. Report large dumping.	If present in or around the pavement.	Monthly (Spring through Fall)
Structural Components			
Pavement Repair	Repair damaged pavement.	Damaged pavement.	As needed
Power-wash	Power-wash pavement to drive debris and sediment out of joints.	Clogged pavement.	Biannually or as needed
Vacuum Sweep	Vacuum or dry sweep pavement depending on manufacturer recommendations or available equipment.	Standing water on the surface of the pavement after a precipitation event.	3x per Year or as needed
Vegetation			
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present in joints.	Biannually
Leaf Blow or Vacuum Sweep	Remove surface debris by sweeping, vacuuming, or leaf-blowing debris.	If debris and/or sediment accumulate on pavement.	Monthly (Spring through Fall)
Filter Medium Components			

Gravel Joint Filling	Use mechanical sweeping or brush to replace joint aggregate.	Aggregate loss (either by time or after vacuum).	As needed (approximately every 5 years)
Winter Maintenance			
Deicing	Remove ice from pavement surface either by a deicing agent free from magnesium chloride, ammonium nitrate or ammonium sulfate.	Before storm events	As needed
Plowing	Use snowplow to remove snow from surface of pavement.	Storm event.	As needed (during or after storm)

PERMEABLE INTERLOCKING CONCRETE PAVEMENT EXPECTED ANNUAL MAINTENANCE

It is recommended to complete eight (8) site visits annually (not including visits for deicing and plowing) for permeable interlocking concrete pavement maintenance. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall ¹
Site Inspection	1				2
Vacuum Sweep / Leaf Blowing	2	2	2		2
Power-wash	1		2		
Manual Weed Control	1		1		2
Plowing				*	
Deicing				*	
Trash Removal	2	2	2		2
Total Minimum Annual Expected Maintenance	2	2	2	*	2
¹ A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes. *Plowing and deicing are dependent on number of snowfalls. Plowing should take place during/after every storm event, and deicing should be done prior to storm event.					

4.6 Pervious Concrete

DESCRIPTION

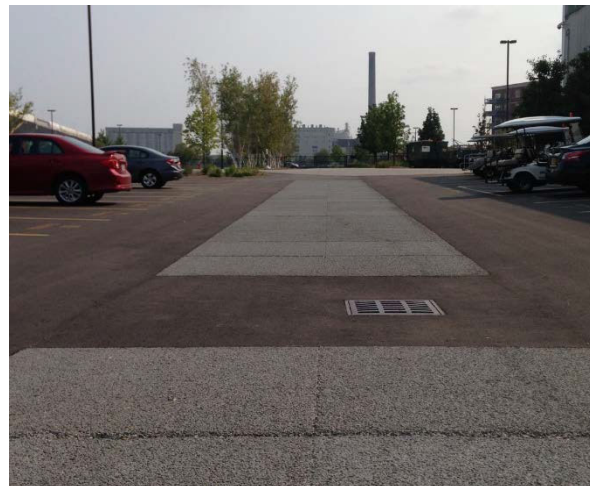
Pervious concrete is an open-graded rigid pavement typically consisting of approximately 20% voids. It lacks the fine aggregates of standard concrete and is primarily comprised of rounded and angular aggregates such as gravel and crushed stone. The appearance of pervious concrete is like that of a Rice-Krispy treat. Pervious concrete provides infiltration and recharge and is capable of a tremendous amount of storage. Of equal importance is the structural pavement functionality. The pavement system depth is designed as a rigid pavement for structural load, desired storage and frost depth requirements. Meltwater readily drains through porous surfaces thereby preventing black ice. Use of added thickness and admixtures are commonly used for heavy duty applications. Pervious concrete systems may include an underdrain in the storage layer to collect and convey water out of the system if it does not infiltrate within



the design period, which is typically 48 to 72 hours. Pervious concrete is more resistant to long-term clogging than porous asphalt because, once cured, the pavement does not remain tacky. As such clogged pervious concrete can be more successfully restored. Pervious concrete has the added benefit of being a cooler surface than dark pavements and reduces heat island effects.

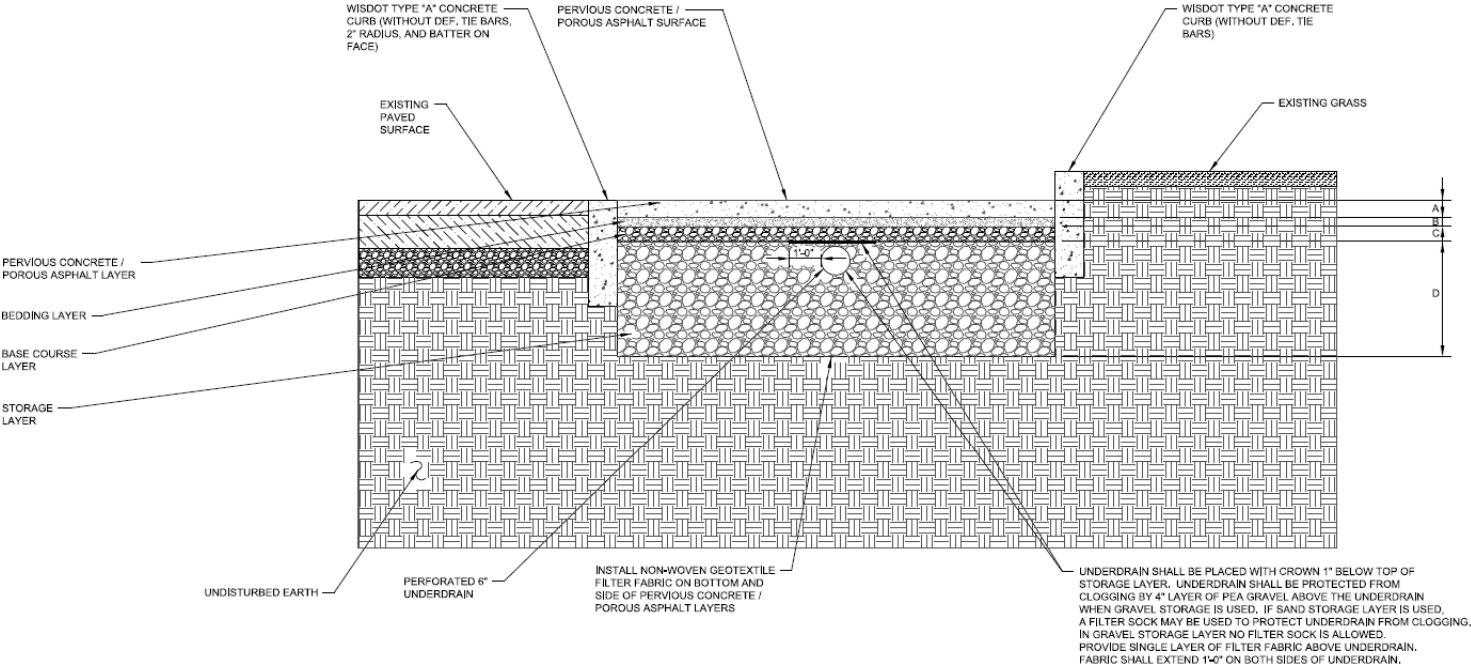
COMMON PRACTICES & APPLICATIONS

Pervious concrete is well-suited for parking areas, sidewalks, recreational areas, driveways, and roadways with proper design considerations. Higher volume applications require a commitment to proper design, construction quality assurance, and long-term operations and maintenance. Construction requirements include allowing 7 to 14 days (depending upon mix design and weather conditions) for concrete cure prior to usage. Pervious concrete is best used in locations with low to no usage of chloride deicers. Heavy usage of chloride deicers has resulted in rapid deterioration of pervious concrete.



PERVIOUS CONCRETE TYPICAL SECTION OR COMPONENTS

(taken from MMSD’s Porous Pavement GSI Strategy Typical Details which can be found in MMSD’s GSI Calculator download Check the link for the most up-to-date sections: https://www.freshcoastguardians.com/static/GI_calc.zip)



PERVIOUS CONCRETE / POROUS ASPHALT TYPICAL CROSS-SECTION

SECTION A
NTS 1/16

DIMENSION	LAYER NAME	DEPTH
A	PERVIOUS CONCRETE / POROUS ASPHALT	X
B	BEDDING	X
C	BASE COURSE	X
D	STORAGE	X

PERVIOUS CONCRETE INSPECTION AND MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and the upstream land use. Site-specific maintenance plans should always be consulted, as the successful functionality of the pavement may have specific maintenance requirements that were considered during design.

There are a number of important principles for pervious concrete inspection and maintenance that will extend the life and function of these systems.

Reducing run-on of sediment and debris: Controlling run-on and preventing tracking or transport of debris onto pervious surfaces is key to extending the life of pervious systems. Approaches to this include:

- Practice strict erosion and sediment control on adjacent or contributing areas.
- Vacuuming or sweeping of adjacent non-pervious concrete that contributes sediment or debris can be effective in minimizing run-on.
- Do not store materials such as sand, salt, mulch, soil, yard waste, and other stockpiles on pervious surfaces.
- Stockpiling snow on pervious concrete is not recommended and will lead to premature clogging. Stockpiled snow areas on pervious concrete will require additional maintenance and vacuuming to prevent clogging and deterioration.

Repairing cuts for utilities: Repairs may be needed for cuts made for utilities. Repairs can typically be made using standard (non-porous) concrete for most damages. Repairs using standard concrete should not exceed 15% of the total area.

Informational Signs: Posting signs that alert people to the use of pervious surfaces are helpful and recommended. Signage should indicate any limitations on design load (i.e. passenger vehicles only, light truck traffic, etc.) as well as, applicable warnings regarding plowing, use of salt, snow stockpiling, and avoiding debris run-on.

Surface Raveling: Occurs when surface aggregates loosen and is common only in the first few weeks after concrete is laid. This can be reduced with proper compaction and curing techniques.

Routine Pervious Concrete Maintenance:

Routine preventative cleaning of pervious concrete is more effective than corrective cleaning, but both practices are feasible and will be needed at some point in the life of the pervious system. At

a minimum, if the recommendations above regarding stockpiling and run-on prevention are followed, 3x yearly vacuum cleaning of the interlocking concrete pavers will remove sediments and contaminants to prevent clogging. All sweepings from routine vacuuming must be disposed of according to appropriate standards. Power-washing is recommended during high-use periods, or if sediment and debris has washed onto pervious surfaces.

Power-washing of pervious concrete should be used for cleaning acutely clogged areas.

- Power-washing activity should only be done in conjunction with use of a high velocity vacuum head so that debris is removed, and not just displaced. A power vacuum, such as Elgin Whirlwind or Tymco 500X is recommended.
- Power-washing may be required prior to vacuum sweeping to dislodge trapped particles in acutely clogged areas.
- Power-washing should occur at mid-pressure, typically less than 500 pounds per square inch, and at a low angle less than 45 degrees, to drive sediment and material out of the void spaces, instead of deeper clogging.

Additional Standards: This list provides a quick reference for pervious concrete maintenance:

- No winter sanding of pervious concretes is permitted.
- Minimize application of salt for ice control.
- Never reseal or repave with impermeable materials.
- Inspect annually for pavement deterioration or spalling.
- Monitor periodically to ensure that the pavement surface drains effectively after storms.
- Clean routinely and preventatively during high-use periods using a vacuum sweeper.
- Power-washing may be required prior to vacuum sweeping to dislodge trapped particles in acutely clogged areas.
- Major clogging may necessitate replacement of the paving surface.

Restoration and Cleaning of Acutely Clogged Areas:

Cleaning and rehabilitation of pervious concrete is recommended for pavement areas that are acutely clogged and where standard vacuum cleaning is insufficient. Pavement restoration cleaning can be conducted by using a high-suction vacuum head used in combination with a vacuum/jet truck. The Bunyan Infiltration Restoration Device (BIRD) uses an array of high-pressure water nozzles to loosen material while simultaneously removing the material from the surface by vacuum.

- Restorative cleaning can be very effective and provide a substantial maintenance benefit not achieved through routine cleaning by regenerative air vacuum.

- The cleaning method, while costly due to the intensive labor and equipment needs, can be done effectively after as many as five years after pavement installation.

Winter Pervious Concrete Maintenance Guidance

Regular winter maintenance is critical to effective and safe operation of pervious concrete.

- Plow after every storm. Special plow blades may be used to prevent scarring but are not necessary. Raised blade plowing is not recommended.
- Salt of any type can damage concrete surfaces and should be used sparingly. Salt usage will vary and is heavily dependent upon shading. For shaded areas, pervious concrete may not achieve salt reduction.
- Apply anti or deicing treatment before plowing to control compact snow and ice not removed by plowing. Magnesium chloride should not be used, nor should deicers that contain ammonium nitrate or ammonium sulfate. Similar to all types of concrete pavement, pervious concrete has the concern in northern climates for damage from chloride deicing.

Site Inspections: A site inspection should be performed once after snow melt (mid-April) to identify any items that might occur during expected annual maintenance, but also need special attention to, specific to pervious concrete including:

- Identifying any damaged pavement.
- Identifying any structural component issues, including cleanouts and outfalls.
- After rainfall, ensure that system is draining and there is no standing water on the pavement system.

PERVIOUS CONCRETE MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, sign, or GI strategy surfaces.	If graffiti is present on GSI sign, or adjacent to GSI area.	As needed
Trash Removal	Remove trash from surface and surrounding areas. Report large dumping.	If present in or around the pavement.	Monthly (Spring through Fall)
Structural Components			
Pavement Repair	Repair damaged pavement.	Damaged pavement.	As needed
Power-wash	Power-wash pavement to drive debris and sediment out of joints.	Clogged pavement.	Monthly (Spring through Fall)
Vacuum Sweep	Vacuum or dry sweep pavement depending on manufacturer recommendations or available equipment.	Standing water on the surface of the pavement after a precipitation event.	3x per Year or as needed
Vegetation			
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present in joints.	Biannually
Leaf Blow or Vacuum Sweep	Remove surface debris by sweeping, vacuuming, or leaf-blowing debris.	If debris and/or sediment accumulate on pavement.	Monthly (Spring through Fall)
Winter Maintenance			

Deicing	Remove ice from pavement surface either by a deicing agent free from magnesium chloride, ammonium nitrate or ammonium sulfate.	Before storm events	As needed
Plowing	Use snowplow to remove snow from surface of pavement.	Storm event.	As needed (during or after storm)

PERVIOUS CONCRETE EXPECTED ANNUAL MAINTENANCE

It is recommended to complete eight (8) site visits annually (not including visits for deicing and plowing) for pervious concrete. The timing and the tasks related to each of these site visits are detailed in the below table.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall ¹
Site Inspection	1				2
Vacuum Sweep	1	1	1		2
Power-wash	2	2	2		2
Manual Weed Control	1		1		2
Plowing				*	
Deicing				*	
Trash Removal	2	2	2		2
Total Minimum Annual Expected Maintenance	2	2	2	*	2
¹ A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes. *Plowing and deicing are dependent on number of snowfalls. Plowing should take place during/after every storm event, and deicing should be done prior to storm event.					

4.7 Porous Asphalt

DESCRIPTION

Porous asphalt pavements are an open graded flexible pavement combined of coarse aggregate and asphalt binder and commonly a strength modifier. Typically, porous asphalt has about 18% or greater voids and an aggregate storage reservoir road base. Porous pavements provide infiltration and recharge and are capable of a tremendous amount of storage. Of equal importance is the structural pavement functionality. The pavement system depth is designed for structural load, desired storage and frost depth requirements. Porous pavement systems may include an underdrain and liner if necessary.

