Tisbury MA Impervious Cover Disconnection (ICD) Project

An Integrated Stormwater Management Approach for Promoting Urban Community Sustainability and Resilience

Task 4E Municipal Coordination Meeting

Prepared for:

U.S. EPA Region 1

Tisbury, MA

Martha's Vineyard Commission

Prepared by:

Paradigm Environmental

UNH Stormwater Center

Great Lakes Environmental Center

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Sep 12, 2019

Meeting Agenda

Sep 12, 2019

- Introduction/Project Overview
- Review of Concept Designs
- Review of Modeling Tasks
- Team Discussion
- Lunch Break
- Watershed Tour
- Conclusion/Next Steps

An Integrated Stormwater Management Approach for Promoting Urban Community Sustainability and Resilience

Introduction

Project Overview

Project Goals

- Identify and quantify opportunities for the disconnection of impervious cover (IC)
- Building an understanding and capacity for integrating green infrastructure (GI) and other stormwater control measures (SCM) into municipal land use decision making
- Demonstrate the benefits that GI SCM provides for mitigating flooding and improving water quality
- Close collaboration and sharing information with municipal officials and representatives from the Town

Project Milestone & Timeline

Project Task	Delivery Date	Status
Task 0: Work Plan	Dec 04, 2018	Complete
Task 1: Quality Assurance Project Plan (QAPP)	Dec 13, 2018	Complete
Task 2: Kickoff **Meeting at Boston MA**	Oct 24, 2018	Complete
Task 3: Municipal Coordination **Meeting at Tisbury MA**	Nov 29, 2018	Complete
Task 4A: GIS Analysis: Watershed Characterization (HRU Development) and GI SCM Opportunity Area Screening	Dec 15, 2018	Complete
Task 4B: Opti-Tool Analyses for Quantifying Stormwater Runoff Volume and Pollutant Loadings from Watershed Source Areas (HRU Timeseries Development)	Jun 27, 2019	Complete
Task 4C: Opti-Tool Application for Two Pilot Drainage Areas (Outfall #2 and #7) to Evaluate Source Area Contributions and GI SCM Reduction Benefits	Feb 14, 2020	In Progress
Task 4D: Develop Planning Level GI SCM Performance Curves for Estimating Cumulative Reductions in SW-Related Indicator Bacteria	Sep 30, 2019	Draft version
Task 4E: Identify Green Infrastructure Stormwater Control Opportunities and Potential Management Strategies for Tisbury (**Meeting at Tisbury MA**)	Sep 12, 2019	Current

Project Milestone & Timeline

Project Task	Delivery Date	Status
Task 4F: Conduct Field Investigations to Further Evaluate Community GI SCM Opportunities and Strategies	Dec 13, 2019	In Progress
Task 4G: Develop GI SCM Conceptual Designs	Jan 15, 2020	In Progress
Task 4H: Quantify Benefits for Municipal Long-Term GI SCMs Implementation Strategies	Feb 14, 2020	-
Task 4I: Develop Streamlined Technical Support Document to Quantify Benefits of GI SCMs for IC Disconnection	Feb 14, 2020	-
Task 4J: Final Project **Meeting at Tisbury MA** and Final Project Report	Mar 05, 2020* Mar 27, 2020	-
Task 5: Develop Streamlined Technical Support Document for Developing Long-Term Community SCM IC Disconnection Strategies	Mar 27, 2020	-
Task 2: Conduct a **Webinar**	Mar 19, 2020*	-

* tentative

An Integrated Stormwater Management Approach for Promoting Urban Community Sustainability and Resilience

Terms and Concepts

This slides in this section provide clarification of some important terms and concepts used throughout this presentation.

Soils. The United States Department of Agriculture (USDA) developed a simple classification schema for soils. According to this schema, soils may be classified as A, B, C or D. As a general rule, the infiltration rate (related: permeability, hydraulic conductivity) decreases from A to D. That is, **A soils (sands) have the highest infiltration rate capacity** and **D soils (clays) have the lowest**. For more information, refer to the USDA National Resources Conservation Service's (NRCS) May 2007 publication entitled "Part 630 Hydrology National Engineering Handbook, Chapter 7: Hydrologic Soil Groups" available here: https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba

Urban Soils. As a general rule, it is difficult to characterize urban soils according to the USDA schema. This is because the development and redevelopment of urbanized areas and roadways results in quite significant excavation and relocation of soils, resulting in a patchwork of soils (i.e., "fill") used for and during construction. The characteristics of such fill may vary depending on where it was sourced.

In Tisbury, the B1 Business District (B1 District) is situated at an elevation close to the ocean shoreline, suggesting that soils in the B1 District may have some characteristic of marine clay (e.g., USDA C or D soils). Conversely, it is reasonable to presume that some of these soils are of a more sandy type (e.g., USDA A or B) and/or that soils relocated to the B1 District would likely have been sourced from more sandy soil areas of Martha's Vineyard.

Consequently, for this project and this presentation, urban soils have been depicted as "less likely". However, it is possible these soils could have a high infiltration rate, but the exact composition of B1 District soils would need to be confirmed during development, redevelopment and/or construction / implementation of SCMs for runoff control. **The phrase "less likely" on slides 44 and 46–48 should be read as "possible – needs confirmation."**

Hydrologic Response Unit (HRU). Hydrologists need a way to express stormwater runoff that occurs over large areas of land composed of differing land types (e.g., residential, commercial, industrial, forest) having different soil types (e.g., A, B, C, D) and characteristics (e.g., percent slope; percent impervious cover (%IC), etc.). Hydrologists use the hydrologic response unit – or HRU.

The combinations (or permutations) of these different land characteristics result in multiple unique HRUs (e.g., 1. residential – A soil – 5% slope – 100%IC; 2. residential – B soil – 5% slope – 100%IC; . .. and so on). Because each of **these HRU combinations** describe an existing discrete land use type, they **become the hydrologic 'building blocks'** for evaluating stormwater runoff for a given community.

Once the set of possible HRUs have been defined for a given land area, the HRUs can be used to map and model runoff occurring on the land. In addition, HRUs help identify the nature and range of SCM opportunities.

Note: some HRUs make little or no practical sense (e.g., forest with 100%IC) – and as such, they do not apply (n/a).

Depth to Groundwater. This EPA project relies on readily available geo-spatial data, such as geographical information system (GIS) data and data layers, and other general land use descriptions available for Tisbury by way of Town records, etc. As described above, one of the uncertainties associated with characterizing the Tisbury B1 Business District for this project (and other similar districts across Martha's Vineyard) is the composition of urban soils (fill).

Another uncertainty is depth to groundwater. The depth to groundwater is an important factor for determining the depth of soil above the groundwater table (unsaturated zone soils (UZS)) and therefore, runoff, that can be accommodated by infiltration (it is also an important factor to consider when constructing SCMs, or for development/redevelopment of roads or infrastructure).

Based on the available data including the topography of Tisbury, as a general rule, the available UZS very likely increases upgradient of the B1 District (e.g., residential areas). Depth to groundwater would need to be determined as part of a pre-design phase associated with any construction action, such as SCM implementation. Notably, **the HRU 'building blocks' discussed above DO NOT include depth to groundwater**.

Relationship of Impervious Cover (IC) to Stormwater Runoff and Stream/Water Quality (S/WQ), Generally. Stormwater scientists discovered that as IC increases, the impact on runoff and S/WQ increase. As such, IC can be used as a 'surrogate' for predicting both runoff and S/WQ. The illustrations on the next two slides depict the effect of IC on runoff and S/WQ . ..

It should be noted that EPA has observed impacts to stream/water quality at IC as low as 8%.

Stormwater - Relationship between Impervious Cover (IC) and Surface Runoff

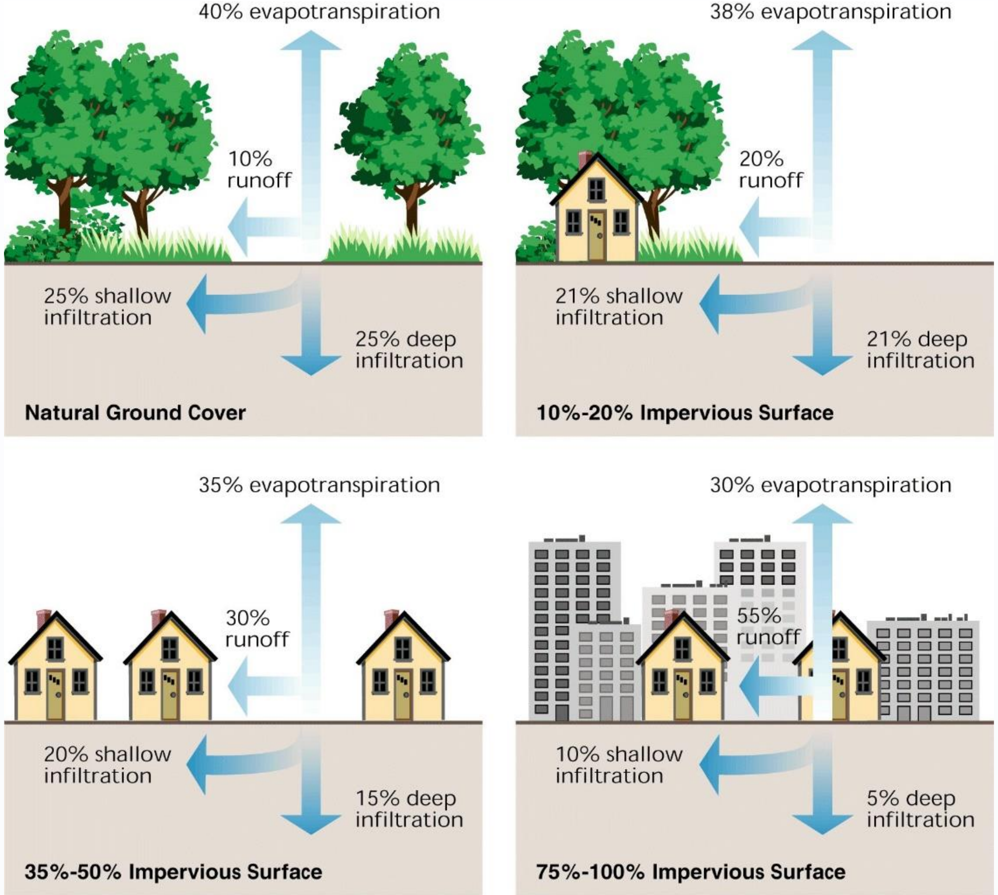
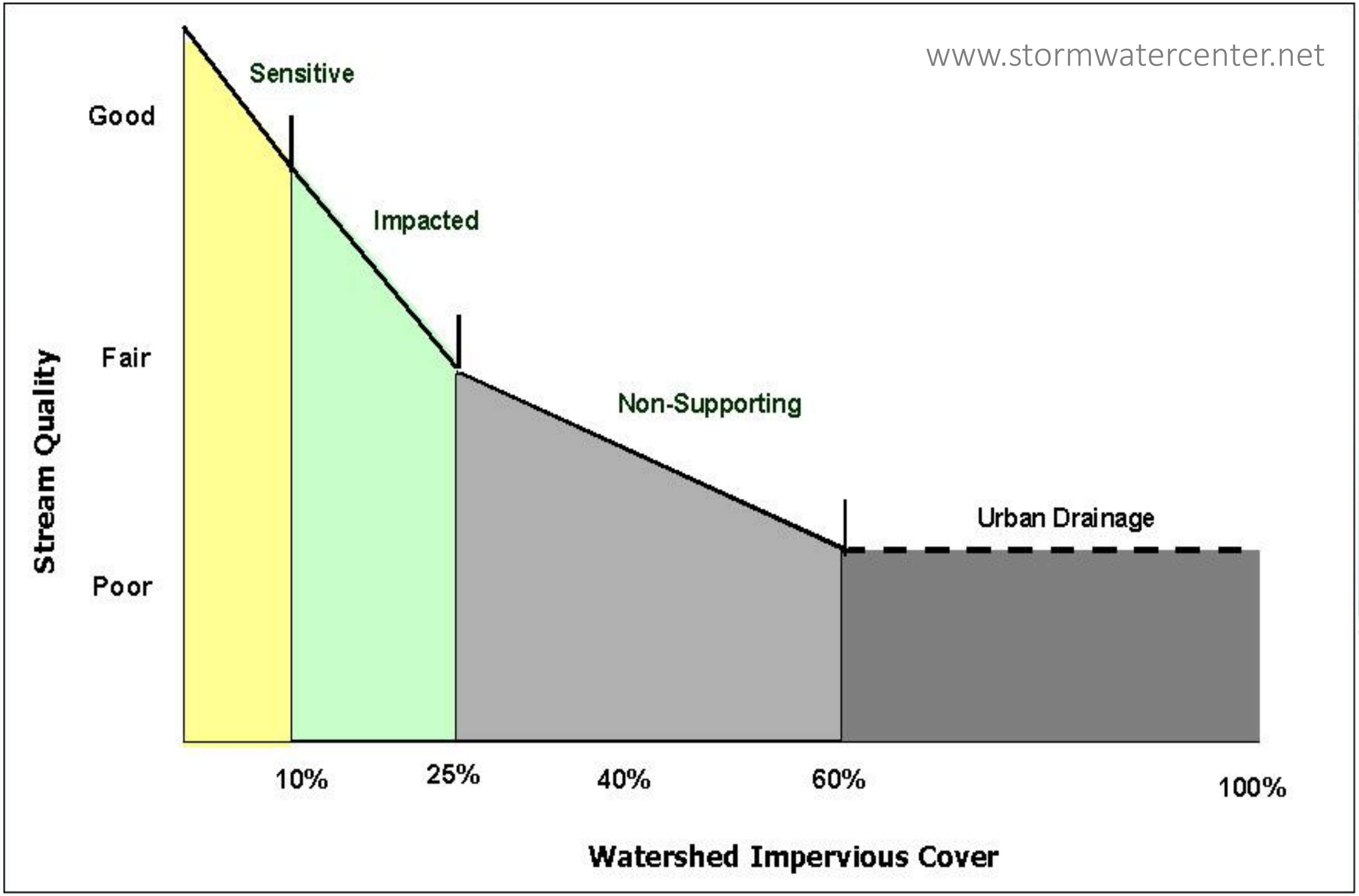


Fig. 3.21 -- Relationship between impervious cover and surface runoff. Impervious cover in a watershed results in increased surface runoff. As little as 10 percent impervious cover in a watershed can result in stream degradation.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
By the Federal Interagency Stream Restoration Working Group (FISRWG) (15 Federal agencies of the U.S.)

Reference: Federal Interagency Stream Corridor Restoration Working Group (FISRWG). 1998. Stream Corridor Restoration: Principles, Processes, and Practices. PB98-158348LUW.

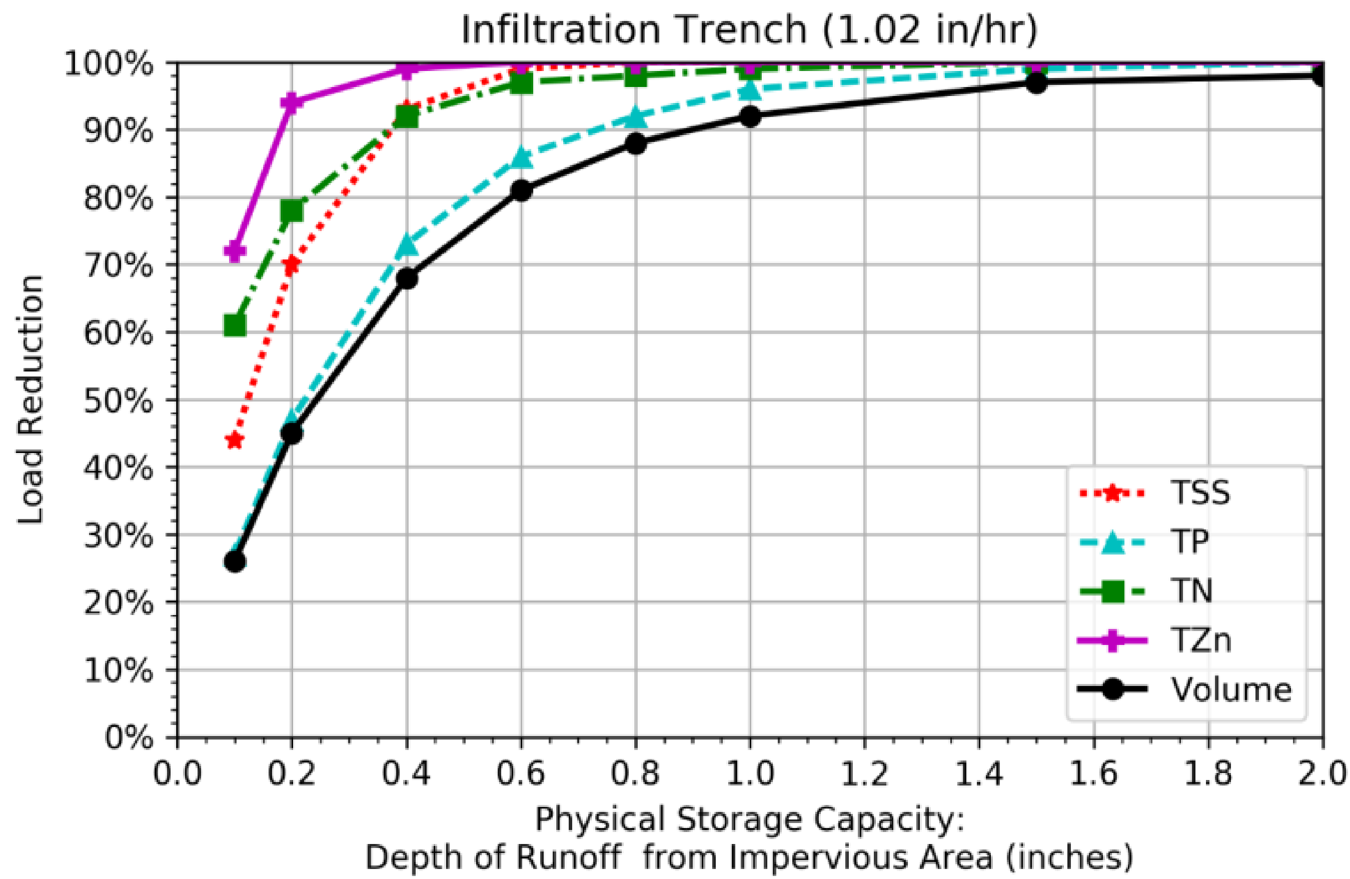
Stormwater - Impact of Impervious Cover on Stream Quality



Performance Curves. EPA included the development of Performance Curves for bacteria into this project in part because, to date, EPA had not developed PCs for bacteria, but also in part because bacteria is a primary reason for control of stormwater – because elevated bacteria can cause closure of beaches and/or shellfishing areas.