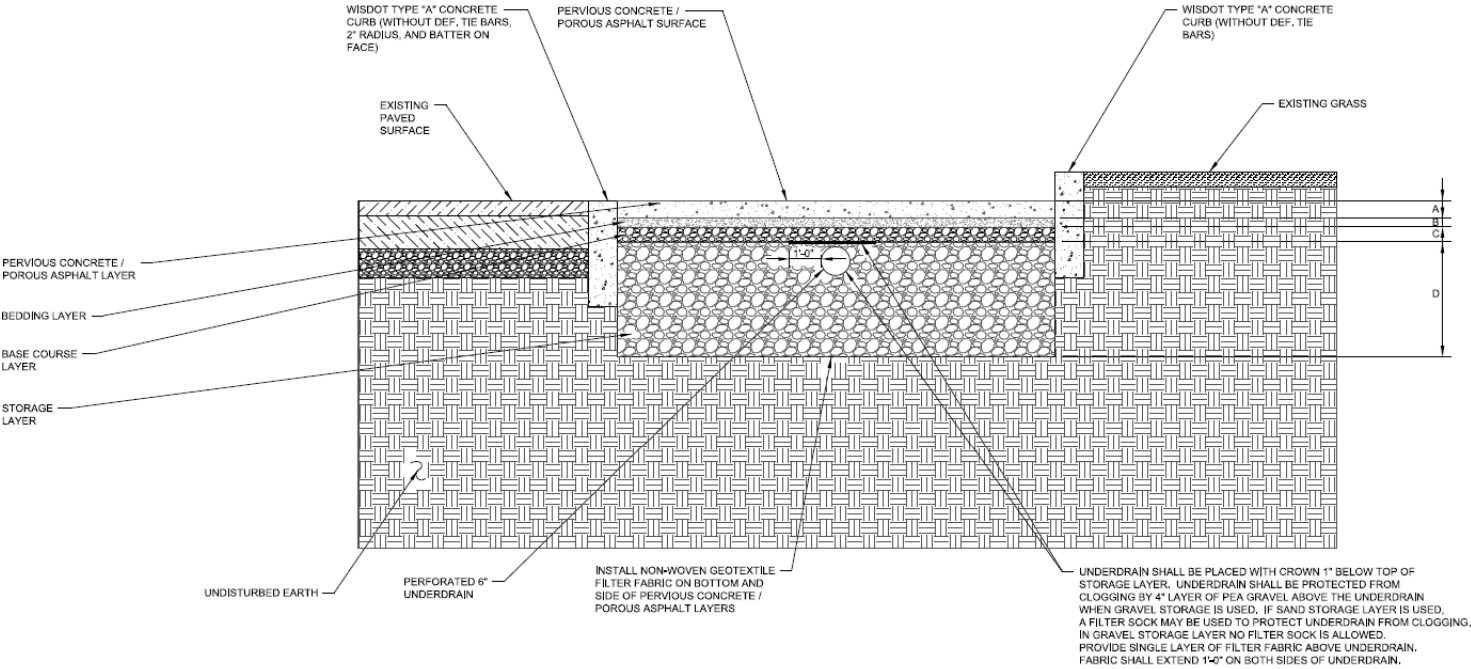
COMMON PRACTICES & APPLICATIONS

Porous asphalt is well-suited for parking areas, recreational areas (e.g., basketball and tennis courts), driveways, and roadways with proper design considerations. Porous asphalt can also be used for sidewalks and pathways. Higher volume roads and highways have also been constructed of porous asphalt with some success but require a commitment to proper design, construction quality assurance, and long-term operations and maintenance.



POROUS ASPHALT TYPICAL SECTION OR COMPONENTS

(taken from MMSD’s Porous Pavement GSI Strategy Typical Details which can be found in MMSD’s GSI Calculator download Check the link for the most up-to-date sections: https://www.freshcoastguardians.com/static/GI_calc.zip)



PERVIOUS CONCRETE / POROUS ASPHALT TYPICAL CROSS-SECTION

SECTION A
NTS C-16

DIMENSION	LAYER NAME	DEPTH
A	PERVIOUS CONCRETE / POROUS ASPHALT	X
B	BEDDING	X
C	BASE COURSE	X
D	STORAGE	X

POROUS ASPHALT INSPECTION AND MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and upstream land use. Site-specific maintenance plans should always be consulted, as the successful functionality of the porous asphalt may have specific maintenance requirements that were considered during design.

There are a number of important principles for porous asphalt inspection and maintenance that will extend the life and function of these systems.

Reducing run-on of sediment and debris: Controlling run-on and preventing tracking or transport of debris onto porous surfaces is key to extending the life of porous systems. Approaches to this include:

- Practice strict erosion and sediment control on adjacent or contributing areas.
- Vacuuming or sweeping of adjacent non-porous asphalt that contributes sediment or debris can be effective in minimizing run-on.
- Do not store materials such as sand, salt, mulch, soil, yard waste, and other stockpiles on porous surfaces.
- Stockpiling snow on porous asphalt is not recommended and will lead to premature clogging. Stockpiled snow areas on porous asphalt will require additional maintenance and vacuuming to prevent clogging and deterioration.

Repairing cuts for utilities: Repairs may be needed for cuts made for utilities. Repairs can typically be made using standard (non-porous) asphalt for most damages. Repairs using standard asphalt should not exceed 15% of the total area.

Informational Signs: Posting signs that alert people to the use of porous surfaces are helpful and recommended. Signage should indicate any limitations on design load (i.e. passenger vehicles only, light truck traffic, etc.) as well as, applicable warnings regarding plowing, use of salt, snow stockpiling, and avoiding debris run-on.

Routine Porous Asphalt Maintenance:

Routine preventative cleaning of porous asphalt is more effective than corrective cleaning, but both practices are feasible and will be needed at some point in the life of the pervious system. At a minimum, if the recommendations above regarding stockpiling and run-on prevent are followed, 3x yearly vacuum cleaning of the porous asphalt will remove sediments and contaminants to prevent clogging. All sweepings from routine vacuuming must be disposed of according to

appropriate standards. Power- washing is recommended during high-use periods, or if sediment and debris has washed onto porous surfaces.

Power-washing of porous asphalt should be used for cleaning acutely clogged areas.

- Power-washing activity should only be done in conjunction with use of a high velocity vacuum head so that debris is removed, and not just displaced. A power vacuum, such as Elgin Whirlwind or Tymco 500X is recommended.
- Power-washing may be required prior to vacuum sweeping to dislodge trapped particles in acutely clogged areas.
- Power-washing should occur at mid-pressure, typically less than 500 pounds per square inch, and at a low angle less than 45 degrees, to drive sediment and material out of the void spaces, instead of deeper clogging.

Additional Standards: This list provides a quick reference for porous asphalt maintenance:

- No winter sanding of porous asphalt is permitted.
- Minimize application of salt for ice control.
- Never reseal or repave with impermeable materials.
- Inspect annually for pavement deterioration or spalling.
- Monitor periodically to ensure that the pavement surface drains effectively after storms.
- Clean routinely and preventatively during high-use periods using a vacuum sweeper.
- Power-washing may be required prior to vacuum sweeping to dislodge trapped particles in acutely clogged areas.
- Major clogging may necessitate replacement of the paving surface.

Restoration and Cleaning of Acutely Clogged Areas:

Cleaning and rehabilitation of porous asphalt is recommended for pavement areas that are acutely clogged and where standard vacuum cleaning is insufficient. Pavement restoration cleaning can be conducted by using a high-suction vacuum head used in combination with a vacuum/jet truck. The Bunyan Infiltration Restoration Device (BIRD) uses an array of high-pressure water nozzles to loosen material while simultaneously removing the material from the surface by vacuum.

- Restorative cleaning can be very effective and provides a substantial maintenance benefit not achieved through routine cleaning by regenerative air vacuum.
- The cleaning method, while costly due to the intensive labor and equipment needs, can be done effectively after as many as five years after pavement installation.

Winter Porous Asphalt Maintenance Guidance

Regular winter maintenance is critical to effective and safe operation of porous asphalt.

- Plow after every storm. Special plow blades may be used to prevent scarring but are not necessary. Raised blade plowing is not recommended.
- Up to ~75% net salt reduction for porous asphalt has been documented. Excess salt applications may be needed during challenging storm events, but salt reductions typically occur between storm events with no black ice formation.
- Apply anti or deicing treatment before plowing to control compact snow and ice not removed by plowing. Magnesium chloride should not be used, nor should deicers that contain ammonium nitrate or ammonium sulfate.

Site Inspections: A site inspection should be performed once after snow melt (mid-April) to identify any items that might occur during expected annual maintenance, but also need special attention to, specific to porous asphalt including:

- Identifying any damaged pavement.
- Identifying any structural component issues, including cleanouts and outfalls.
- After rainfall, ensure that the system is draining and there is no standing water on the pavement system.

POROUS ASPHALT MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, sign, or GI strategy surfaces.	If graffiti is present on GSI sign, or adjacent to GSI area.	As needed
Trash Removal	Remove trash from surface and surrounding areas. Report large dumping.	If present in or around the pavement.	Monthly (Spring through Fall)
Structural Components			
Pavement Repair	Repair damaged pavement.	Damaged pavement.	As needed
Power-wash	Power-wash pavement to drive debris and sediment out of joints.	Clogged pavement.	Monthly (Spring through Fall)
Vacuum Sweep	Vacuum or dry sweep pavement depending on manufacturer recommendations or available equipment.	Standing water on the surface of the pavement after a precipitation event.	3x per Year or as needed
Vegetation			
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present.	Biannually
Leaf Blow or Vacuum Sweep	Remove surface debris by sweeping, vacuuming, or leaf-blowing debris.	If debris and/or sediment accumulate on pavement.	Monthly (Spring through Fall)
Winter Maintenance			

Deicing	Remove ice from pavement surface either by a deicing agent free from magnesium chloride, ammonium nitrate or ammonium sulfate.	Before storm events.	As needed
Plowing	Use snowplow to remove snow from surface of pavement.	Storm event.	As needed (during or after storm)

POROUS ASPHALT EXPECTED ANNUAL MAINTENANCE

It is recommended to complete eight (8) site visits annually (not including visits for deicing and plowing) for porous asphalt maintenance. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall ¹
Site Inspection	1				2
Vacuum Sweep	1	1	1		2
Power-wash	2	2	2		2
Manual Weed Control	1		1		2
Plowing				*	
Deicing				*	
Trash Removal	2	2	2		2
Total Minimum Annual Expected Maintenance	2	2	2	*	2
¹ A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes. *Plowing and deicing are dependent on number of snowfalls. Plowing should take place during/after every storm event, and deicing should be done prior to storm event.					

4.8 Rain Garden

DESCRIPTION

A stormwater management practice consisting of a depression in the soil that is planted with dense, herbaceous vegetation, including both flowers and grasses, designed to capture stormwater runoff and melting snow, naturally absorbing them into the ground. Though rain gardens and bioswales appear similar from above, rain gardens often use the surrounding native topsoil and they are not constructed with the gravel storage layer or underdrain and sewer system functions.



Rain gardens are completely reliant on the native subgrade to infiltrate the collected runoff, in addition to minor amounts of evapotranspiration. It is important that the subgrade soils are well draining, otherwise rain gardens will begin to pool and fail to drain properly.

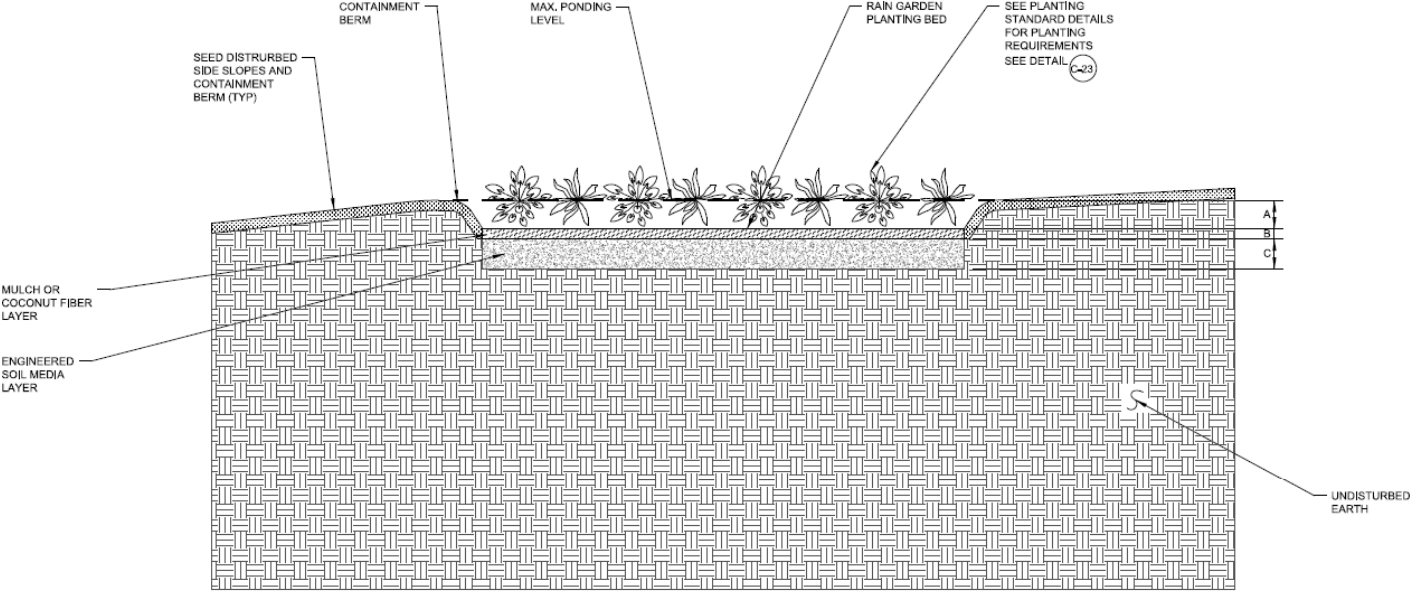
COMMON PRACTICES & APPLICATIONS

Rain gardens are most applicable to small drainage areas, making them most applicable for use on residential properties. Commonly, downspouts from rooftops are directed to drain into rain gardens. However, they can also be designed to collect and absorb water from hillsides, driveways, and other impervious surfaces.

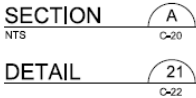


RAIN GARDEN TYPICAL SECTION OR COMPONENTS

(taken from MMSD’s Rain Garden GSI Strategy Typical Details which can be found in MMSD’s GSI Calculator download Check the tool for the most up-to-date sections: https://www.freshcoastguardians.com/static/GI_calc.zip)



RAIN GARDEN TYPICAL CROSS-SECTION



DIMENSION	LAYER NAME	DEPTH
A	SURFACE PONDING	X
B	MULCH OR COCONUT FIBER	X
C	ENGINEERED SOIL MEDIA	X

RAIN GARDEN INSPECTION AND MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and upstream land use. Site-specific maintenance plans should always be consulted, as the successful functionality of the rain garden may have specific maintenance requirements that were considered during design.

Referring to Planting Plans & Photos: It is especially important to refer to planting plans and photos that show what types of vegetation should be present, and where maintenance crews should or should not mow.

Timing of Inspections: Rain gardens maintenance can typically be performed as part of standard landscaping. Regular inspection and maintenance, beginning after snow melt, is critical to the effective operation of rain gardens to insure they remain clear of leaves and debris, support healthy vegetation, and are free draining. In addition, because erosion and inflows from large storm events can damage vegetation, cause erosion and ponding, and clog downspouts, rain gardens should be inspected after any rain event of 2 inches in 24 hours or more. Inspection during the time of weed growth is also especially critical, as it is usually the top maintenance activity associated with these systems. For the City of Green Bay, this will begin in late May / early June.

Inspection Focus: Inspections should focus on the growth and condition of vegetation, including any weeds or invasives; soil conditions (especially sediment build-up or clogging); and stormwater flow paths and erosion. Maintenance of any items identified in the inspections should be completed within 7 days of the inspection.

Initial Site Inspection: A site inspection should be performed after snow melt (mid-April) to identify any items that would not be covered in the expected annual maintenance visits. This would include:

- Identifying any bare areas in the rain gardens
- Identifying any low or eroded areas in the engineered soil
- Identifying any structural component issues

Manual Weed Control: Depending on establishment and condition of planting bed, as many as 12 weeding visits could occur during the typical six-month growing season of mid-April through mid-October. The weeds are growing most aggressively from early May through mid-July (before native warm season grasses have filled out). During this period, visits may need to be weekly. Ornamental landscapes will typically require more visits than naturalized ones, but to begin with, naturalized landscapes will require more visits. As naturalized landscapes are established, the frequency of manual weed control will taper off.