So, what is a Performance Curve?

A Performance Curve tells a stormwater practitioner how much of a given pollutant (e.g., nitrogen, bacteria) can be controlled *simply on the basis of the size of the stormwater control measure (SCM)*. This is important, because the practitioner need not spend time and resources monitoring the SCM for pollutants. Rather, the emphasis for practitioners is on (a) construction of the SCM to specification (to ensure it operates correctly) and (b) operation and maintenance of the SCM. Across New England, EPA estimates this approach – using Performance Curves – will save tens of millions of municipal dollars.



This is a Performance Curve for an Infiltration Trench SCM. At a design sizing of 0.4 in. of runoff depth, a practitioner can expect to control better than 90% of the nitrogen load. It's as simple as that! Moreover, for nitrogen, the curve tells the practitioner not to build an SCM for more than about 0.6 in. of runoff depth – because very little additional load reduction results from a larger SCM. This saves design and construction $$$!!!

For more information on Performance Curves, refer to:

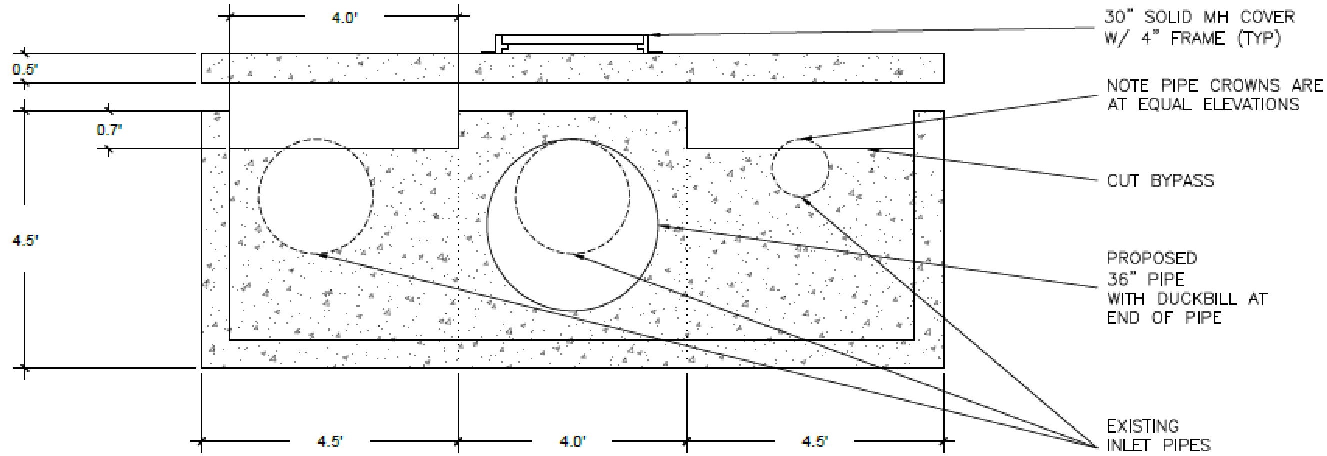
- USEPA (2018), Stormwater Control Measure Nomographs with Pollutant Removal and Design Cost Estimates (developed for EPA Region 1 by the University of New Hampshire Stormwater Center (UNHSC), available at: https://www3.epa.gov/region1/npdes/stormwater/assets/pdfs/ms4-permit-nomographs.pdf

- USEPA (March 2010), Stormwater Best Management Practices (BMP) Performance Analysis, available at: https://www3.epa.gov/region1/npdes/stormwater/assets/pdfs/BMP-Performance-Analysis-Report.pdf

An Integrated Stormwater Management Approach for Promoting Urban Community Sustainability and Resilience

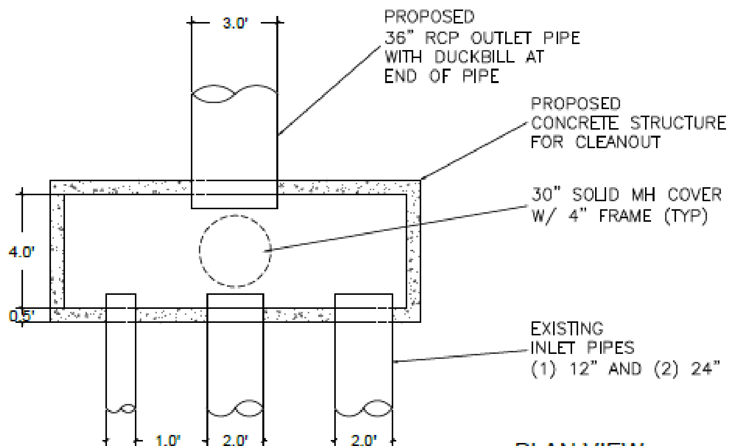
Review of Concept Designs


The Black Dog Tavern
Steamship
ority Vineyard...
A E Kirkpatrick
Cape Cod 5
Lending and Wealth...
Vineyard
Caribbean Cu
XtraMart
The Black Dog
Water St. Bakery
Extension



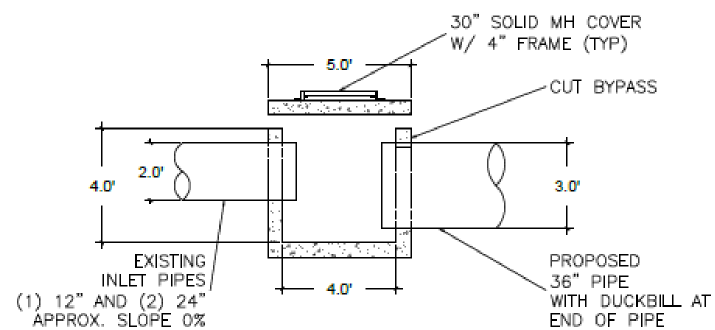
END WALL DETAIL

GRAPHIC SCALE 1:2



PLAN VIEW

GRAPHIC SCALE 1:4



CROSS-SECTION VIEW

EXISTING CONDITIONS

PROPOSED DESIGN

NOTE: DIMENSIONS AND LOCATIONS ARE APPROXIMATE AND MAY VARY. MUST FIELD VERIFY LOCATIONS

The table on the next slide compares the volumetric and pollutant load reduction attributable to two green infrastructure (GI) stormwater control measures (SCM), the infiltration trench (IT) and gravel wetland (GW), assuming an infiltration rate (IR) of 1.02 inches per hour. As a general rule, the IT outperforms the GW.

Some points to consider:

- The IR of 1.02 in/hr is conservative for A and/or B soils. With the possible exception of the soils identified as "urban", the Tisbury soils likely have a significantly higher infiltration rate than 1.02 in/hr;
- Nitrogen, as nitrate (NO3–) or nitrite (NO2–), is soluable in water. The exact fate of such nitrogen that is infiltrated will depend on where it is infiltrated. For example, as a general proposition, it would not be advisable to infiltrate stormwater containing high concentrations of soluable nitrogen near a waterbody, such as Lagoon Pond. The higher upgradient (and away from a surface water body) that infiltration occurs, the more likely such nitrogen will be naturally attenuated.