RAIN GARDEN MAINTENANCE TASKS, INDICATORS AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, sign, or GI strategy surfaces.	If graffiti is present on GSI sign, or adjacent to GSI area.	As needed
Structural Components			
Structural Clearing & Maintenance	Clear trash, debris, sediments, etc. from conveyance structures or gutters draining to the rain garden.	Clogged downspouts, gutters, pipes, or structures.	Biannually
Vegetation Components			
Invasive Species Control	Control invasive species impacting desired plant species in rain garden. Refer to Appendix of Invasive Species for list of the most common invasive species found in GSI strategies in Northeastern WI.	Invasive plants are present in rain garden.	Biannually
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present in rain garden.	Monthly (Spring through Fall – more frequently May through July)

Mowing	Mow plants if height of vegetation exceeds recommended heights. Mow perimeter edge of naturalized GSI within vegetated grassy areas.	If height of vegetation exceeds recommended heights.	Annually
Pest Management*	Inspect plants for signs of disease or predation.	Presence of pests or diseased plants.	Biannually
Plant Replacement	Remove and replace dead plants.	If at least 10% of the plants have died.	As needed
Pruning	Remove damaged, diseased or dead branches or woody plants, small trees, or shrubs	If damaged, diseased, or dead branches are present, or if safe line of sight is obstructed.	Annually
Vegetation Maintenance	Trimming and/or transplanting annual herbaceous vegetation.	Presence of decayed material.	Annually
Watering	Water plants as necessary to ensure survival during extended dry periods.	Yellow or brown tips or leaves, dying plants, or wilted/dehydrated leaves or stalks. Note, yellow leaves can also be an indicator that plants are receiving too much water.	As needed, depending on weather
Woody Vegetation Removal	Remove woody vegetation or saplings.	If unplanned woody vegetation or saplings are present in rain garden.	Annually
Growing Medium/Planting Bed Components			
Erosion Repair	Stabilize any disturbed areas with live plantings or seed and biodegradable erosion matting.	If minor (<20 sf), nonrecurring erosion is present within the rain garden, or if erosion is deeper than 2 inches.	As needed

Mulch Amendment/Replacement	Amend (i.e. rake, aerate, and add material), or replace mulch in rain garden.	If visible mulch is observed to have bare spots, depth is less than 2 inches or appears compacted or disarrayed in or around the rain garden.	Annually or as needed
Organic Debris Removal	Remove excess organic debris (e.g., leaves, plant decay, etc.) from rain garden surfaces.	If present in rain garden.	Biannually
Sediment Removal	Remove sediment from rain garden basin and surrounding areas, including gutters and sidewalks.	If sediment is present or visible in or around the rain garden, and if sediment is more than 1 inch.	Biannually or as needed
Settling Repair	Repair rain garden areas that have settled.	Area is observed to be lower than surrounding areas of designed elevation of the rain garden.	As needed
Surface Media Renovation	Remove top inches of filter media and cultivating the surface.	Rain garden area is clogged or not draining properly within 48 hours of a rainfall.	As needed
Trash Removal	Remove trash from rain garden planting beds and surrounding areas. Report any evidence of dumping.	If present in or around the rain garden.	Monthly (Spring through Fall)
* Integrated Pest Management (IPM) routines are encouraged. This involves inspecting the plants for signs of disease or predation. The IPM approach encourages non-chemical methods for treated diseases or pests as a first resort.			

RAIN GARDEN EXPECTED ANNUAL MAINTENANCE

It is recommended to complete twelve (12) site visits annually for rain garden maintenance. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall ¹
Site Inspection	1 ²				2
Mowing			1 ³		
Manual Weed Control	3	3	3		
Pest Management		1	1		
Invasive Species Control		1	1		
Vegetation Maintenance	1				
Trash Removal	2	2	2		2
Organic Debris Removal	1		1		2
Pruning			2		
Structural Clearing & Maintenance	1				2
Woody Vegetation Removal			1		
Sediment Removal	1		1		2
Mulch Amendment/Replacement	1				2
Total Minimum Annual Expected Maintenance	4	3	3		2

¹ A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

² Initial site inspection shall be completed mid-April after snowmelt. The site inspection should be the focus and other maintenance tasks **should not be considered** at this time. Site inspections conducted after 2-inch rainfalls can be combined with other maintenance tasks as needed.

³ Mowing frequency is based on an established, native landscape. Mowing may take place in late-fall or early-spring depending on plant species.

If the native landscaping is recently established, the mowing is usually conducted in decreasing frequencies from the date of planting. Often five mowings the first full growing season, four the second, three the third, and so on. This allows the native seed to germinated and prevent annual weeds from flowering and setting seed.

If ornamental grasses are used, they are not mown, but usually trimmed back in early spring of each year.

4.9 Rainwater Harvesting (Cisterns)

DESCRIPTION

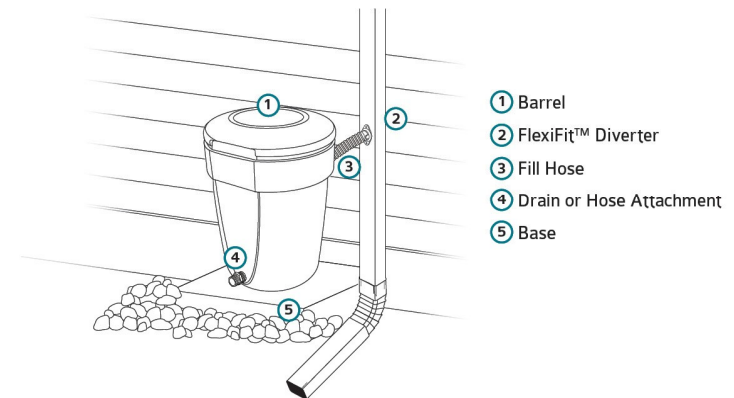
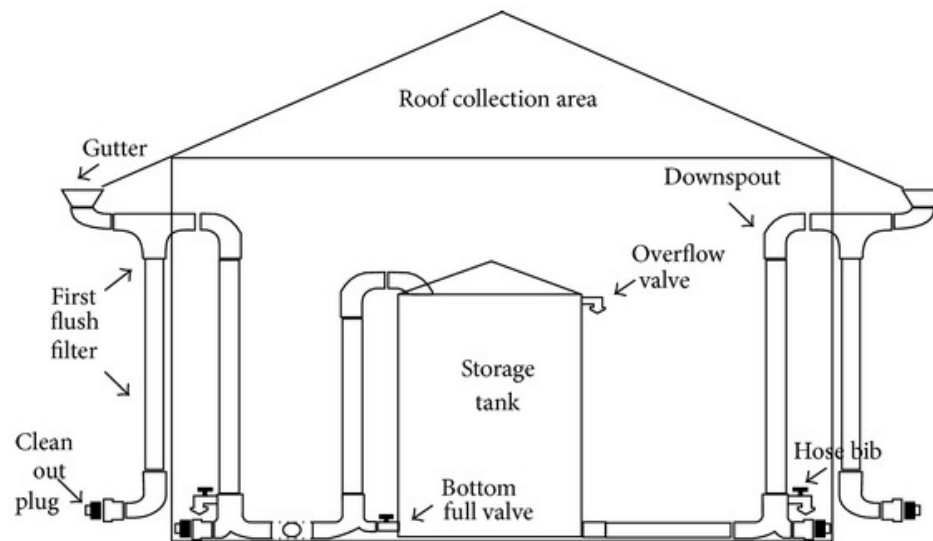
Rainwater harvesting systems typically divert and store runoff from residential and commercial roofs. They tend to be lower maintenance than most GSI strategies and might only require periodic cleaning of leaf debris and rooftop particulates. Rainwater harvesting can collect water from fields and parking as well. Rooftop runoff is typically considered 'clean' runoff; however, it may contain airborne pollutants (nutrients), pollutants from roofing materials (metals or hydrocarbons), and bacteria from birds. Rooftop runoff contamination is usually at low levels of concern in comparison with other impervious surfaces. Rainwater harvesting systems typically capture rooftop runoff by diverting downspouts through a prefilter and into a rain barrel or cistern. Cisterns and barrels are commonly dark opaque materials to prevent algae growth, with large systems often underground. Non-potable uses are most common which require a separate plumbing system for irrigation. The basic components of a rainwater harvesting system include a catchment surface, gutters and downspouts, leaf screens, first-flush diverters, and roof washer, one (or more) storage tanks, delivery system, and treatment/purification. Rain barrels tend to be more simplified versions of rainwater harvesting systems but include many of the same components.

COMMON PRACTICES & APPLICATIONS

Rainwater harvesting can be used to capture and store water for reuse for small residential applications to large scale commercial and industrial. Rainwater reuse is typically non-potable and used for irrigation, graywater systems (toilets and laundry), and fire suppression with proper considerations for usage and demand. Rainwater harvesting can be easily converted to drinking water quality standards with the proper disinfection and testing needs. Rainwater harvesting often is not used for large volume control for stormwater management simply because of the large volumes required. For example, rain barrels commonly capture 50 gallons of rooftop runoff and a 1,200 square-foot rooftop generates approximately 695 gallons for a 1-inch rain. Though that is not always the case, another reason they are not always used for volume control is because the systems need to be emptied after rain events, and to be used as a water source, the systems need to be full. For rainwater harvesting to be a feasible type of stormwater management requires substantial storage volume, planning, and design.

RAINWATER HARVESTING TYPICAL SECTIONS OR COMPONENTS

(Schematic of rainwater harvesting system (Shitirah Akib). from https://www.researchgate.net/figure/Schematic-of-a-rainwater-harvesting-system_fig8_259923841)



RAINWATER HARVESTING INSPECTION AND MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less-frequent maintenance needs depending on a variety of factors including the occurrence of large storm events and type of system. Site-specific maintenance plans should always be consulted, as the successful functionality of the rainwater harvesting system may have specific maintenance requirements that were considered during design.

Inspection Focus: Rainwater collection and storage facilities require a variety of forms of routine maintenance. Some of the routine maintenance activities that are needed periodically are:

- Removing debris from the roof, leaf guard, gutter, gutter screen, and first-flush diverter.
- Inspecting and repairing vent screens.
- Removing sediment from the tank.
- Testing the coliform bacteria levels in your untreated-water storage tank. Note for rain barrels, if purpose of rainwater collection is non-potable uses, testing is not necessary.
- Disinfecting the water storage tank if total coliform levels reach 500 colony-forming units per 100 milliliters (500 CFU/100 ml) or if fecal coliform levels reach 100 CFU/100 ml.

Untreated water with total coliform levels above 500 CFU/100 ml or where fecal coliform levels rise above 100 CFU/100 ml should not be used, even for non-potable purposes until it has been disinfected. Disinfection can also help prevent heavy biological growths that can foul your treatment system and contaminate your plumbing system. The most convenient way to control biological growth in the storage tank is for them to be constructed below ground surface or in a dark opaque container. If biological growth occurs, the addition of a small amount of chlorine bleach periodically.

Rainwater harvesting systems almost always require a pump to pressurize the water and deliver it to its intended use. When the use is located in the building, there is usually a day tank involved so that any sanitation required is only sanitizing a small amount of water, not the entire system. Other system set ups use an on-demand pump. In this case, there would be a fine filter involved, similar to a cartridge filter, especially if the water is used for drip irrigation or in a building.

Depending on the type of rainwater harvesting system, the maintenance tasks may be refined, but the tasks, indicators, and expected frequency are general recommendations. Refer to manufacturer recommendations for specific maintenance activities and recommendations.

Initial Site Inspection: A site inspection should be performed after snow melt (mid-April) to identify any items that would not be covered in the expected annual maintenance visits. This would include:

- Installing the system components after winter, if necessary. This includes disinfecting the system if it was not used during winter months.
- Identifying any structural component issues.

RAINWATER HARVESTING MAINTENANCE TASKS, INDICATORS, AND EXPECTED FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down signage.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from structure or signs.	If graffiti is present on structures or adjacent signs and structures.	As needed
Structural Components			
Sanitizing	Sanitizing if positive tests for contamination.	Positive test for contamination.	Monthly (Spring through Fall)
Sediment Removal	Removal sediment from prefilter and tank.	Visible sediment in prefilter or tank.	Monthly (Spring through Fall)
Structural Clearing & Maintenance	Clearing trash, debris, sediment from screens, conveyance structures, including roof and gutters draining to the cistern.	Clogged gutters, cisterns, or conveyance structures.	Biannually or as needed
Testing	Testing the coliform bacteria levels in tank.	Presence of biological growth.	Monthly (Spring through Fall)
Winterizing	Winterize system per manufacturer recommendations prior to freeze thaw conditions.	Prior to freeze thaw conditions.	Annually
Many components of rainwater harvesting systems tend to be specific to manufacturer. Refer to manufacturer recommendations for specific maintenance activities and contact the manufacturer for repair or replacement of parts.			

RAINWATER HARVESTING EXPECTED ANNUAL FREQUENCY

It is recommended to complete ten (10) site visits annually for rainwater harvesting maintenance.

The timing and the tasks related to each of these site visits is detailed in the below table.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall ¹
Site Inspection	1 ²		1		2
Sanitizing	2	2	2		
Sediment Removal	2	2	2		
Structural Clearing & Maintenance	1		1		
Testing ³	2	2	2		2
Winterizing			1 ⁴		
Total Minimum Annual Expected Maintenance	3	2	3		2

¹ A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

² Initial site inspection shall be completed mid-April after snowmelt. The site inspection should be the focus and other maintenance tasks **should not be considered** at this time. Site inspections conducted after 2-inch rainfalls can be combined with other maintenance tasks as needed.

³ For rain barrels, if purpose of rainwater collection is non-potable uses, testing is *not* necessary.

⁴ Winterizing instructions shall be followed according the specific product and manufacturer recommendations. The focus of this inspection is to winterize or disconnect the system and should be performed separate from other maintenance tasks.

4.10 Soil Amendments

DESCRIPTION

Soil amendments transform lawns to act like stormwater sponges. Healthy lawns develop thick root systems that help absorb more rain, reduce water pollution, and the amount of water that gets into sewers. Grasses with thick root systems become more drought-tolerant and out-compete weeds.

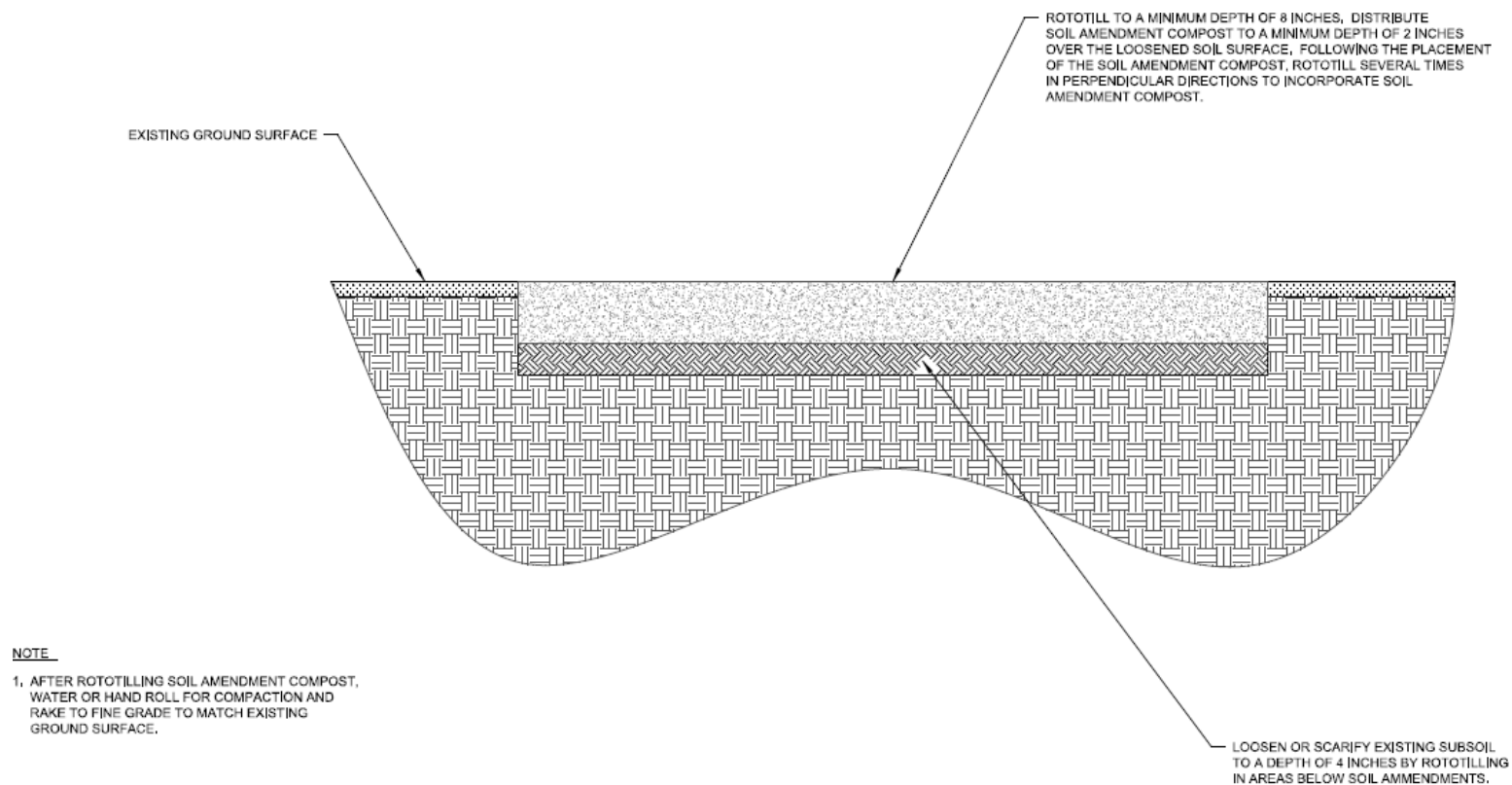
COMMON PRACTICES & APPLICATIONS

Soil amendments may include top-dressing areas of vegetation, or removing, amending, and replacing soil by excavation. For turfgrass applications, the use of sod is discouraged, and seed is recommended. Soil amendments can be implemented in almost all sites with lawns but are commonly found on residential lawns.



SOIL AMENDMENT TYPICAL SECTION AND COMPONENTS

(taken from MMSD's Soil Amendment GSI Strategy Typical Details which can be found in MMSD's GSI Calculator download) Check the link for the most up-to-date sections: https://www.freshcoastguardians.com/static/GI_calc.zip



**SOIL AMMENDMENT
TYPICAL CROSS-SECTION**
NTS

SOIL AMENDMENT INSPECTION AND MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and the upstream land use. Site-specific maintenance plans should always be consulted, as the successful functionality of the soil amendments may have specific maintenance requirements that were considered during design.

Referring to Planting Plans & Photos: It is especially important to refer to planting plans to note the type of soil amendment that was installed.

Inspection Focus: The maintenance steps are site dependent and must be adapted to site and soil conditions. In some cases, soil may simply be aerated to alleviate compaction. In other cases, soils may need to be excavated and a portion replaced with one of several types of soil amendment materials. In all cases, care must be taken to ensure the proper revegetation and erosion control are practices for disturbed areas.

SOIL AMENDMENT MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, signage, or surrounding surfaces.	If graffiti is present on GSI signage, or adjacent to GSI area.	As needed
Vegetation Components			
Invasive Species Control	Control invasive species impacting desired plant species in amended area. Refer to Appendix of Top 10 Invasive Species for list of the most common invasive species found in GSI strategies in Southeastern WI.	Invasive plants are present in amended area.	Biannually or as needed
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present in amended soil areas.	Monthly (Spring through Fall)
Pest Management*	Inspect plants for signs of disease or predation.	Presence of pests or diseased plants.	Biannually
Watering	Water plants as necessary to ensure survival during extended dry periods.	Brown tips of grass, or grass or seed is not growing.	As needed, depending on weather
Growing Medium/Planting Bed Components			
Erosion Repair	Stabilize any disturbed areas with seed and biodegradable erosion matting.	If minor (<20 sf), nonrecurring erosion is present within the area, or if erosion is deeper than 2 inches.	As needed

Organic Debris Removal	Remove excess organic debris (e.g., leaves, plant decay, etc.) from soil surfaces.	If present in or around the amended areas.	Biannually
Settling Repair	Repairing areas of practice that have settled.	Area is observed to be lower than surrounding areas of designed elevation.	As needed
Trash Removal	Remove trash from amended and surrounding areas. Report any evidence of dumping.	If present in or around the amended areas.	Monthly (Spring through Fall)
* Integrated Pest Management (IPM) routines are encouraged. This involves inspecting the plants for signs of disease or predation. The IPM approach encourages non-chemical methods for treated diseases or pests as a first resort.			

SOIL AMENDMENT EXPECTED ANNUAL FREQUENCY

It is recommended to complete eight (8) site visits annually for soil amendment maintenance. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall ¹
Site Inspection	1				2
Manual Weed Control	2	2	2		
Pest Management		1	1		
Invasive Species Control		1	1		
Trash Removal	2	2	2		2
Organic Debris Removal	1		1		2
Mulch Amendment/Replacement	1				2
Total Minimum Annual Expected Maintenance*	2	2	2		2

¹ A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

*These visits are separate from those made to mow the turfgrass, of which there are approximately 26.

4.11 Stormwater Trees

DESCRIPTION

Stormwater trees are trees that can hold rainwater in their leaves and branches, infiltrate it into the ground, absorb it through their root systems, and evapotranspire it into the atmosphere. They can be used in conjunction with engineered soils and other types of GSI and work best when they are mature. Per City Code of Ordinances Sec.16-79, "Stormwater tree means a tree selected and installed, either with or without an engineered box or structure, as an integral and intentional component of a stormwater management or landscape plan, at points or sites where the tree will have the effect of capturing stormwater runoff and increasing tree canopy coverage."

COMMON PRACTICES & APPLICATIONS

Stormwater trees are commonly planted adjacent to roadways or sidewalks in urban areas. They can also be found in conjunction with other stormwater-managing landscapes and practices,



including bioswales, native landscaping, and soil amendments.

STORMWATER TREE INSPECTION AND MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and upstream land use. Site-specific maintenance plans should always be consulted, as the successful functionality of the trees may have specific maintenance requirements that were considered during design.

Inspection Focus: Stormwater trees require specific maintenance measures during establishment, (i.e. 1– 3 years after planting) that generally are not required once the tree is well-established. Stormwater tree maintenance should be performed in the fall after leaf-off and any time that the following conditions are observed:

- Tree roots are exposed.
- Trash, debris, litter and leaves are present.
- Evidence of standing water on or around the tree 48 hours after rainfall.
- Evidence of animal burrows, other holes, or erosion.
- Drought conditions.
- Dead, dying or damaged branches or leaves are present.

Manual Weed Control: Depending on establishment and condition of planting bed, as many as 12 weeding visits could occur during the typical six-month growing season of mid-April through mid-October. The weeds are growing most aggressively from early May through mid-July (before native warm season grasses have filled out). During this period, visits may need to be weekly. Ornamental landscapes will typically require more visits than naturalized ones, but to begin with, naturalized landscapes will require more visits. As naturalized landscapes are established, the frequency of manual weed control will taper off.

STORMWATER TREE MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Signage Care	Wipe down signage.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, signage, or surrounding surfaces.	If graffiti is present on GSI signage, or adjacent to GSI area.	As needed
Structural Components			
Tree Grate	Monitor trunk growth and repair or replace damaged tree grates.	Trunk growing too close to the grate opening or damage to tree grate.	As needed
Vegetation Components			
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present around tree area.	Monthly (Spring through fall)
Pest Management*	Inspect plants for signs of disease or predation.	Presence of pests or diseased plants.	Biannually
Pruning (Structural)	Pruning trees or tree branches.	If tree is becoming too large for designated space, or if low branches are growing outside the space over streets or sidewalks.	Annually
Watering	Water plants as necessary to ensure survival during extended dry periods.	Yellow or brown tips of leaves, dying plants, or wilted/dehydrated leaves or stalks. Note, yellow leaves can also be an indicator that plants are receiving too much water.	As needed, depending on weather

Growing Medium/Planting Bed Components			
Organic Debris Removal	Remove excess organic debris (e.g., leaves, plant decay, etc.) from tree areas.	If present in or around tree area.	Biannually
Mulch Amendment/Replacement	Amending or replacing mulch in tree area.	If mulch is observed to have bare spots, depth is less than 2 inches or appears compacted or disarrayed in or around tree area.	Annually or as needed
Trash Removal	Remove trash from tree planting beds and surrounding areas. Report large dumping.	If present in or around the tree area.	Monthly (Spring through Fall)
* Integrated Pest Management (IPM) routines are encouraged. This involves inspecting the plants for signs of disease or predation. The IPM approach encourages non-chemical methods for treated diseases or pests as a first resort.			

STORMWATER TREE EXPECTED ANNUAL FREQUENCY

It is recommended to complete eight (8) site visits annually for stormwater tree maintenance. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall ¹
Site Inspection	1				2
Pest Management		1	1		
Manual Weed Control	2	2	2		
Pruning			1		
Trash Removal	2	2	2		2
Organic Debris Removal	1		1		2
Mulch Amendment/Replacement	1				2
Total Minimum Annual Expected Maintenance	2	2	2		2
¹ A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.					

5 Maintenance Tasks

5.1 Concrete Repair

DESCRIPTION

This section describes the procedure for repairing hairline or larger cracks in the concrete within a GSI area. This task should be performed for any cracks found during inspections of the GSI area.

EQUIPMENT & MATERIALS

- Chisel
- Hammer
- Masonry Trowel
- Scrub Brush
- Concrete Crack Patching Compound
- Concrete Mixing Tray
- Water
- Tarp
- Personal Protective Equipment (PPE): gloves

INSTRUCTIONS

- 1) Protect surrounding plants and GSI components by covering them with a tarp.
- 2) Undercut the crack using a chisel and small hammer to widen the base of the crack.
- 3) Remove all debris and small particles.
- 4) Mix the concrete crack patching compound per the manufacturer's recommendations.
- 5) Tamp the mixture to remove air pockets.
- 6) Smooth the mixture with a trowel and wait for the patch to set.

SPECIAL CONSIDERATIONS

- Schedule concrete work early in the day for final setting to occur during the workday. Protect the patch from pedestrian and vehicular traffic using safety cones or other barricades and ensure that personnel are present during the final setting period to prevent vandalism and damage.
- Maintain protective measures during the five to seven day curing period.
- Concrete repairs should be limited to days with temperature ranges between 40- and 80-degrees Fahrenheit.
- Concrete repair shall be avoided within a 48-hour period of forecasted rain.

5.2 Deicing

DESCRIPTION

This section describes the procedures for the deicing of permeable, pervious, and porous pavement. This task should be performed before and after snow events, sleet events, freezing rain events, and as needed during the winter season. Accumulated snow should be removed by shoveling, sweeping or plowing before it bonds with the pavement. If ice or snowpack accumulates, road salt or other deicers can be used in moderation to clear the pavement. Magnesium chloride should not be used, nor should deicers that contain ammonium nitrate or ammonium sulfate.

EQUIPMENT & MATERIALS

- Deicer
- Bucket
- Shovel
- Broom
- Snowplow
- Personal Protective Equipment (PPE): boots and gloves

INSTRUCTIONS

- 1) Shovel/sweep/plow snow in pavement area. (See Plowing Section.)
- 2) Apply deicer to pavement area if shoveling/sweeping/plowing is not sufficient.
- 3) Repeat as necessary.

SPECIAL CONSIDERATIONS

- Deicers should be used in moderation.
- Sand or cinders should not be applied onto or adjacent to any porous pavement.

5.3 Erosion Repair

DESCRIPTION

This section describes the procedure for the repair of eroded areas. This task should be performed when water has eroded soils, causing bare spots or depositions of eroded soils in the bottom of the strategy. If erosion caused plants to wash away or die off, additional plantings may be necessary.

EQUIPMENT & MATERIALS

- Soils
- Shovel
- Wheelbarrow
- Seed
- Mulch or Matting
- Plants
- Personal Protective Equipment (PPE): gloves

INSTRUCTIONS

- 1) Remove debris and loose soils.
- 2) Apply replacement soils to fill in cracks, low spots.
- 3) Cover with seed and mulch/matting.
- 4) Replace plants that were affected in the repaired area.

SPECIAL CONSIDERATIONS

- Consult with facilities manager prior to repairing eroded area. GSI strategy may have specialty soils or plants.
- Note that constant erosion is an indicator that there is an issue with run-on, either too much run-on, or it is entering the strategy too quickly. If erosion of same location in practice persists after the first erosion repair, steps may need to be taken to address the run-on problem.

5.4 Graffiti Removal

DESCRIPTION

This section describes the procedure for the removal of graffiti from GSI elements. This task should be performed as necessary when graffiti is present on any GI, signage, or areas adjacent to the GSI strategy area.

EQUIPMENT & MATERIALS

- Tarp
- Pressure Washer
- Chemical Graffiti Removal Solvent
- Metal/Plastic Brush
- Utility Knife
- Paint
- Rags
- Trash Bags
- Personal Protective Equipment (PPE): gloves

INSTRUCTIONS

- 1) Cover surrounding areas with a tarp to protect plants and GSI strategy components.
- 2) If graffiti is sticker based, remove sticker from surface by holding the utility knife at a low angle relative to surface to prevent scratching.
- 3) Use a pressure washer to wash the surface.
- 4) Apply chemical graffiti removal solvent per the manufacturer's instructions.
- 5) Scrub surface with metal or plastic brush.
- 6) Wipe away graffiti solvent with rags.
- 7) Pressure wash or rinse surface clean.
- 8) If necessary, re-paint the affected area.

SPECIAL CONSIDERATIONS

- Remove to the greatest extent possible and report any graffiti that could not be removed.

5.5 Gravel Joint Filling

DESCRIPTION

This section describes the procedure for filling the joints in permeable interlocking concrete pavements with gravel. This task should be performed when approximately 20% of the gravel is missing between the joints, typically after 5 years, or after a sweeping event occurs where joint material is incidentally removed.

EQUIPMENT & MATERIALS

- Disposal Bin
- Skid Steer with Mechanical Brush Attachment or Broom
- (Clear-washed) Gravel Material

INSTRUCTIONS

- 1) Obtain clear-washed joint material and check the manufacturer specifications for the type of gravel joint material needed for specific product.
- 2) Dump gravel joint material onto pavement.
- 3) If using skid steer, use mechanical brush attachment with the brush turned to 30-degree angle to push piles of gravel in passes over the permeable interlocking concrete pavement to fill joints.
- 4) If using broom, brush gravel over permeable interlocking concrete pavement to fill joints.
- 5) Brush using either of the two methods until joints are full or to “lip” of pavers. Joints are full when excess material is left at the end of a pass with broom or brush.
- 6) Store or dispose of excess material and trash at an approved facility or location.

SPECIAL CONSIDERATIONS

- Obtain clear-washed joint material from a reputable vendor.
- Review facility plans, manufacturer specifications, and manufacturer recommendations for joint material sizes, and product recommendations.

5.6 Manual Weed Control

DESCRIPTION

This section describes the procedure for controlling weeds by hand. This task should be performed routinely, when undesirable plant growth is observed in between the desired plants.

EQUIPMENT & MATERIALS

- Rake
- Shovel
- Trowel/Soil knife
- Wheelbarrow/Bucket
- Personal Protective Equipment (PPE): gloves

INSTRUCTIONS

- 1) Identify unwanted weeds.
- 2) Pull weeds to remove entire plant and as much of the root system as possible. Note: Placing a foot next to the base of the weed that is going to be pulled will help keep the soil in place as the roots slide out of the ground.
- 3) Do not impact remaining plant growth.

SPECIAL CONSIDERATIONS

- If available, use planting plan to identify the plants that were initially intended, and be sure not to remove plants that are not weeds.
- Hand pulling of weeds is easiest when the soil is moist, immediately after a rain.
- The use of chemical herbicides or algaecides in waters of the state, including storm water treatment facilities, is regulated by the Wisconsin Department of Natural Resources-Aquatic Plant Management Program under NR 107, Wisconsin Administrative Code. Contact the WDNR to apply for applicable permits prior to using herbicides and/or algaecides in pre-treatment forebays or in constructed wetlands. In addition to contacting the WDNR, consider “hand-wicking” then weeding rather than spray application to reduce the amount of herbicide needed and to be more deliberate in the application.
- Certain plants may cause skin irritation, such as poison ivy (*Toxicodendron radicans*), poison sumac (*Toxicodendron vernix*), poison oak (*Toxicodendron deversilobum*), stinging nettle (*Urtica dioica*), wild parsnip (*Pastinaca sativa*) and more. In addition, some plants have thorns or can prick skin when in contact with the plant, such as raspberries (*Rubus*, sp.), thistle (*Cirsium arvense*), and more. Be sure to wear gloves and long sleeves to cover arms when working with invasive plants or weeds.
- Invasive plants that should be pulled in early spring before it goes to seed. Refer to Appendix of Invasive Species for list of the most common invasive species in

northeastern Wisconsin. Removed plants should be placed in a bag and disposed of in the trash, not included in a compost pile to avoid spreading the invasive plant further.