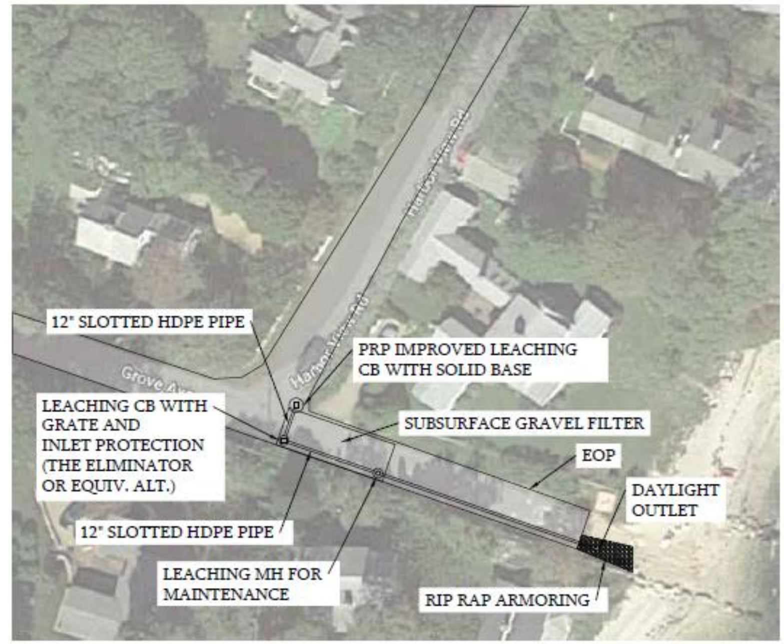
BMP ID/Name			VP 1	VP 2
BMP	-	-	Infiltration Trench	Gravel Wetland
Infiltration Rate	Inf	in/hr	1.02	
BMP Capacity: Depth of Runoff from Impervious Area	PSC	in	1.00	0.24
Runoff Volume Reduction	Volume	-	92%	0%
Phosphorus Load Reduction	TP	-	96%	29%
Nitrogen Load Reduction	TN	-	99%	37%
Cumulative TSS Load Reduction	TSS	-	100%	66%
Cumulative Zinc Load Reduction	TZn	-	100%	72%
TP Load reduction	0.8			lbs/yr
TN Load reduction	6.71			lbs/yr

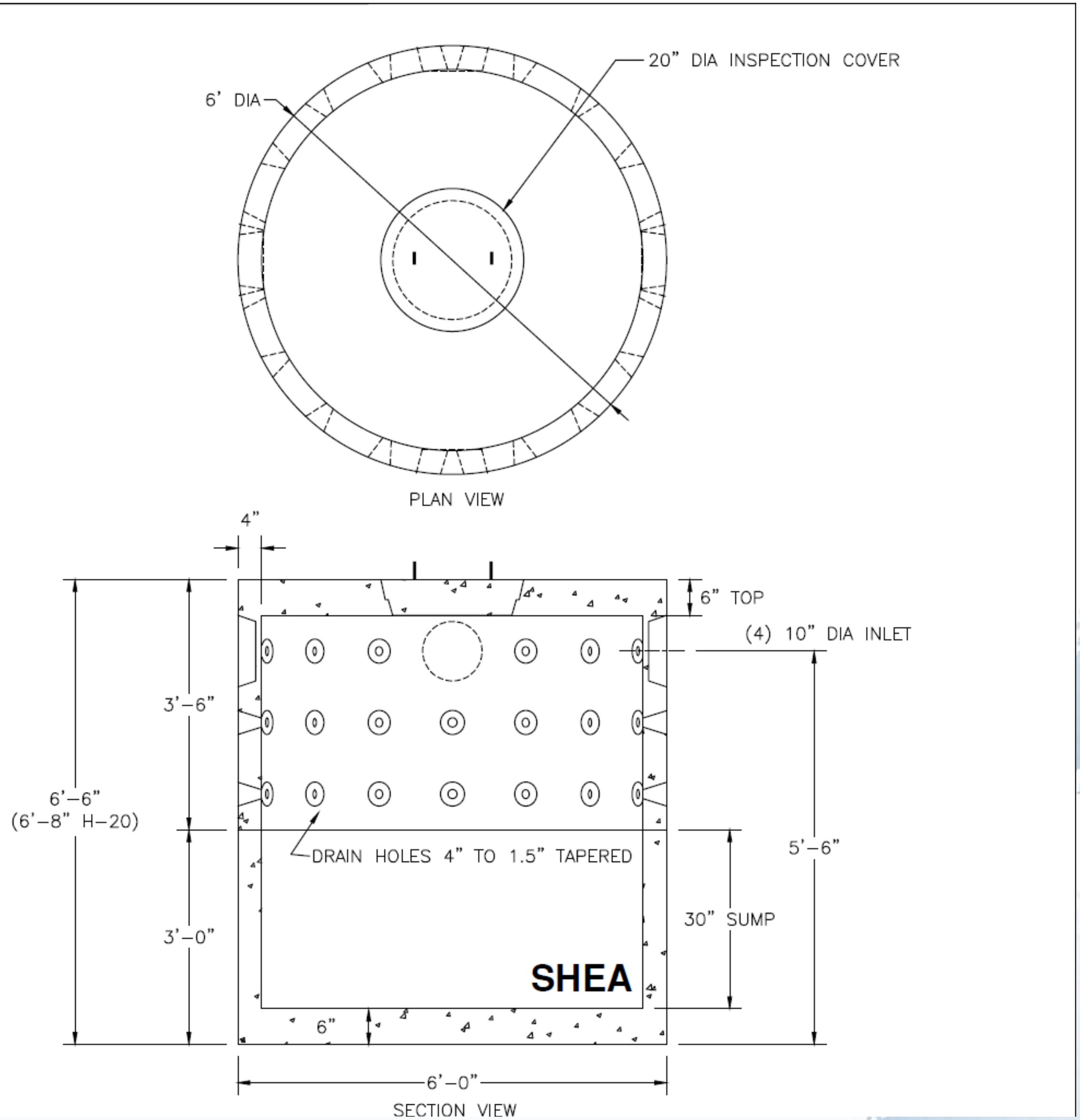
Harbor View Rd
Harbor View Rd
Grove Ave

EXISTING CONDITIONS

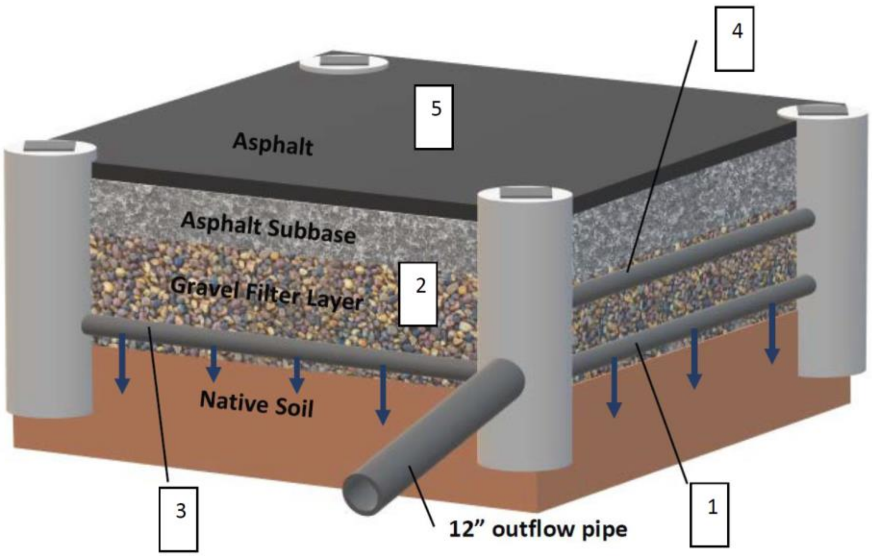
PROPOSED DESIGN

NOTE: DIMENSIONS AND LOCATIONS ARE APPROXIMATE AND MAY VARY. MUST FIELD VERIFY LOCATIONS




20" DIA INSPECTION COVER
6' DIA
PLAN VIEW
4"
6" TOP
(4) 10" DIA INLET
3'–6"
6'–6"
(6'–8" H–20)
DRAIN HOLES 4" TO 1.5" TAPERED
5'–6"
30" SUMP
3'–0"
SHEA
6"
6'–0"
SECTION VIEW