5.7 Mowing

DESCRIPTION

This section describes the procedure for mowing vegetation in GSI strategies. This task should be performed once during the year, in spring or fall, in areas planted with native species, to reduce weed growth and to prevent the release of excess nutrients from decaying plants in fall. Bioswales planted with low-growing, manicured grasses should be mowed more frequently, depending on rainfall and plant growth.

EQUIPMENT & MATERIALS

- Flail Mower
- Lawn Mower
- Weed Wacker
- Oil/Gas
- Rake
- Wheelbarrow
- Tarp
- Personal Protective Equipment (PPE): safety glasses

INSTRUCTIONS

- 1) Walk site to observe and remove any debris or unsafe materials that may be in the work zone.
- 2) Mow grasses to approximately 3-4 inches in height.
- 3) Mow native flowering plants to 6-8 inches in height.
- 4) Rake/remove cuttings and dispose of properly. Grass clipping should not be allowed to accumulate on the street, near the storm inlet, or in the GSI strategies (as not to clog the area for infiltration).

SPECIAL CONSIDERATIONS

- Once established, native plantings should be burned. If burning is not possible, mowing may occur once per season in late spring or early fall and the cuttings removed and disposed of. Note burn permits or approvals from the local fire department may be required
- Take precautions to stay away from ground-nesting birds, wildlife, and nesting areas. You can find more information on nesting birds and their nesting times on the Wisconsin Department of Natural Resources Website:
<https://dnr.wi.gov/files/PDF/pubs/ER/ER0633.pdf>

5.8 Invasive Species Control

DESCRIPTION

This section describes the procedure for controlling invasive species in GSI strategies. This task should be performed when invasive species are observed in the GSI strategy, before they can flower and set seed, and begin impacting the desired plant species and performance of the practice.

EQUIPMENT & MATERIALS

- Rake
- Shovel
- Trowel/Soil knife
- Clipper/Loppers
- Saw
- Wheelbarrow/Bucket/Bags
- Native seed/soil mix or mulch
- Personal Protection Equipment (PPE) & Proper Clothing: closed-toed shoes, long pants, long sleeve shirts, and gloves

INSTRUCTIONS

- 1) Identify invasive species.
- 2) Pull invasive plants to remove the entire plant and as much of the root system as possible. Note: Placing a foot next to the base of the plants that is going to be pulled will help keep the soil in place as the roots slide out of the ground.
- 3) Do not impact remaining plant growth.
- 4) Cover exposed earth with native seed/soil mix or mulch.
- 5) Clean equipment when done working on a site with invasive species to prevent the spread of invasives to other sites.

SPECIAL CONSIDERATIONS

- Invasive plants that should be pulled before they go to seed. Refer to Appendix of Invasive Species (WDNR Invasives Species recommendations).
- Garlic mustard (*Alliaria petiolata*) should be placed in a bag and disposed of in the trash, not included in a compost pile to avoid spreading the invasive plant further.
- Hand pulling of plants is easiest when the soil is moist, immediately after a rain.
- The use of chemical herbicides or algacides in waters of the state, including GSI strategies, is regulated by the Wisconsin Department of Natural Resources- Aquatic Plant Management Program under NR 107, Wisconsin Administrative Code. Contact the WDNR

to apply for applicable permits prior to using herbicides and/or algaecides in pre-treatment forebays or in constructed wetlands. In addition to contacting the WDNR, consider “hand-wicking” the weeding rather than spray application to reduce the amount of herbicide needed and to be more deliberate in the application.

- Certain plants may cause skin irritation, such as poison ivy (*Toxicodendron radicans*), poison sumac (*Toxicodendron vernix*), poison oak (*Toxicodendron deversilobum*), stinging nettle (*Urtica dioica*), wild parsnip (*Pastinaca sativa*) and more. In addition, some plants have thorns or can prick skin when in contact with the plant, such as raspberries (*Rubus*, sp.), thistle (*Cirsium arvense*), and more. Be sure to wear gloves, long pants, closed-toed shoes, and long sleeve shirts when working with invasive plants or weeds.

5.9 Mulch Amendment & Replacement

DESCRIPTION

This section describes the procedure for a mulch amendment or replacement. This task should be performed when visible mulch is observed to have bare spots, if the depth of mulch is less than 2 inches, or if mulch appears to be compacted or disarrayed. When plants are established and lush, no additional mulch amendment is necessary, and can be counter-productive in disturbing soil beds, filling in storage capacity and adding more “floatable” matter to cause outlet blockages.

EQUIPMENT & MATERIALS

- Mulch: decomposed leaf mulch or shredded hardwood bark mulch
- Rake
- Shovel
- Wheelbarrow
- Tarp
- Personal Protective Equipment (PPE): gloves and eye protection

INSTRUCTIONS

- 1) Rake decomposed leaf mulch in areas with herbaceous plants and rake shredded hardwood bark mulch in areas with woody plantings to maintain a loose top layer. Rake away from vegetation, trees, or shrubs. If replacing, use rake and shovel to remove, making sure not to disturb vegetation.
- 2) Apply mulch as needed to maintain a three (3) inch layer. Do not apply mulch against the trunks of trees and shrubs in a volcano-like mound as this will damage the plants.

SPECIAL CONSIDERATIONS

- Consult with facilities manager prior to amendments or replacements. GSI strategy may have specialty mulch such as a fungi-enhanced mulch.
- When applying mulch, mulch dust may irritate eyes, nose, and lungs if exposed for extended periods of time.

5.10 Organic Debris Removal

DESCRIPTION

This section describes the procedure for removing accumulations of excess organic debris from GSI strategy. This task should be performed routinely in mid to late spring after snowmelt, or when accumulations of decaying material have been observed.

EQUIPMENT & MATERIALS

- Rake
- Shovel
- Clippers/Loppers
- Broom
- Wheelbarrow
- Tarp/Bags
- Personal Protective Equipment (PPE): gloves and eye protection

INSTRUCTIONS

- 1) Identify decaying organic material to be removed and note any damaged or dead plants nearby that should be replaced.
- 2) Rake or shovel decaying material and place in wheelbarrow or on tarps, in bags. Decaying material that does not consist of invasive plants can be disposed of in compost piles.
- 3) Inspect areas where decaying material accumulated for evidence that the regular plant growth needs to be replaced/re-seeded.
- 4) Replace/re-seed plants as necessary.

SPECIAL CONSIDERATIONS

- Consult with facilities manager to review planting plan to confirm recommended replacement plantings.
- Weeds or invasive plants should not be added to compost piles to avoid spreading the plant further.
- Note the type of excess debris may dictate when it should be removed. For example, drifted piles of leaves from large shade trees are best removed in November.
- In naturalized landscapes where biomass is particularly dense, burning should be considered. Note burn permits or approvals from the local fire department may be required.

5.11 Pipe Jetting

DESCRIPTION

This section describes the procedure for pipe jetting. Pipe jetting should be performed when 30% or more of the cross-sectional area of a pipe is blocked or when specified by the owner or operator.

EQUIPMENT & MATERIALS

- Crowbar
- Measuring Wheel
- Hand Tools
- Manhole Hooks
- Closed-Circuit Television (CCTV) Equipment
- Push Broom
- Jetter Hoses, Fittings, Clamps, Nozzles
- High Pressure Pumping System
- Shovel or Spade
- Ladder
- Flashlight
- Personal Protective Equipment (PPE)

INSTRUCTIONS

- 1) Sweep the area surrounding the structure.
- 2) Remove any trash, sediment, or debris that is restricting access or flow control.
- 3) Remove pre-treatment device if not permanently attached to the structure and clean if necessary.
- 4) Position jet system so that reel is adjacent to the selected access structure and utilize a inlet, manhole, or control structure as the primary maintenance access point.
- 5) Insert jetter hose into pipe through the flexible hose guard.
- 6) Insert hose guard into the pipe to guide the jetter hose and prevent wear from friction.
- 7) Ensure a vacuum tube is present within the structure to vacuum jetted waste material (see vacuum section).
- 8) Start high-pressure pump after ensuring the nozzle is fully secured. Jet-rod the conveyance pipe structure and perform as many passes as needed to clean the structure.
- 9) Pipe jetting is complete once the jetted water is clear.
- 10) Complete a post-maintenance inspection of pipes with CCTV camera.

SPECIAL CONSIDERATIONS

- Vacuuming should not be performed within 48 hours of a significant rainstorm (>1-inch) rainstorm.
- Confirm that the jetter equipment waste storage tank is free from debris from another project.
- When using hydraulically propelled cleaning tools, all access structures that are not used as entry points must be closed and secured.
- When using hydraulically propelled cleaning tools, take precaution to ensure that the water pressure does not damage or cause flooding to nearby property.

5.12 Plowing

DESCRIPTION

This section describes the procedure for snow plowing. Plowing should be performed to remove snow after and/or during every snowstorm. Special plow blades may be used to prevent scarring but are not necessary. Raised blades are not recommended.

EQUIPMENT & MATERIALS

- Shovel
- Gloves
- Snowplow
- Deicer (See Deicing Section)
- Personal Protective Equipment (PPE)

INSTRUCTIONS

- 1) Use snowplow or shovel to remove snow from permeable/pervious/porous pavement surface.
- 2) Apply deicing treatments during and after storms as necessary to control compact snow and ice not removed by the plow.

SPECIAL CONSIDERATIONS

- See manufacturer recommendations for special plow blades.

5.13 Pruning (Structural)

DESCRIPTION

This section describes the procedure for maintenance pruning, including woody plants, small trees, and shrubs. Maintenance pruning should be completed as necessary to remove damaged, diseased, or dead branches. Vegetation adjacent to walkways or street intersections should be maintained to keep safe lines of sight for pedestrians and vehicles.

EQUIPMENT & MATERIALS

- Chain Saw
- Hand Saw, Pruning Pole Saws, Pole Clips
- Pruning Shears and Loppers
- Push Broom
- Chipper trailer
- Lift with a dump box or Wheelbarrow
- Rake
- Personal Protective Equipment (PPE)

INSTRUCTIONS

- 1) Using clean and sterilized pruning tools, make clean and even cuts using proper tools for the size of each branch.
- 2) Remove low limbs as needed to maintain safe overhead and line of sight clearances for pedestrians and vehicles.
- 3) Remove all dead, damaged, diseased, or dying branches back to the nearest branching point taking care to avoid damage to the branch collar.
- 4) Carefully cut as close to the branch collar without cutting the branch collar itself. Preserve the branch collar for proper healing.
- 5) Cut branches into pieces that can easily be carried and remove any material to be disposed of at an approved off-site location.

SPECIAL CONSIDERATIONS

- Pruning efforts should be made to protect clear sight lines. Ensure that branches and limbs are not impeding street traffic, pedestrian traffic, or structures. Ideal clearances may not be practical in all cases, particularly for young trees.
- Owner or operator shall make arrangements with the utility company for the removal of any limbs or branches in conflict with electrical distribution lines. Tree pruning near electrical wires shall only be conducted by a qualified line clearance arborist. Electrical Utilities warn to keep 10 feet from all primary/distribution power lines.

- Avoid pruning the following during the growing season to reduce the likelihood of injury due to fungus and parasites: oaks (prune in winter or early spring), elms (prune in early spring), and fruit trees (prune in winter).

5.14 Sanitizing

DESCRIPTION

This section describes the procedure for sanitizing. Sanitizing should be completed for cisterns, tanks or rain barrels if trash, sediment, or organic debris is present within the rainwater harvesting system, the system has just been installed, or a bacterial test result is positive.

EQUIPMENT & MATERIALS

- Screwdrivers
- Wrenches
- Pliers
- Mallet
- Crowbar
- Unscented liquid household bleach
- Pressure washer
- Manhole hooks
- Metal/Plastic Brush
- Detergent
- Personal Protective Equipment (PPE): safety glasses and gloves

INSTRUCTIONS

- 1) Drain: Empty any water using approved vacuum cleaning and waste disposal protocols.
- 2) Clean:
 - a. Clean and scrub all internal surfaces using a brush or high-pressure washer and a mixture of detergent and water.
 - b. Wash all internal surfaces using a pressure washer or fill the tank with water and let stand for a few hours. Drain all water using approved waste disposal protocols.
- 3) Sanitize:
 - a. Fill 25% of the tank with clean water.
 - b. Add 3 cups of 5%-8.25% unscented liquid household bleach for every 100 gallons of water (a chlorine concentration of about 100 ppm or mg/L).
 - c. Mix the solution in the tank and fill to full capacity with clean water.
 - d. Let the solution stand for 24 hours with all covers and valves closed.
 - e. Empty the tank using approved waste disposal protocols.
- 4) Check the tank for residual chlorine concentration.
 - a. Refill the tank with clean water and let stand for 30 minutes.
 - b. Test the chlorine levels. The tank is safe for use if the chlorine concentration is 0.5 mg/L or less.

- c. If the concentration is higher, empty the tank using approved waste disposal protocols and repeat the above steps until the concentration is 0.5 mg/L or less.
- 5) Sanitize any associated piping or hoses using the same procedures as described above.

SPECIAL CONSIDERATIONS

- If the tank is required for use urgently, the bleach concentration can be doubled, and the standing time can be reduced from 24 hours to 8 hours.
- Contaminated water must be disposed of using approved waste disposal protocols.

5.15 Sediment Removal

DESCRIPTION

Removing sediment from GSI strategies and structures is crucial to their function. Sediment can damage vegetation by burying stems and coating leaves. Excess sediment also clogs soil beds and surfaces, leading to reduced infiltration and reduced storage capacity. This section describes procedures for removing sediment from the surfaces, inflow, and outflow points of GSI strategies, and from pre-treatment devices.

EQUIPMENT & MATERIALS

- Broom
- Digging fork
- Scoop shovel
- Flathead shovel
- Leaf blower
- Brush
- 5-gallon bucket
- Tarp
- Trash bags
- Personal Protective Equipment (PPE): safety vest, safety glasses, and gloves

INSTRUCTIONS

For All Areas:

- 1) Use a tarp to contain and collect sediment for bagging and removal.
- 2) Take care to note areas of erosion, clogging, and soil compaction when performing these tasks.

For GSI Strategy Surface Areas:

- 1) Observe the surface area for areas of sediment accumulation and flows.
- 2) Using a small rake, shovel or trowel, separate accumulated sediment from soil or soil media by gently scraping the top surface of the practice to a depth of 1 to 3 inches, depending upon the depth of the accumulated sediment. Sediment may be mixed in with mulch, which should be removed and replaced as necessary. Take care not to damage plants or remove filter media unless the media is compacted or clogged (see Surface Media Renovation).
- 3) Using a flat head shovel, carefully remove the excess sediment from the practice and place in a container for disposal.
- 4) Note any underlying areas with soil compaction, erosion, or flow paths; see procedures for "Soil Amendment".

- 5) Any bare areas within a vegetated practice must be immediately repaired or stabilized; see procedures for “Soil Amendment,” “Mulch Amendment,” and “Surface Media Renovation.”

For Inflow and Outflow Areas:

- 1) Sweep and dispose of accumulated sediment in the area extending 4 to 5 feet on either side of curb cut openings, gutter lines, and areas up-gradient (uphill) of inflow areas.
- 2) For trench drains, use a leaf blower to blow out accumulated sediment. In some cases, grates or covers may need to be removed to fully access the inflow area.

For Pre-Treatment Devices such as forebays, filter strips, or inlet filters:

- 1) Evaluate the extent of sedimentation. Where any clogging has occurred, use a scrub brush or pressure washer to remove fine sediment from filters or pores, taking care not to tear or damage the material.
- 2) If tears of 3 inches or more are found in any filter fabric inlet devices, the device must be replaced; note to a field supervisor the location of any that need replacement.

SPECIAL CONSIDERATIONS

- While sediment tends to be heavier after winter snow melts, sediment removal should be done year-round.
- Some practices in areas with more sediment-generating land uses, or erodible soils, may require more frequent sediment removal. In these cases, field supervisors should note where pre-treatment or non-structural controls such as more frequent sweeping may be beneficial.
- Early spring is particularly important for sediment removal in order to remove any de-icing salts that may have accumulated over winter months.
- Removal of sediment from subsurface structures such as inlets, pipes and culverts are described in the “Pipe Jetting” and “Vacuum Cleaning” sections.
- If there is a significant volume of sediment, or it accumulates in permanently wet or hard-to-access locations, mechanized equipment such as a mini-excavator or portable vacuum excavator may be used at the discretion of the forewoman or field supervisor to provide more efficient and safe removal.