Generic Subsurface Gravel Filter Detail



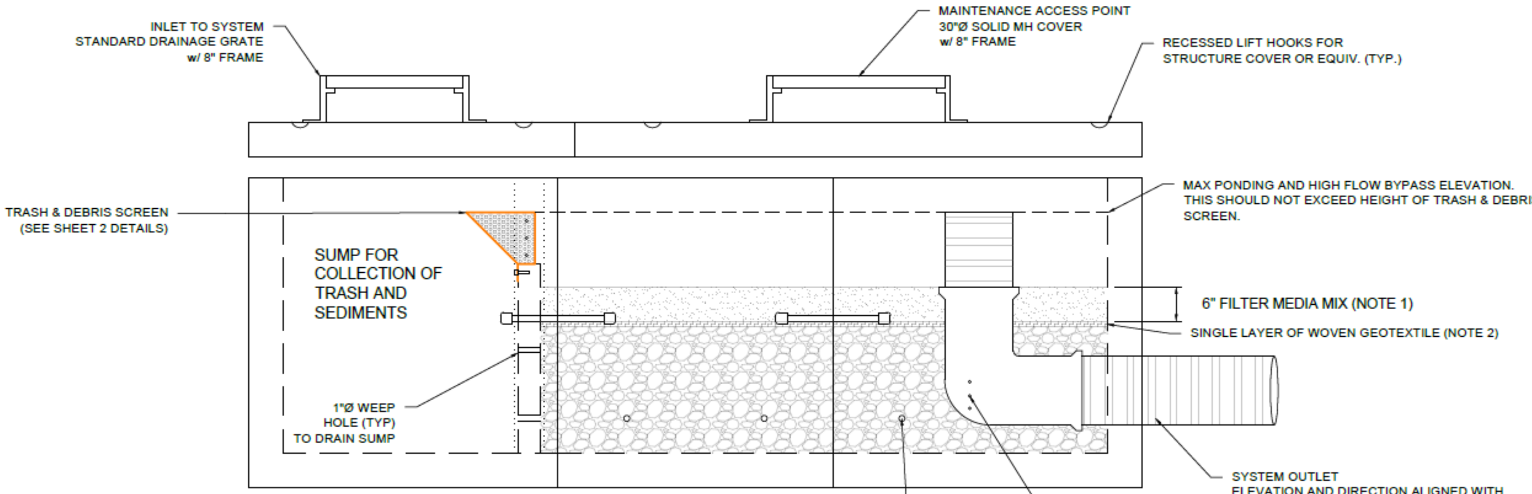
Notes

1. Heavy equipment shall not be used such that will jeopardize infiltration capacity of the native sub-grade.
2. Storage layer can be comprised of materials (natural or manufactured) to hold the design storage volume (DSV).
3. Overflow shall be located to drain back to existing storm drainage. Elevation can be varied to meet existing infrastructure inverts and flow controlled through orifice or weir features.
4. Hydraulic inlets should be drained by gravity to the extent practicable and include adequate pretreatment to reduce incidence of clogging and long-term maintenance.
5. Surface cover may vary and include pavement, grass, trees, soil or any combination desirable by end user and site specific requirements.


Maciel Way
Lagoon Pond Rd
Map
Google

Vineyard Haven
Fire Department
Martin Rd
W William St
W William St
Spring St
Pine Tree Rd
W Spring St

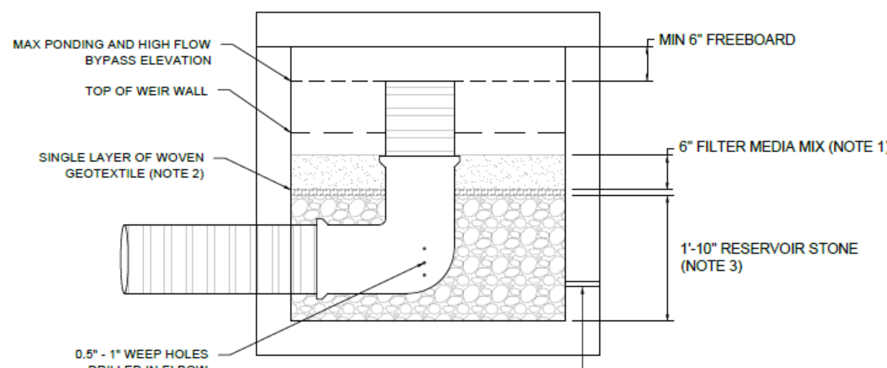

Spring St
©2019 Google
©2019 Google
Google
Image capture: Sep



SIDE VIEW CROSS-SECTION

NOTES:

1. FILTER MEDIA COMPOSITION IS MIXED BY TOTAL VOLUME REQUIRED
   1.1. 75-85% COARSE SAND (ASTM C-33 OR EQUIVALENT)
   1.2. 15-25% LOAM OR TOP SOIL
   1.3. 0-5% WATER TREATMENT RESIDUALS OR IRON FILINGS. THIS IS AN AMENDMENT USED FOR ENHANCED PHOSPHORUS ADSORPTION
2. WOVEN GEOTEXTILE LAYER OR SILT FENCE MATERIAL. THIS LAYER IS TO REMOVE ALL SILT SIZE PARTICLES AND LARGER AND PROTECT THE RESERVOIR STONE FROM FILLING WITH FINES. THIS IS ALSO THE DEPTH OF ROUTINE MAINTENANCE, WHICH INVOLVES REMOVING FILTER MEDIA AND GEOTEXTILE AND REPLACING WITH NEW.
3. RESERVOIR STONE CAN CONSIST OF A WIDE RANGE OF STONE SIZES. PREFERABLY A WASHED STONE OF CONSISTENT GRADATION, e.g. ¾" OR No. 57 STONE.
4. SYSTEM OUTLET CONFIGURATION CONSISTS OF A 90° ELBOW AND SHORT STUB PIECES OF HDPE DOUBLE WALLED OR SDR 35. THE ELEVATION AND DIRECTION THAT THE OUTLET EXITS THE SYSTEM WILL BE DETERMINED BY THE RESIDENT ENGINEER. THE OUTLET CAN BE PLUMBED TO BEST FIT THE EXISTING INFRASTRUCTURE.THE OUTLET PIPE SHALL BE SIZED TO PASS THE PREFERRED DESIGN STORM.
5. DRAINAGE HOLES SHOULD BE DRILLED IN THE OUTLET ELBOW TO DRAIN THE WATER DURING AND BETWEEN STORMS. THE HOLES SHALL BE IN A VERTICAL PLACEMENT TO PROVIDE ADDITIONAL CAPACITY AS THE SYSTEM FILLS. THE HOLES SHOULD BE SMALL ENOUGH TO PREVENT RESERVOIR STONE FROM DRAINING THROUGH. NUMBER AND SIZE OF HOLES CAN BE DETERMINE BY RESIDENT ENGINEER.
6. OPTIONAL 1" WEEP HOLES IN EXTERIOR WALLS OF BOX STRUCTURE CAN BE REMOVED FROM PRODUCTION OR PLUGGED IF PREFERRED. BENEFITS INCLUDE: SYSTEM DRAIN DOWN BETWEEN STORMS, GROUNDWATER RECHARGE, AND VOLUME REDUCTION.



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An Integrated Stormwater Management Approach for Promoting Urban Community Sustainability and Resilience

Review of Modeling Tasks

Task 4A. GIS Analysis (HRU/SCM Categories)

Hydrologic Response Unit Development

- **Land Use Classification (commercial, industrial, residential, etc.)**
- **Land Cover (pervious, impervious, buildings)**
- **Soil Classification (A, B, C, D)**
- **Slope (low, medium, high)**

Potential SCM Opportunities

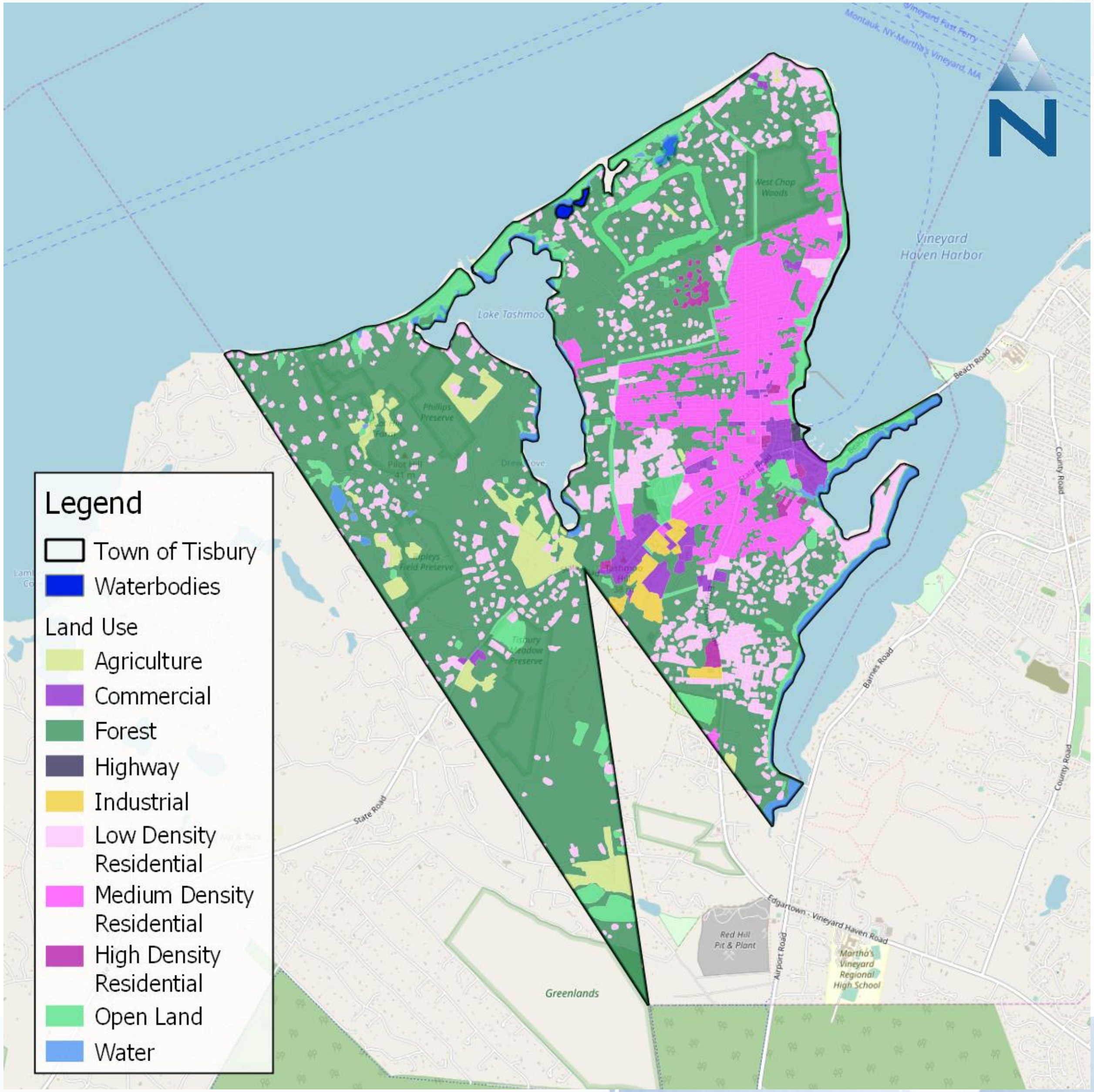
- **Site Suitability Criteria**
- **GIS Layers**
- **Town Owned Parcels**
- **Zoning layer**