5.16 Seeding

DESCRIPTION

This section describes the procedure to re-seed areas of GSI strategies that have eroded, where vegetation has not survived, or where repairs have been completed. This task should be performed as needed in conjunction with other tasks to ensure vegetation cover and root systems will provide slope stability and promote infiltration allowing the practice to function as designed. Seeding to establish permanent plants should only be completed when ground temperatures are above 53 degrees Fahrenheit, during spring and early fall (typically mid-April through mid-September) to avoid hot temperatures and direct sunlight during summer when seed and sprouting vegetation tend to burn out. Temporary seeding can be done during fall, before the first frost, to establish a temporary growth of vegetation. This is typically done with quick growing plants to minimize erosion and soil loss over winter and in early spring.

EQUIPMENT & MATERIALS

- Seed
- Soil
- Mulch
- Rake
- Spreader / Seeder
- Trash bag (for removing invasives)
- Personal Protective Equipment (PPE)

INSTRUCTIONS

- 1) Remove weeds and other debris that will prevent seeds from getting established.
- 2) The use of herbicides to prepare the soil should follow safety protocols and manufacturers' directions.
- 3) Rake area to be seeded to establish a loose top layer. Fill and repair any gullies, low or eroded areas.
- 4) Spread seed uniformly in two directions. If mechanical seed driller or silt seeder is used in place of spreader or seeder, then omit Step 4.
- 5) Cover seeded area with no more than ¼-inch of soil.
- 6) Water seeded area.
- 7) Mulch seeded area to prevent area from drying out and to protect seed and sprouts from burning out in direct sunlight.
- 8) Repeat watering daily (if it does not rain) to establish vegetation.

SPECIAL CONSIDERATIONS

- Heavy rains that occur before seed gets established may require additional seeding if rains wash the seed away.

- Dormant seed can be planted after November 1st.

5.17 Settling Repair

DESCRIPTION

This section describes the procedure for repairing areas of a GSI strategy that have settled. This task should be performed when areas are observed to be lower than the surrounding areas or lower than the elevations as designed.

EQUIPMENT & MATERIALS

- Rake
- Shovel
- Wheelbarrow
- Tarp
- Soil or stone
- Personal Protective Equipment (PPE)

INSTRUCTIONS

- 1) Identify area that has settled which needs repair.
 - a. If area is very large, or if the settling is greater than 2 feet, contact project manager/ review original designs, planting plans, etc.
- 2) Scrape/remove rock and stone from settled areas. If planted, remove plants carefully, taking care not to harm the plant or the root systems.
- 3) Fill area with stone or soil as directed by the project manager. Restore surface as directed.

SPECIAL CONSIDERATIONS

- If site is too deep (> 2 feet) or too large, contact project manager or site engineer to determine if the repair will maintain the performance of the GSI strategy as designed.

5.18 Soil Amendment

DESCRIPTION

Soil Amendment is the process of improving disturbed soils and soils with a low organic content by restoring soil porosity and adding a soil amendment, such as compost, for the purpose of re-establishing the soil's long-term capacity for infiltration, pollutant removal, and supporting healthy plant growth. Soil amendment media usually consists of compost but can also include the use of mulch, manures, sand, and manufactured microbial solutions.

The maintenance steps in this section must be adapted to site and soil conditions. In some cases, soil may simply be aerated to alleviate compaction. In other cases, soils may need to be excavated and a portion replaced with one of several types of soil amendment materials. In all cases, care must be taken to ensure that proper re-vegetation and erosion control are practiced for all disturbed areas.

EQUIPMENT & MATERIALS

Soil Amendment may be done mechanically or by hand. The following tools are required for amending soil by hand:

- Engineered soil, where specified for bio-swales
- Other soil amendment material as specified
- Topsoil (for back-fill where aeration/de-compaction is required)
- Shovel
- Hand rake
- Tamper
- Water tank and hose
- Bucket
- Trash bags
- Spading fork
- Pitchfork
- Wheelbarrow
- Personal Protective Equipment (PPE): safety glasses, safety vest, and gloves

INSTRUCTIONS

- 1) Where necessary, carefully remove any accumulated sediment or soil and transfer to disposal containers.
- 2) Observe the underlying surface area and conditions to note areas of erosion, flow paths, and soil compaction/ hardening.

- 3) In areas of soil compaction/hardening, check for the depth of compaction with a spading fork. Excavate to compacted depth with a shovel. Till/aerate the surrounding edges of the excavated area. Following specifications for the GSI strategy, backfill with engineered soil, or a combination of topsoil and amended soil at a ratio of 2:1.
- 4) In areas of evident flow paths, gently rake the surface soils to loosen to a depth of roughly 1-inch. Apply engineered soil or amended topsoil.
- 5) In areas of erosion, replace lost soil with engineered soil or amended topsoil.
- 6) Rake and shovel soil to conform to the slope specified by the design. Gently tamp into place – do not compact the soils.
- 7) Replant and water any vegetation disturbed by the soil amendment.
- 8) Clean up any excess soil that may have been blown or transported into surrounding non-vegetated areas.

SPECIAL CONSIDERATIONS

- Carefully observe sediment deposits, erosion areas, or compacted soil, and alert a field supervisor if necessary. Sedimentation and soil compaction can seriously affect a practice's function.
- Soil amendment is highly site-specific and will depend both on design and on the nature of the land uses in the area. Soil tests should be conducted during construction and periodically to predict both the type of soil amendment needed, and the frequency with which amendments may be required.
- Typically, where compost is used, compost should be added at a volume of 2 parts soil to 1-part compost (2:1). If a proprietary product is used, the manufacturer's instructions should be followed in terms of mixing and application rate.
- Soil compaction (i.e. hardening) can be treated by tilling and other physical loosening of the soil. Compaction must be addressed prior to adding a soil amendment.

5.19 Structural Clearing & Maintenance

DESCRIPTION

This section describes the procedure for clearing and maintaining inlets and catch basin structures. This includes sediment, trash, and debris removal.

EQUIPMENT & MATERIALS

- Shovel
- Rake
- Vacuum or Vacuum Truck
- Tarp
- Manhole Pick or Crowbar
- Sledgehammer
- Personal Protective Equipment (PPE): gloves

INSTRUCTIONS

- 1) Carefully use hands, or proper tools to remove the inlet, catch basin, or manhole cover. If a manhole cover is difficult to remove, use sledgehammer and crowbar to loosen cover from structure.
- 2) If structure is more than 2-inches full of sediment, and access allows, use shovel to remove sediment and debris.
- 3) If site allows for onsite disposal of organic debris, spread organic debris and sediment onsite. If not, or if sediment and debris contain non-organic materials, dispose at approved facility or location.
- 4) If sediment has caused pipes to clog, or access or depth of material does not allow, use vacuum truck to clear completely.

SPECIAL CONSIDERATIONS

- Removal of debris from inlets may require confined space entry.

5.20 Surface Media Renovation

DESCRIPTION

This section describes the procedure for renovating surface media. This task is different from mulch amendment/replacement as it applies to GSI strategies where conventional mulch is not used. This task should be performed when the surface layer of a practice is visibly compacted, or where mulch and soil have been removed due to sediment accumulation (see “Sediment Removal” and “Soil Amendment”). Surface media renovation must be done with the proper mix of engineered soil, topsoil, and/or soil amendment specified for the practice and requires coordination with the field supervisor or designer.

EQUIPMENT & MATERIALS

- Soil Amendment, engineered soil and/or topsoil as specified
- Mulch (if specified)
- Digging Fork
- Rake
- Shovel
- Tamper Bucket
- Trash Bags
- Personal Protective Equipment (PPE): safety vest, safety glasses, and gloves

INSTRUCTIONS

- 1) Observe the surface area to note any areas of compaction, erosion, or flow paths.
- 2) Where surface media is highly compacted or coated with sediment, gently rake the material and remove with a shovel into a container for disposal.
- 3) Gently rake the exposed surface to loosen the soil to a depth of approximately 1 to 3 inches, taking care to rake away from vegetation, trees, or shrubs.
- 4) Apply approximately 2 to 3 inches of engineered soil, amended soil or topsoil, as directed. Use the rake to mix gently into the loosened soil.
- 5) Contour the soil material to the specified grade of the practice’s surface area. Tamp gently, but do not compact the soil.
- 6) Where mulch is to be used, apply mulch as needed to maintain a three (3) inch layer.

SPECIAL CONSIDERATIONS

- Ensure that mulch and all accumulated debris and sediment are removed before starting this task.
- Consult with the field supervisor or facilities manager before proceeding to ensure the correct surface amendment material is used.

5.21 Trash Removal

DESCRIPTION

This section describes the procedure for trash removal. This task should be performed when trash is present in or around the GSI strategy. Trash should be removed all year round, and as necessary. Certain locations, especially those with heavy pedestrian traffic, may require more frequent trash removal.

EQUIPMENT & MATERIALS

- Trash Bags or Disposal Bin
- Trash picker
- Gloves
- Rake
- Personal Protective Equipment (PPE): gloves

INSTRUCTIONS

- 1) Use hands, rake, or trash picker to collect and remove trash from strategy or surrounding site.
- 2) Dispose of trash at an approved disposal facility or location.

5.22 Watering

DESCRIPTION

Proper and timely watering are essential to the establishment, function, and longevity of all vegetated practices. This section provides guidance on the timing and approaches for maintenance-related watering.

EQUIPMENT & MATERIALS

For municipal staff or contractors utilizing public hydrants:

- Hydrant key/wrench
- Backflow preventer

For truck/trailer mounted water tanks:

- Watering tank(s)
- Truck/trailer
- Water pump
- $\frac{3}{4}$ " hose

All cases:

- Rain gauge
- Watering wand/nozzles
- Gator bags
- Personal Protective Equipment (PPE): gloves, safety glasses, and safety vest

INSTRUCTIONS

If watering off a public hydrant:

- 1) Install hydrant backflow preventer.
- 2) Open hydrants permitted to be opened with appropriate hydrant key/wrench.
- 3) Attach hose and adapter to backflow preventer.

For watering from tanks mounted on trucks or trailers:

- 1) Attach hoses to appropriate gravity or mechanical pumps for water tank(s).

All cases:

- 1) Soak the top 6 to 8 inches of soil evenly by constantly spraying water across the surface, rather than concentrating spray in one place.
- 2) Water trees by placing and filling gator bags.
- 3) Remove gator bags at the end of the growing season and no later than October.

SPECIAL CONSIDERATIONS

- A simple rain gauge can be mounted near GSI strategies to monitor rainfall and more accurately predict when water will be necessary.
- Watering generally should be conducted from April through November.
- If possible, watering should occur at night or in the morning to minimize evaporation.

- Watering restrictions imposed due to drought must be observed; contact appropriate water agency to determine whether and when drought-related restrictions apply.
- Where not irrigated, watering of herbaceous plants should occur after 4 days without rainfall of 0.3-inch or greater, and herbaceous trees should be watered after 7 days without rain fall of 0.3-inch or greater.
- However, there are many times when judgment must be used to determine appropriate watering frequency. Maintenance staff must observe and consider weather forecasts, site conditions, and temperature to determine watering frequencies and needs. A log may be a useful tool to keep track of inches of water from watering and rain. Herbaceous plantings generally need 1-inch of water per week in cooler months and up to 2 inches of water per week during warmer months.
- Note that yellow leaves are also a common indicator of plants receiving too much water.

5.23 Woody Vegetation Removal

DESCRIPTION

This section describes the procedure to remove woody vegetation or saplings. This task should be performed annually to prevent unplanned small trees from growing in GSI strategies.

EQUIPMENT & MATERIALS

- Pruning shears
- Brush Cutter
- Rake
- Shovel
- Wheelbarrow
- Tarp/Bags/Bucket
- Soil
- Seed
- Personal Protective Equipment (PPE): safety glasses, safety vest, and gloves

INSTRUCTIONS

- 1) To hand pull woody vegetation:
 - a. Pull woody plants from the base to completely remove the plant and roots disturbing as little soil as possible. It can be helpful to place a foot next to a sapling when removing it to prevent pulling up the adjacent soil.
 - b. Use a hand shovel or spade to loosen the soil around larger plants to completely remove the root system.
- 2) To cut small woody vegetation:
 - a. Use pruning shears or a brush cutter to cut small trees, woody vegetation to a height of 4-6 inches.
 - b. Rake and collect removed plants for proper disposal.
- 3) Remaining holes from pulled plants should be filled with soil and re-seeded.

SPECIAL CONSIDERATIONS

- Consult with facilities manager prior to removing woody plants to ensure small trees were not previously placed to replace other vegetation.
- Pull plants when the soil is wet and loose (after a rainstorm) to reduce soil disturbance during removal. Disturbing the soil will bring weed seeds to the surface where they can germinate.
- Buckthorn (*Rhmanus* sp.) should be removed completely. If buckthorn will only be cut low, then it should be treated to prevent it from re-growing.

5.24 Vacuum Cleaning

DESCRIPTION

This section describes the procedure for vacuum cleaning permeable/pervious/porous pavement types. This task should be performed after the pavement is found to have standing water on the surface after a precipitation event.

EQUIPMENT & MATERIALS

- Vacuum Truck or Vacuum Attachment (wet and/or dry)
- Personal Protective Equipment (PPE)

INSTRUCTIONS

- 1) Safely block off area and surrounding area that needs to be cleaned.
- 2) Use vacuum truck or vacuum attachments to make slow passes over the pavement until the entire or target surface area has been cleaned.
- 3) Note, if vacuuming permeable interlocking concrete pavement systems with joint material, vacuuming will remove some joint aggregate material. Replenish removed joint aggregate material to “lip” over paver (see Gravel Joint Filling Section).
- 4) Clean machinery and dispose of collected trash, debris, etc. at approved disposal facility.

SPECIAL CONSIDERATIONS

- Refer to manufacturer specifications and recommendations for approved types of vacuum trucks or propriety vacuum attachments.

5.25 Vegetation Maintenance

DESCRIPTION

This section describes the procedures for annual herbaceous vegetation maintenance, trimming and transplanting. This task should be performed annually in spring and/or fall, depending on the plant species, to provide a healthy, appealing plant display and to thin aggressively growing plants.

EQUIPMENT & MATERIALS

- Rake
- Spade/Shovel
- Garden Knife
- String Trimmer
- Wheelbarrow
- Tarp/Bucket/Bags
- Personal Protective Equipment (PPE): gloves

INSTRUCTIONS

Vegetation Maintenance

- 1) Consult planting plan to determine varieties and location/extent of desired species in strategy.
- 2) Remove decayed material from previous season, including dried stalks, organic/leaf debris, and other loose/dislodged material.
- 3) Hand pull dried plant matter from previous season that is attached to existing plants without disturbing current plant growth.
- 4) Trim herbaceous plants to 4-6 inches in height with string trimmer in late spring and as needed to maintain safe sight lines in roadside facilities.
- 5) Rake removed/trimmed plant debris and place on tarp, in wheelbarrow/buckets/bags to dispose of properly off-site.

Transplanting

- 1) Consult planting plan to determine varieties and location/extent of desired species in strategy.
- 2) Use spade/shovel or garden knife to split or dig out plants to be thinned and/or transplanted through to the roots.
- 3) Dig a hole 1 ½ times the size of the root ball to be replanted. Cover root systems and base of plant with soil, so the top of the root ball/plant is even with the surrounding ground.
- 4) Fill remainder of hole with soil.
- 5) Water thoroughly to provide water to root systems.

- 6) Provide confirmation of transplanted species to facility manager for planting plan updates.

SPECIAL CONSIDERATIONS

- Note bare spots where last season's plant growth did not return and advise facility manager.
- Vegetation maintenance and transplanting should not be done in overly saturated soils.
- Remove all tags/labels/strings from new plants after planting.