Land Use Classification Table

Original Land Use Class	Reclassified Land Use	Total Area (acres)	Percent of Total Area
Brushland/Successional	Agriculture	147	4%
Cropland			
Pasture			
Commercial	Commercial	113	3%
Transitional			
Urban Public/Institutional			
Forest	**Forest**	**2,398**	**57%**
Transportation	Highway	3	0%
Industrial	Industrial	42	1%
Waste Disposal			
Low Density Residential	**Low Density Residential**	**553**	**13%**
Very Low Density Residential			
Medium Density Residential	**Medium Density Residential**	**479**	**11%**
High Density Residential	High Density Residential	28	1%
Multi-Family Residential			
Cemetery	Open Land	336	8%
Forested Wetland			
Golf Course			
Non-Forested Wetland			
Open Land			
Participation Recreation			
Powerline/Utility			
Saltwater Sandy Beach			
Saltwater Wetland			
Water-Based Recreation			
Water	Water	86	2%
Total		4,183	100%

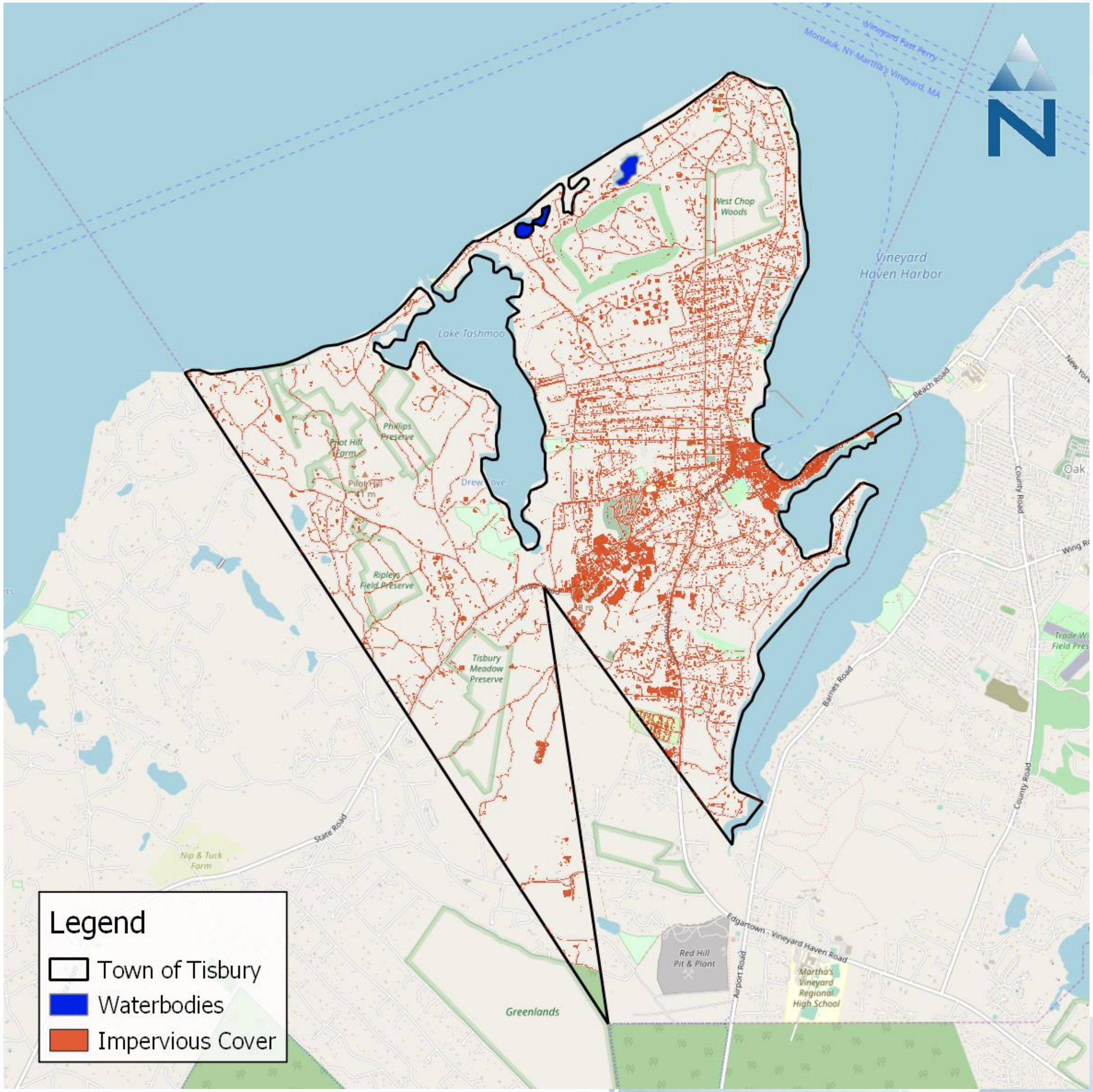
Source: Land Use 2005 polygons (MassGIS)

Major Land Uses Map



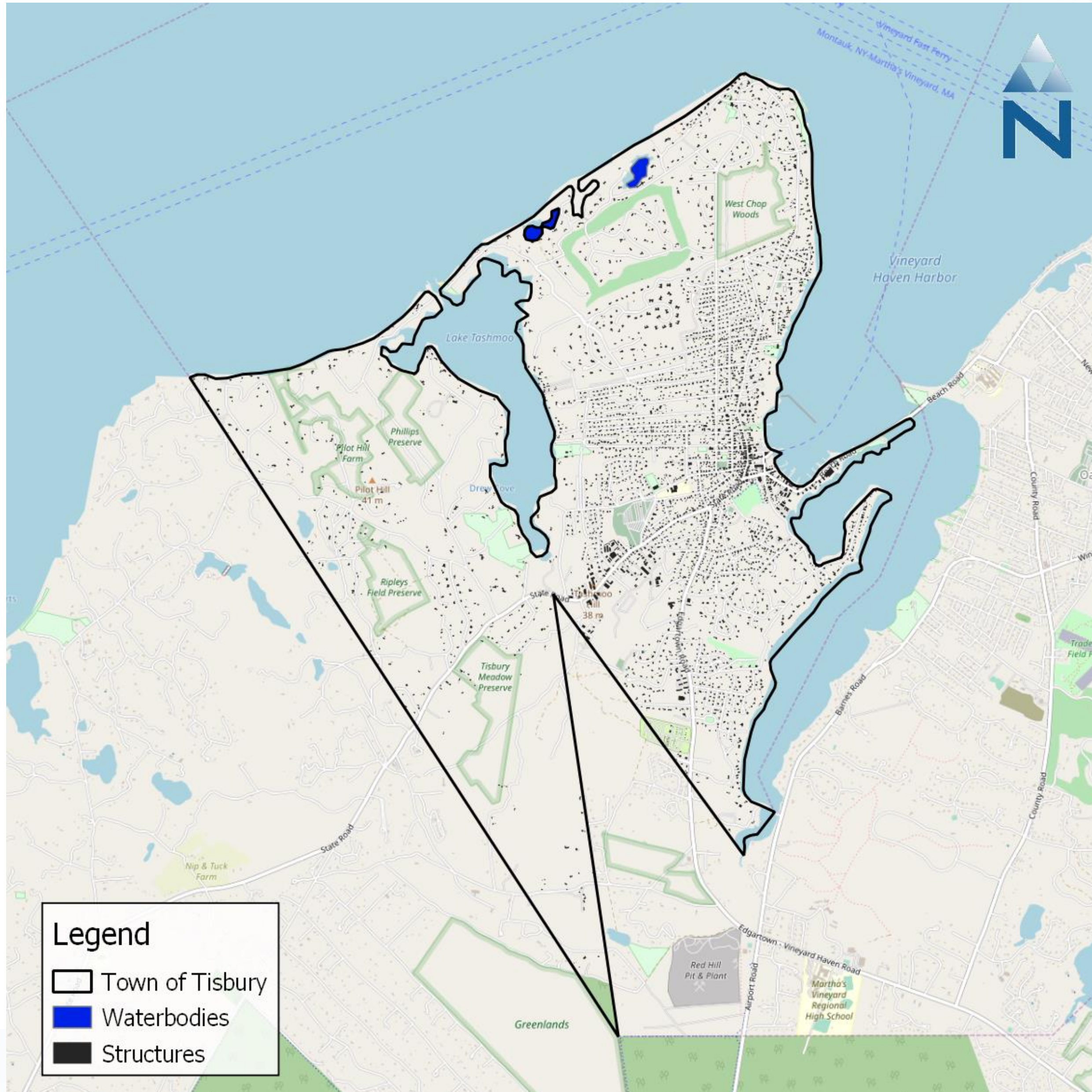
Source: Land Use 2005 polygons (MassGIS)