6 Invasive Species

6.1 Invasive Species in Green Stormwater Infrastructure in Brown County and Northeast Wisconsin

Please see the Wisconsin Department of Natural Resources website for invasive species typically found in the City of Green Bay. <https://dnr.wisconsin.gov/topic/Invasives>

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MMSD RESOURCES		
RESOURCE	AVAILABLE FROM	WEB ADDRESS
PLANS		
Regional Green Infrastructure Plan	MMSD	https://www.mmsd.com/static/MMSDGIP_Final.pdf
GI Operations & Maintenance Implementation Framework, 2016	MMSD	https://www.freshcoastguardians.com/application/files/6115/0427/9939/GI_OM_2016_Final_Report.pdf
Milwaukee Green Streets Plan, 2013	City of Milwaukee	https://www.mmsd.com/application/files/7814/8779/8665/Green_Streets_Stormwater_Manag.pdf
Various Plans	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/our-plans
SIZING AND DESIGN OF GREEN INFRASTRUCTURE		
Green Infrastructure Desktop Sizing Tool	MMSD	http://www.freshcoastguardians.com/resources/sizing-your-project
Green Infrastructure Standard Specifications and Plan Templates, 2016	MMSD	https://www.mmsd.com/application/files/7514/8658/7515/MMSD_GI_Specs_and_Plan_Template_Report.FINAL.012717.pdf
Green Infrastructure Plant Selection Tool	MMSD	https://www.freshcoastguardians.com/resources/services/plant-selection
MAINTENANCE AND CARE OF GREEN INFRASTRUCTURE		
Fresh Coast Resource Center	MMSD	https://www.freshcoastguardians.com/contact
Operation & Maintenance Manual		
Green Infrastructure Care:	MMSD	
Rain Barrels	Fresh Coast Resource Center	https://www.freshcoastguardians.com/application/files/1915/5119/6195/13-056c2_DiverterRainBarrel02142019_Web.pdf
Rain Gardens	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/green-strategies/rain-gardens
Soil Amendments	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/green-strategies/soil-amendments
Native Landscape	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/green-strategies/native-landscaping
Stormwater Tree	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/green-strategies/stormwater-trees
Green Roofs	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/green-strategies/green-roofs
Porous Pavements	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/green-strategies/porous-pavement
Bioswales	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/green-strategies/bioswales
Wetlands	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/green-strategies/wetlands
VENDORS AND GREEN INFRASTRUCTURE TRAINING		
Green Vendor List	MMSD	https://www.freshcoastguardians.com/resources/vendors
Fresh Coast Resource Center Training Support	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/services/workforce-development-training
FUNDING PROGRAMS		
Fund for Lake Michigan	FFLM	https://fundforlakemichigan.org/apply-for-funding/
Wisconsin Coastal Management Program	Wisconsin Office for Coastal Management	https://doa.wi.gov/Pages/LocalGovtsGrants/CoastalGrants.aspx

8 Acknowledgements

CITY OF GREEN BAY

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City of Green Bay
**City-Wide Green
Stormwater
Infrastructure (GSI)
Plan**



AQUALIS
Formerly Stormwater Solutions Engineering

Prepared October 2023 by:
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247 Freshwater Way, Suite 410
Milwaukee, WI 53204



1.0 EXECUTIVE SUMMARY

October 14, 2023

Ms. Melissa Schmitz, Resiliency Coordinator
City of Green Bay Department of Public Works
100 N. Jefferson Street
Green Bay, WI 54301

Dear Ms. Schmitz:

The City of Green Bay, like many cities along the Lake Michigan coast is highly urbanized with dense development and large expanses of impervious surface such as pavements, roofs, and parking lots. As such there are flood-prone and stormwater ponding areas and water quality challenges facing the City and its residents. Green Stormwater Infrastructure (GSI) is one strategy for mitigating the effects of urbanization on water quality by managing the stormwater where it falls on each property in each watershed. GSI attempts to mimic the natural environment by capturing, storing, treating, and slowly releasing stormwater runoff thereby improving water quality and reducing the peak load on the stormwater drainage system and receiving waters.

This plan identifies the priority areas within the city where GSI strategies would have the greatest positive impacts as well as an evaluation of the cost-effectiveness of implementing GSI strategies in those identified priority areas. The plan gives the City's decision makers a clear guide to achieving the goals of reduced flood risk and healthier surface waters and environment, while improving the quality of life for its residents in the most cost-effective manner possible.

This report serves to detail the final deliverables and recommendations for the City-Wide Green Stormwater Infrastructure (GSI) plan for the City of Green Bay.

The major components contained within this report include:

- Background, Goals and Objectives
- Summary of the Analysis and Identification of the Highest Priority Subbasin Locations
- Identification and Prioritization of 30 Public and 20 Private GSI Projects Within the Priority Subbasins and the water quality and quantity modeling used to ID the projects
- Output Summary of Triple Bottom Line (TBL) Analysis of Proposed GSI Projects
- Summary of GSI Location Maps and GIS Tracking Tool
- Evaluation Process Tool for the Feasibility of GSI Projects Within the Public Right of Way
- Design Guidance for GSI Projects
- Maintenance & Operations Guidance for Identified GSI Projects

Please do not hesitate to reach out to us at 414.810.1245 if you have any questions regarding this report.



Sincerely,

AQUALIS Engineering Services Division

A handwritten signature in black ink, reading "Carrie Bristol-Groll". The signature is written in a cursive, flowing style.

Carrie Bristol-Groll, PE, ENV SP
Executive VP, Engineering Services

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ATTACHMENTS

Attachment A: GSI Maps

Attachment B: Kick-off Meeting Polls and Materials

Attachment C: 30 Public GSI Projects

Attachment D: 20 Private GSI Projects

Attachment E: Right-of-Way Project GSI Evaluation Tool

Attachment F: GSI Detail Drawings

Attachment G: GSI Standard Specifications

Attachment H: Green Stormwater Infrastructure (GSI) Operations and Maintenance Plan

A drainage subbasin map is included in Attachment A.

2.4 Goals and Objectives of the Plan

The City of Green Bay, like many cities along the Lake Michigan coast is highly urbanized with dense development and large expanses of impervious surface such as pavements, roofs, and parking lots. As such there are flood-prone and stormwater ponding areas and water quality challenges facing the City and its residents. Green Stormwater Infrastructure (GSI) is one strategy for mitigating the effects of urbanization on water quality by managing the stormwater where it falls on each property in each watershed. GSI attempts to mimic the natural environment by capturing, storing, treating, and slowly releasing stormwater runoff thereby improving water quality and reducing the peak load on the stormwater drainage system and receiving waters.

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2.5 Types of Green Stormwater Infrastructure

The following is a brief description of each of the potential GSI strategies available to be implemented in the urban environment. These strategies vary in cost, effectiveness, appropriate locations, and maintenance considerations. Choosing the appropriate strategy to achieve the desired outcome is key to the success of the project.

2.5.1 Bioswales/Bioretention

Landscape features with engineered soil and native vegetation that capture, treat and infiltrate runoff. Bioswales typically include an underdrain that is connected to the municipal storm sewer system.

2.5.2 Blue Roofs

Roofs that are designed to temporarily store water with either passive or active control devices.

2.5.3 Green Roofs

Partially or completely planted roofs with vegetation growing in soil or other growing media to hold rainwater.

2.5.4 Greenways

Riparian and non-riparian buffer zones and strips that store and drain stormwater runoff into the ground naturally.

2.5.5 Native Landscaping

Native plants that can tolerate drought and flooding cycles because of deep roots and climate-specific adaptations.

2.5.6 Porous Pavement

Pavement that can reduce and infiltrate surface runoff through its permeable surface into a stone or filter media below.

2.5.7 Rain Gardens

Gardens that are watered by pooled stormwater runoff, slowly infiltrating it into the ground along deeply rooted vegetation.

2.5.8 Rainwater Catchment / Cisterns / Rainwater Planters

The capture and storage of water, potentially for reuse later. StormGUARDen™ is one rainwater planter that is mentioned due to the extra gallons capacity and patented filtering technology.

2.5.9 Removal of Pavement & Structures

Removal of structures or paving for the purpose of allowing infiltration.

2.5.10 Soil Amendments

Organic materials mixed into soil or spread on existing lawn to enhance its ability to infiltrate or absorb water.

2.5.11 Stormwater Trees

Trees that hold rainwater on their leaves/branches, infiltrate it into the ground, absorb it through root systems and release it into the atmosphere (also known as evapotranspiration).

2.5.12 Constructed Stormwater Wetlands

Similar to stormwater detention ponds in that they hold a large volume of water, but are designed with shallow open-water surfaces, native vegetation and deep organic soils that are inundated or saturated for part of the year or the entire year.

3.0 CITY OF GREEN BAY WATERSHED SUBBASIN ANALYSIS

3.1 Analysis Methodology and Results

Following the initial kickoff meeting held on December 8, 2022, two informal polls were distributed to the attendees to select the criteria to be used in evaluating the need and placement of future GSI strategies. The results of those polls may be found in Attachment B. The first poll asked respondents when considering the *need* for GSI to rank a list of criteria from most important to least important. The result of this poll indicates the top 5 criteria to be:

1. Flood prone/historic ponding areas
2. High pollutant loading areas/need to meet WDNR Stormwater Permit requirements
3. To reduce costs of storm sewer system upgrades
4. Areas of known stormwater inflow to sanitary sewers, leading to basement backups (tied for 4th)
5. Poor water quality in rivers, streams, and Bay (tied for 4th)

The list of stakeholder-selected criteria above was used as the basis in assigning an impact score to each subbasin. A Geographic Information System (GIS) exercise was performed using data collected from the City, and developed by the Team for determining project locations. A number of GIS maps were created to highlight several factors within each subbasin as described:

Maps 1 – Impaired Water Quality per Subbasin

Water quality modeling results from WinSLAMM software was developed previous to this project for the City's WDNR Municipal Separate Storm Sewer System (MS4) Permit. The WinSLAMM model provides output of average annual Total Suspended Solids (TSS) and Total Phosphorus (TP) in pounds per storm sewer outfall. This information was uploaded into GIS, per subbasin, to develop heatmaps of water quality per subbasin (Attachment A, Map 1 – Impaired Water Quality). Four (4) versions of Map 1 are provided, with emphasis on (1) Total Phosphorus, (2) Total Suspended Solids, and (3,4) highlighting neighborhoods within Maps (1) and (2) for the purpose of implementing the City's Residential [GSI Revolving Loan Fund](https://greenbaywi.gov/1422/Residential-Green-Stormwater-Infrastruct) (<https://greenbaywi.gov/1422/Residential-Green-Stormwater-Infrastruct>). Also provided within the maps are the watershed delineations for the Apple Creek, Ashwaubenon Creek, Duck Creek, East River, East Shore of Green Bay, and Lower Fox River Main Channel, and cross-hatching for those that are listed on EPA's 303(d) list for Impaired Waters.

Maps 2 – Flooding Drainage Risk

Known flood points data was provided by the City. The causes of flooding were often not made clear through simple analysis of drainage by GIS. The types of flooding in commonly flooded locations was not identified through the data received. Various causes of flooding or ponding are common in cities. Flooding could be assumed to be overbank/river flooding, localized intersection/low point ponding, storm sewer capacity or maintenance related conveyance ponding, or surcharging from high water at the storm sewer outfall. As a result, and without performing hydraulic analysis of each stormwater conveyance system which was not within the scope of this project, the Team must rely upon their experience, use of local data and tools such as aerial imagery, topography, GIS sewer system maps, and the location of flooding in relation to nearby waterways, to identify if GSI would provide flooding relief in certain areas. The summation of these points of data were used as the basis for Maps 2. The maps show the points of flooding experienced. The more data points in a subbasin, the greater the color of heatmap in the subbasin. Map 2 is provided as a stand-alone map, and with neighborhoods highlighted for the purpose of neighborhood flood planning.

Map 3- Public Property Opportunities

The City's Capital Improvement Program (CIP) was provided to the Team and mapped as Map 3. Map 3 also incorporates the results from Maps 1 and 2, to show a heatmap of areas where highest priority subbasins coincide with the locations of CIP projects, providing near term impacts and best use of funding to implement GSI.

Map 4- Private Property Opportunities

As private properties within cities redevelop over time, existing stormwater management ordinances may require stormwater volume/peak flow control and water quality improvements also be made. In many cases, however, the ordinances are triggered by percent impervious surface or increase in volume or peak flow, and when a city lot is redeveloped, the percent impervious may not change. Adding green infrastructure ordinances have become more common, such as that added by the City of Milwaukee, WI, which requires GSI on projects of 5,000 sf or more new impervious surface within high priority areas in the City, and Philadelphia, PA which requires GSI on projects with 15,000 square feet or more of land disturbance. For the purpose of this project, the Team identified 20 locations where new or redevelopment is either known, planned, or potential based upon the age and condition of current structures. Map 4 details the commercial and industrial zoning, along with property values below the City's median value. Wherever possible, it is advantageous to add GSI to neighborhoods to improve property values.

Map 5 – Barriers and Opportunities for GSI

Where the previous maps show areas of need or opportunity, Map 5 provides insight on what would be considered barriers to GSI. This map includes GIS layers such as high groundwater table, high bedrock, areas of existing wetlands, and slopes exceeding 6% where GSI would be difficult to install. The area of sandy soils is actually an opportunity to encouraging greater infiltration, and is also highlighted on Map 5, in the interest of reducing the total number of maps.

Map 6 – Priority Basins for GSI

The final map, Map 6, summarizes all previous data sets to provide the priority subbasins for GSI. All proposed GSI projects developed through this project are also shown on Map 6, to be discussed later in this report.

3.1.1 Priority Subbasin Determination Methodology

Results from Maps 1 (water quality), Maps 2 (flood risk), and Map 3 (CIP projects) were compiled to determine the highest priority subbasins. With each of the three rank factors assigned to each subbasin, a GSI priority score was generated. The score was produced by the equation shown below:

$$\text{Priority Subbasin Score} = \frac{\text{water quality rank}}{5 \text{ (highest rank)}} + \frac{\# \text{ common flood points}}{3 \text{ (highest rank)}} + \frac{\# \text{ of CIP}}{8 \text{ (highest rank)}}$$

The highest possible priority score was 3. Subbasins chosen to be investigated further for placement of GSI received a score of approximately 0.71 or higher.

After being identified as a priority subbasin for GSI, each subbasin was investigated for possible placement locations of GSI. The overall goal was to identify 30 public and 20 private GSI projects, spread across priority subbasins. The subbasin may have more than one or only one GSI project, depending upon the suspected causes of pollution and flood related issues. Generally, subbasins that had decent water quality and problems with flooding were considered higher priority than subbasins with medium, poor water quality and no flooding. Upon investigation of the causes of stormwater related issues in each subbasin, an initial 42 project locations were identified.

After a high number of possible GSI projects were identified, project locations were checked against locations of the BRRTS website for Remediation and Redevelopment Continuing Obligations, provided by the Wisconsin Department of Natural Resources. This was done in order to remove any project concepts where contaminated soils or other significant barriers exist. Knowledge of these factors in each project location assisted the Team to determine the feasibility and type of GSI that could be used.

For a better understanding of how GSIs were specifically placed at locations, see Section 9: Feasibility Evaluation Process Tool. Many factors included in this section were used in combination with engineering knowledge and analysis to decide on the exact placement of GSIs inside subbasins. However, it should be clearly understood and noted that GSI project ideas and locations are only conceptual and should not be used as designs for implementing actual GSI. The suggested GSI projects should be used only as starting points for placement and design of the future GSI.

GSI project concepts were created project by project and summarized in information pages, producing a total of 30 public and 20 private project concepts. Many factors went into deciding project concepts and it was attempted to balance those factors based upon the stakeholders' desires and environmental and economic benefits. An effort was made to provide projects in a range of locations with a variety of GSI types.

4.0 SELECTED GSI PROJECT SUMMARIES

Many GSI Plans provide high level overviews on the need and general placement of GSI strategies, without actual project locations. The City requested this plan provide recommendations of catalytic projects to advance the potential for water quality and flood risk reduction from day one!

4.1 Public Projects

Using the list of Capital Improvement Projects from the City, in conjunction with the highest rated subbasins found in Maps 1 and 2, 30 public GSI project sites were selected. For each project area, criteria as provided Section 8. Feasibility Evaluation Process Tool in were used to evaluate the best GSI type selected. See Attachment C – Public GSI Project Summaries.

4.2 Private Projects

Using local redevelopment project information from staff and our Team, in conjunction with the highest rated subbasins found in Maps 1 and 2, 20 private GSI project sites were selected. For each project area, criteria as provided Section 8. Feasibility Evaluation Process Tool in were used to evaluate the best GSI type selected. See Attachment D – Private GSI Project Summaries.

5.0 TRIPLE BOTTOM LINE (TBL) ANALYSIS OF PROPOSED GSI PROJECTS

5.1 TBL Selected Criteria

In addition to proven effectiveness for stormwater management goals, GSI can yield many important co-benefits, including improving property values, beautifying neighborhoods, avoiding flood damages, improving air quality, reducing respiratory and heat-related illnesses, creating green jobs, and more. As communities continue to consider how to best integrate GSI into stormwater management planning efforts and/or expand existing GSI programs, stormwater practitioners have expressed a need for information to help them better quantify and monetize these benefits using a triple bottom line (TBL) approach.