Impervious Cover Map



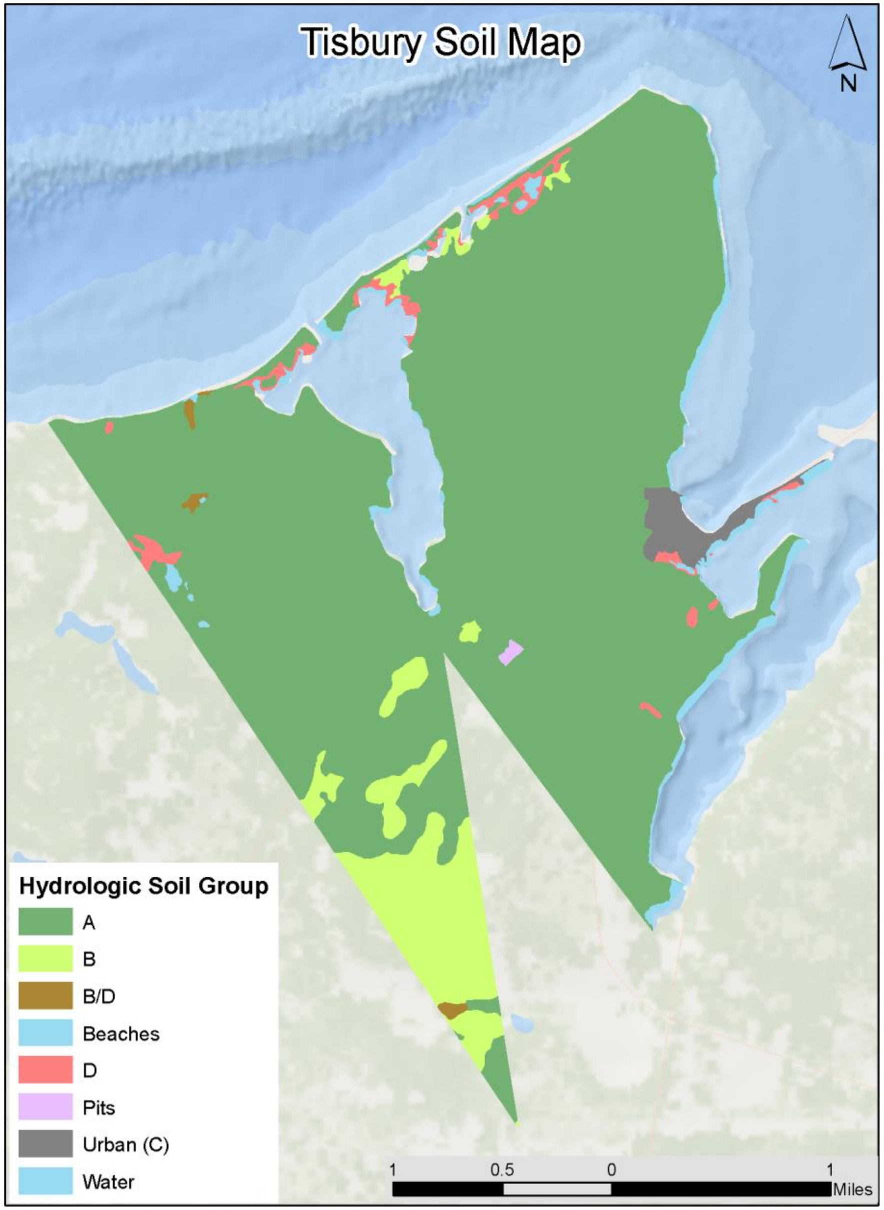
Source: Impervious Surfaces 2005 polygon layer (MassGIS)

Building Structures Map



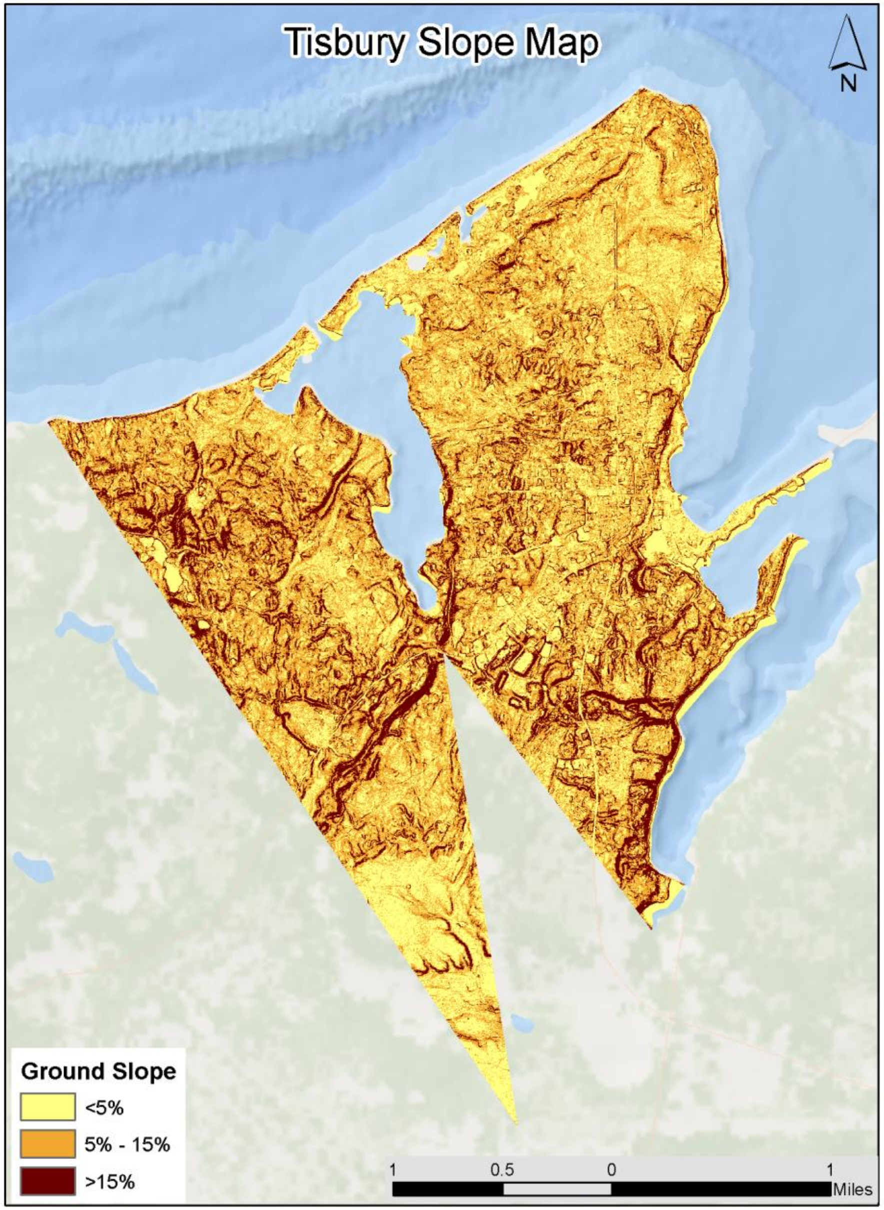
Source: Building Structures 2017 polygon layer (MassGIS)

Hydrologic Soil Group Map



Source: SSURGO 2012 polygon layer (NRCS)