The Water Resource Foundation (WRF) provides a GSI TBL Benefit Cost Framework and Tool, which provides stormwater practitioners with a systematic approach for quantifying and monetizing the financial, social, and environmental benefits of GSI at the community, watershed, or neighborhood scale. The Tool leads users through each step of TBL-based benefit cost analysis, from establishing a baseline, to applying appropriate economic valuation methods, and comparing benefits and costs over time.

The Tool aims to address current research gaps and information needs. Specifically, the Tool incorporates market and non-market economic valuation methods that allow users to understand and value a wide range of TBL benefits, including several harder-to-quantify benefits that have not been incorporated into existing tools or studies. The Tool also aims to strike an appropriate balance between providing enough information and data to allow practitioners to quantify relevant benefits, while requiring enough user input to ensure the process is transparent and community specific.

The Tool is intended for use by utility and municipal staff or other interested stormwater practitioners. The Tool does require some level of expertise and familiarity with GSI implementation and planning; however, users do not need to have an advanced knowledge of economics. The Tool was developed in coordination with The Water Research Foundation's (WRF) Community enabled Lifecycle Analysis of Stormwater Infrastructure Costs (CLASIC) project. The Tool leverages data and information from CLASIC to allow users to not only assess the benefits of alternative GSI scenarios, but to also compare them appropriately to costs. While users can bring inputs to the tool from CLASIC, the Tool is a stand-alone product.

Table 1 provides a breakdown of the model outputs from the Tool, for the City of Green Bay GSI Project as developed herein.

Table 1. Benefits, Annualized and Present Values of GSI for the City of Green Bay

Benefit	Annualized Value	Present Value
Avoided Infrastructure Costs	\$314,056	\$5,135,267
Avoided Replacement Costs	\$70,801	\$1,157,696
Energy Savings	\$9,219	\$150,751
Water Supply	\$35,301	\$577,216
Air Quality	\$3,859	\$63,100
Property Values	\$1,135,906	\$22,154,655
Heat Stress	\$28,386	\$464,148
Recreation	\$624,362	\$10,209,211
Green Jobs	\$25,405	\$415,403
Water Quality	\$3,860,744	\$63,128,705
Carbon	\$5,774	\$94,407
Ecosystem	\$8,025	\$131,227

5.2 TBL Matrix for GSI Strategies

GI Strategy	Economic					Social			Environmental			
	Initial Investment Cost	O&M Cost	Job Growth	Increase Property Values	Relief to Existing Infrastructure	Potential to Reduce Crime	Potential Access to Recreation/Education	Improves Community Connectedness	Improve Water Quality	Energy Savings	Reduces Urban Heat Island	Improves Air Quality
Bioswales	Medium	Medium	Medium	High	Medium	High	High	Medium	High	Medium	Medium	High
Green Roofs	High	Medium	High	Medium	Low	Medium	Low	Low	Low	High	Medium	Low
Greenways	Medium	Low	Medium	High	Low	High	High	High	Low	Low	Medium	Low
Native Landscaping	Low	Low	Low	High	Low	Medium	Medium	Low	Low	Low	Low	Medium
Permeable Pavement	Medium	Medium	Medium	Low	Low	Low	Medium	Low	Medium	Low	Low	Low
Rain Gardens	Low	Low	Low	High	Medium	High	High	Low	Medium	Low	Low	Medium
Catchments/Cisterns	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Removal of Paving & Structures	Medium	Low	Low	Low	Low	Low	Low	Low	Low	Low	Medium	Low
Soil Amendments	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Trees	Low	Medium	Low	High	Low	High	Low	Medium	Low	Medium	High	High
Constructed Wetlands	High	Medium	Medium	Medium	High	Medium	High	High	High	Low	Low	Medium
Stormwater Ponds	Medium	Medium	High	Medium	High	Medium	Low	Low	High	Low	Medium	Low

 High
 Medium
 Low
 None

6.0 WATER QUALITY AND QUANTITY MODELING OF PROPOSED GSI PROJECTS

6.1 Sizing Standards for Hydrologic Modeling

Historically, GSI has been sized for managing what is considered a “water quality storm”, or 0.5” – 1.0” of rainfall. The author’s perspective after having designed and managed installation of hundreds of GSI devices over the past 20 years, is that they can be designed to manage much more water to also provide a flood risk reduction, for incrementally less than also adding stand-alone flood risk devices. In some cases, project area constraints do not allow for taking full advantage of flood risk sizing. For instance,

high groundwater in many areas of the City of Green Bay is less than 3 ft below the ground surface. This restricted the ability to model GSI with deep stone storage.

Where possible, rain gardens were modeled with a 1.5-foot depth of engineered soil media and with plantings. At sites with infiltration constraints, rain gardens were modeled with a 1-foot-depth of engineered media and a weir. The designed ponding depth was 9 inches. Inclusion of an underdrain (of 6" diameter) was determined individually for each project. Bioswales were also modeled with a 1.5-foot depth of engineered soil media. At sites constrained by shallow groundwater, the bioswale models included 2 feet of stone storage and assumed no native soil infiltration. For sites where shallow groundwater was not a constraint, 3 feet of stone storage was modeled with an assumed native soil infiltration of 0.02 in/hr. All stone storage had an assumed porosity of 0.33. The bioswales were designed with a ponding depth of 1 foot with a depth of 1.5 feet. Underdrains were also included for all bioswale models. If shallow groundwater was present, the underdrain was modeled at the bottom of the storage layer with a liner. Otherwise, the underdrain was modeled at the top of the storage layer.

Permeable pavement was similarly modeled to bioswales, in terms of underground storage. Permeable pavement in areas with shallow groundwater was modeled with a 2-foot stone storage layer, with a liner and underdrain at the bottom of the storage layer. Otherwise, the storage layer was modeled as 3 feet deep with an underdrain at the top of the storage layer. The pavement was assumed to be 4 inches thick with a porosity of 0.25, and the bedding layer was 3 inches thick with a porosity of 0.30. Furthermore, porous pavement should not have an impervious run-on ratio of greater than 3:1.

Native landscaping and greenways were not modeled with storage layers below the vegetation. Native landscaping was modeled in HydroCAD as non-grazed meadow. This decreased the runoff curve number (CN) compared to land use of grass or pavement, and therefore decreased runoff in the model. Similarly, the greenway model included native landscaping as part of the concept, so the area was modeled in HydroCAD as non-grazed meadow. In WinSLAMM, the greenway was modeled as a filter strip. The grass retardance factor was B and the grass height was 36 inches.

Green roofs were modeled with similar layer properties to bioswales but with different depths per layer. The engineered media had an assumed porosity of 0.27 and the storage layer had an assumed porosity of 0.33. The depth of the engineered media was 6 inches, and the depth of the storage layer was 2 inches. The total depth of the green roof was modeled as 1 foot, with a weir at the top.

6.2 HydroCAD Model Results

Each GSI Project summary sheet provides total drainage area, proposed area of GSI device, and the gallons captured per device. See Attachments C and D for the GSI Project Summary Sheets.

6.3 WinSLAMM Model Results

WinSLAMM version X.X was used in modeling all proposed GSI devices. The total Suspended Solids (TSS) and Total Phosphorus (TP) was calculated based upon inputs for the local land use and GSI designs. The loadings in pounds of TSS and TP are shown in the GSI Project Summary Sheets. Please see Attachments C and D.

7.0 GEOGRAPHIC INFORMATION SYSTEM (GIS) MAPS AND TRACKING TOOL

7.1 Existing GIS System & Database

7.2 Proposed GIS Tracking Layer for Installed GSI

8.0 FEASIBILITY EVALUATION PROCESS TOOL

8.1 Critical Success Factors

The critical success of GSI is primarily reliant on being the most cost-effective GSI option that is physically reasonable and provides measurable benefits. Certain GSI may be impossible to place at certain types of locations. Among the GSI options for a location, the best choice is often the lowest cost option that provides comparable benefits to the other available options.

GSI can be placed at buildings, at pavement, in green spaces, and in the Right-of-Way (ROW). The success of each type of GSI changes dependent upon the type of location it is placed in.

For buildings, the type of roof and building usage are key in deciding GSI feasibility. A flat or shallow roof has the possibility of placing a green roof, blue roof, or rainwater catchment. For steeply pitched roofs, it is only feasible to place rainwater catchments or a rain garden near the roof. In the case of outbuildings, the most beneficial BMP option may be to remove the structure entirely. Otherwise, a necessary outbuilding with external drainage may implement a rainwater catchment or rain garden nearby.

For pavement areas, land use can be divided into unused/underused pavement, parking, paths, entrance areas, and playgrounds. Pavement that is not used does not need to remain paved and can be turned into GSI that utilizes infiltration. If there is a need for stormwater storage, that area may become porous pavement or a bioswale. The success of GSI in parking lots becomes more complicated due to the regulations and functional design associated with these spaces. Parking lots with vegetated islands already have prime areas for placing vegetated GSI, such as bioswales, native landscaping, and stormwater trees. The same concept applies for parking areas sloped towards vegetated perimeters, where existing vegetation can be made into vegetated GSI.

For parking areas that drain to themselves, pavement that infiltrates is the best option, which would be porous pavement. Porous pavement becomes a more cost effective GSI option when parking lots are already scheduled to be repaved. Paths are more linear than parking lots, and therefore GSI options are limited by that factor. Native landscaping, porous pavement, and stormwater trees are ideal because they do not require a large amount of localized land area. Finally, paved school playgrounds can successfully implement all of the aforementioned BMPs. Pavement removal, native landscaping, and stormwater trees are the simplest options. However, bioswales and porous pavement may also be an option with professional assistance.

For green spaces, there is a wide range of GSI that can be considered. Green spaces can be athletic fields, terraces, buffers, entrance areas, gardens, landscaping, play areas, open green space, courtyards, and outdoor classrooms. The opportunities for GSI on athletic fields are greatly limited, and one of the only feasible options is placing porous turf. GSI options can also be limited for terraces. Less invasive GSI, such as soil amendments and native plantings, is best unless the terrace is not near a building or near a building with no basement. GSI in buffers is successful when natural materials are used. This includes stormwater trees, bioswales, rain gardens, and greenways. However, infiltrative GSI cannot be used for buffers along buildings. Entrance areas have limited space, so GSI with a small footprint, e.g., stormwater trees, soil amendments, and native plantings, are most successful in those spaces.

Gardens are intended to have plantings, so bioswales, rain gardens, native plantings, and orchard/urban agriculture are successful options. The same idea applies for landscaped areas, except they are often too small for orchards or agriculture and may incorporate more linear spaces, like greenways. Play areas are

similar and would successfully incorporate similar GSI, except a non-natural option, like porous turf, may be useful for recreational purposes. Open green spaces have greater area and open opportunities for implementing GSI that requires a lot of space. GSI like constructed wetlands or restored wetlands can provide greater storage and water treatment options. Stormwater trees and GSI that is successful with more area used, such as rain gardens, soil amendments, and native plantings are good options. Courtyards have more limited space, so wetlands and rain gardens are less successful. GSI such as bioswales and porous pavement may be successful in a concentrated space but would require professional assistance to be successful. Furthermore, outdoor classrooms vary in size and are intended for education. Therefore, GSI with visible features and benefits is successful. This means porous turf, porous pavers, and greenways are less likely to provide use in a classroom space.

Streets and right-of-way spaces are common places for public GSI projects. The success of GSI in the right-of-way is mainly restricted by space limitations and utilities. Right-of-way areas could be along residential streets, commercial streets, industrial streets, and alleys. The success of using porous pavement along streets is often dependent upon if there are parking lanes, as that is the most feasible location for porous pavement on roads. Alleys are a good option for porous pavement because GSI can be placed in the center of the alley without coming into contact with heavy vehicle traffic. For bioswales in the ROW, success is most dependent on the ROW being wide enough and far enough from water mains and other limiting utilities. Native landscaping or removing pavement may be the most successful option for narrow ROW areas. However, it is important to maintain safety, such as proper line of sight, when placing landscaping. Commercial and industrial areas may have remediation and redevelopment continuing obligations, in which case placing infiltrative GSI is difficult. In areas that have roadside ditches, without curbs or storm inlets, it may be unsuccessful to try to place bioswales in the ROW, unless they are placed in a center median.

8.2 Right of Way Project GSI Evaluation Tool

The GSI Evaluation Tool is a series of checklists for use by the project designer, to best determine if the project in question is right for GSI, to which GSI is the right fit, and later the design process steps. The Tool guides on topics of Project Budget and Schedule, Project Area Needs, and Project Area Constraints, as shown in the image below.

Project Selection Questions	Rating					Weight
	Yes	Probably	Maybe	Unlikely	No	
Project Schedule and Budget						
Is the project construction scheduled for more than 6 months from today			x			3
Is sufficient budget or grant funding available to allow a GSI device?			x			3
Is the roadway/right-of-way designer on board with adding GSI?			x			3
Do you have the necessary staff available to design GSI for this project?		x				4
Project Area Needs						
Is the project area highly rated for water quality needs according to GSI Map 1?	x					5
Is the project area highly rated to be flood prone according to the GSI Map 2?					x	1
Does the project appear in the City's GSI Plan?					x	1
Is there interest for GSI here for other reasons not yet listed?			x			3
Project Area Constraints						
Does the area have high bedrock or high water table (see Map 5)			x			3
Does the area have sandy soils?	x		x			5
Are buried or overhead utilities buried constraints to the project area?*		x				2
Do residents or abutting property owners in favor of GSI?		x				4
Likelihood of Moving Project Forward	Yes				No	
TOTAL (RECOMMENDED SCORES OVER 60% TO PROCEED)						62%

The designer is guided to move forward through the process with a rating of 60% or more. Projects scoring less than 60% require some additional support to move forward. Source areas (pavement, building, or green space) provide direction for the next step. Suggestions are made for GSI best suited for each area as shown below.

Green Stormwater Infrastructure for Pavement Does your Project Area Have 		Regenerative Stormwater Conveyance	Bioswale	Native Landscaping	Porous Pavement	Remove Pavement	Stormwater Trees
Unused/Underused Pavement							
Roadways							
	Min. of 10' between curb and bldg						
	With vegetated islands						
	With Rural Cross-section/ditches						
	Has inverted crown (alley pavement)						
	Scheduled to be repaved only						
Parking Areas							
	With vegetated islands						
	Sloped towards vegetated perimeter						
	Does not drain towards vegetated perimeter						
	Scheduled to be repaved only						
Paths and Sidewalks							

Design process steps follow from conceptual design, through final design, construction management, maintenance, and grant reporting. See Attachment E for examples of the Tool.

9.0 DESIGN GUIDANCE FOR IDENTIFIED PROJECTS

9.1 GSI Detail Drawings

Typical detail drawings for the GSI devices included in this project area included as Attachment F. The drawings have also been provided to the City as Autocad Civil 3D files.

9.2 GSI Standard Specifications

Standard Specifications provide guidance on installation of each GSI device. Standard Specifications are included as Attachment G.

10.0 MAINTENANCE & OPERATIONS GUIDANCE FOR IDENTIFIED PROJECTS

To provide long term inspection and maintenance guidance is of utmost importance for GSI long-term health and effectiveness. A full Operations and Maintenance Plan has been provided for the City, as Attachment H.

ATTACHMENTS

Attachment A: GSI Maps

Attachment B: Kick-off Meeting Polls and Materials

Attachment C: 30 Public GSI Projects

Attachment D: 20 Private GSI Projects

Attachment E: Right-of-Way Project GSI Evaluation Tool

Attachment F: GSI Detail Drawings

Attachment G: GSI Standard Specifications

Attachment H: Green Stormwater Infrastructure (GSI) Operations and Maintenance Plan



Report to the
Sustainability Commission
of the City of Green Bay

MEETING DATE

October 18, 2023

AGENDA ITEM # G.I

Upcoming Dates for GSI Plan: October 25 Improvement & Services Committee; November 7 Common Council.

BACKGROUND

RECOMMENDATION

FISCAL IMPACT

ATTACHMENTS

None



Report to the
Sustainability Commission
of the City of Green Bay

MEETING DATE

October 18, 2023

AGENDA ITEM # G.2

Upcoming Dates for Clean Energy Plan: November 15 Sustainability Commission; November 29 Improvement & Services Committee; December 5 Common Council.

BACKGROUND

RECOMMENDATION

FISCAL IMPACT

ATTACHMENTS

None