Ground Slope Map

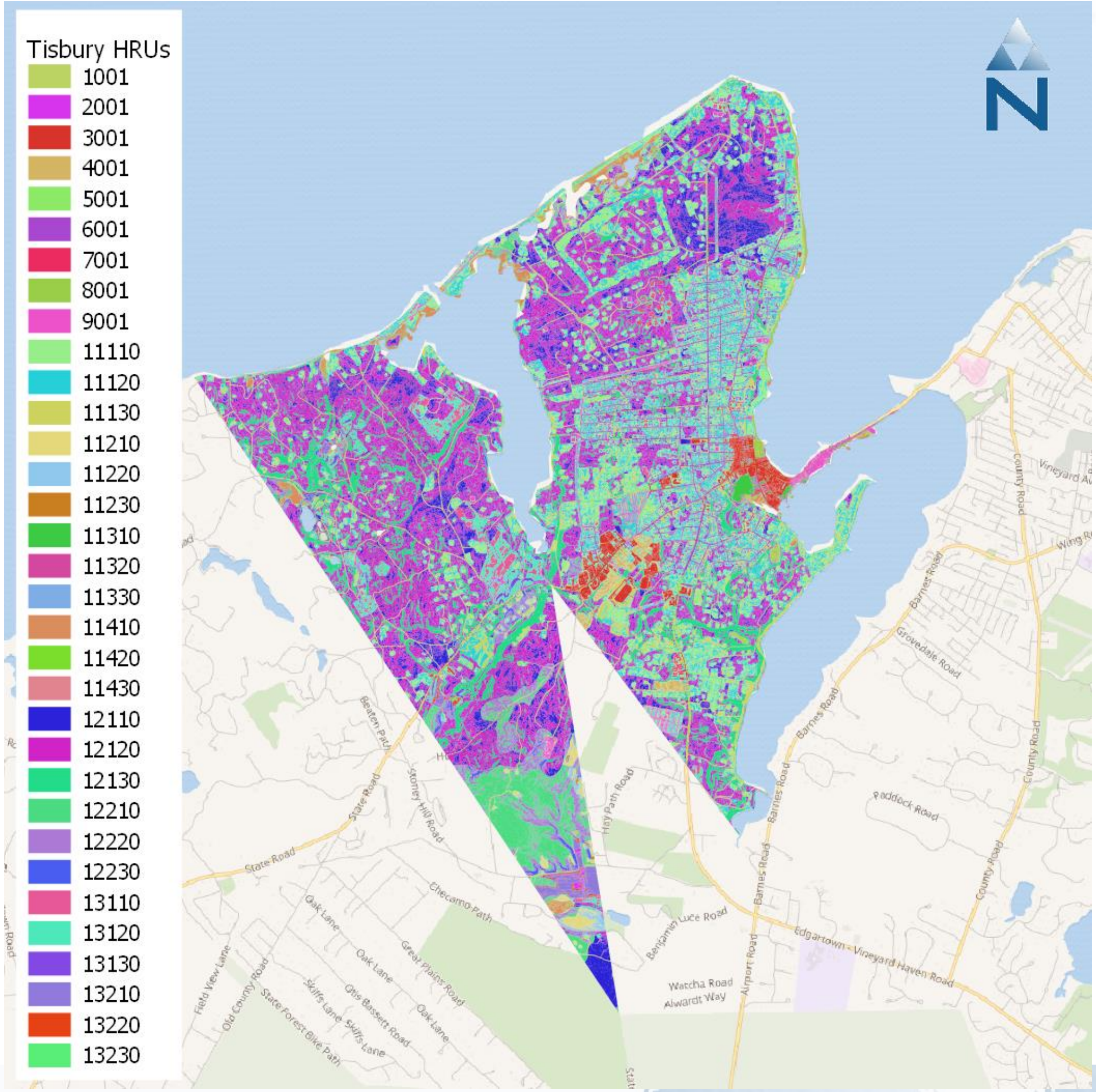


Source: LiDAR Terrain 2014 raster (MassGIS)

HRU Categories

HRU ID	HRU CODE	Land Use	Land Cover	Hydrologic Soil Group	Slope
1	13110	Agriculture	Pervious	A	Low
2	13120	Agriculture	Pervious	A	Med
3	13130	Agriculture	Pervious	A	High
4	13210	Agriculture	Pervious	B	Low
5	13220	Agriculture	Pervious	B	Med
6	13230	Agriculture	Pervious	B	High
7	2001	Agriculture	Impervious	n/a	n/a
8	12110	Forest	Pervious	A	Low
9	12120	Forest	Pervious	A	Med
10	12130	Forest	Pervious	A	High
11	12210	Forest	Pervious	B	Low
12	12220	Forest	Pervious	B	Med
13	12230	Forest	Pervious	B	High
14	1001	Forest	Impervious	n/a	n/a
15	11110	Developed	Pervious	A	Low
16	11120	Developed	Pervious	A	Med
17	11130	Developed	Pervious	A	High
18	11210	Developed	Pervious	B	Low
19	11220	Developed	Pervious	B	Med
20	11230	Developed	Pervious	B	High
21	11310	Developed	Pervious	C	Low
22	11320	Developed	Pervious	C	Med
23	11330	Developed	Pervious	C	High
24	11410	Developed	Pervious	D	Low
25	11420	Developed	Pervious	D	Med
26	11430	Developed	Pervious	D	High
27	3001	Commercial	Impervious	n/a	n/a
28	4001	Industrial	Impervious	n/a	n/a
29	5001	Low Density Residential	Impervious	n/a	n/a
30	6001	Medium Density Residential	Impervious	n/a	n/a
31	7001	High Density Residential	Impervious	n/a	n/a
32	8001	Highway	Impervious	n/a	n/a
33	9001	Open Space	Impervious	n/a	n/a

HRU Map


Tisbury HRUs
1001
2001
3001
4001
5001
6001
7001
8001
9001
11110
11120
11130
11210
11220
11230
11310
11320
11330
11410
11420
11430
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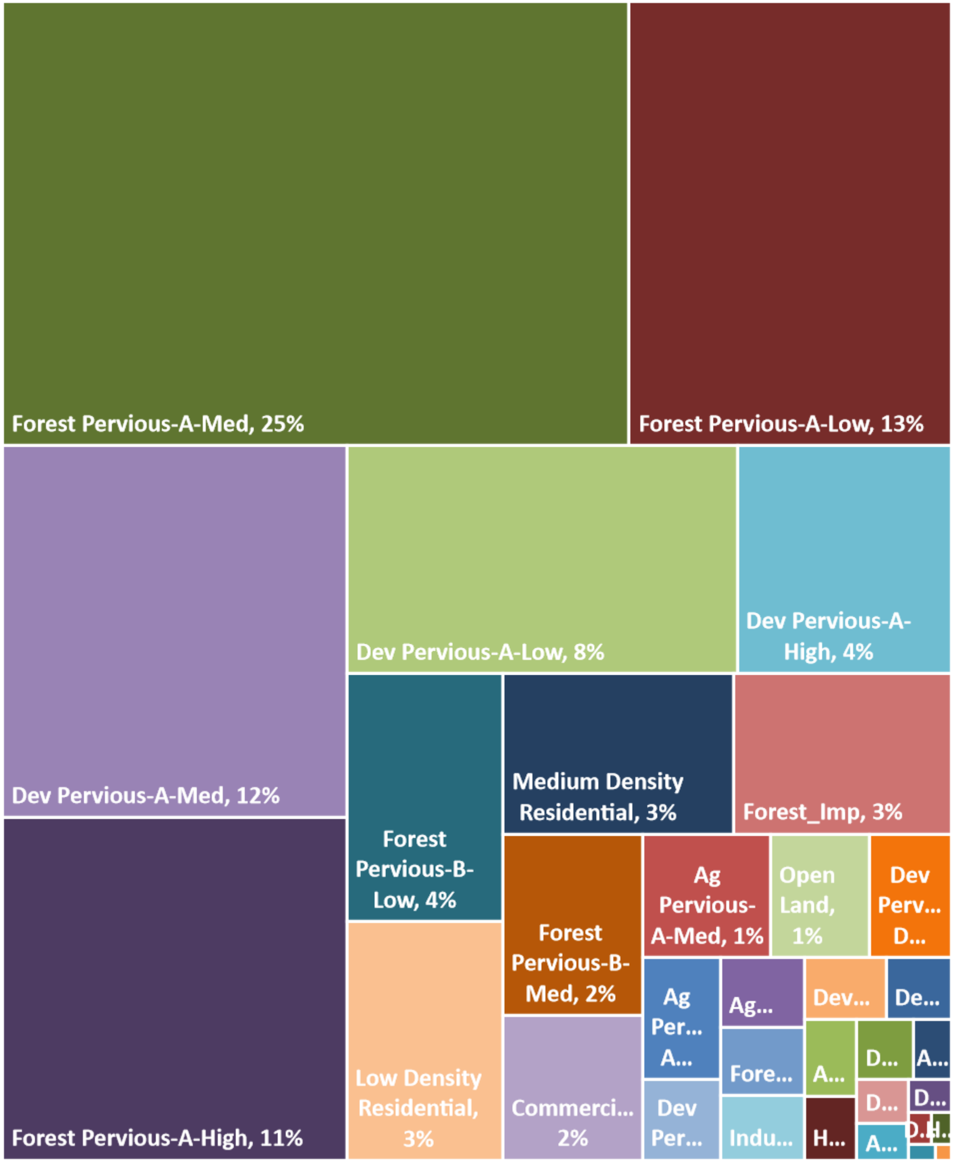
13220
13230
N

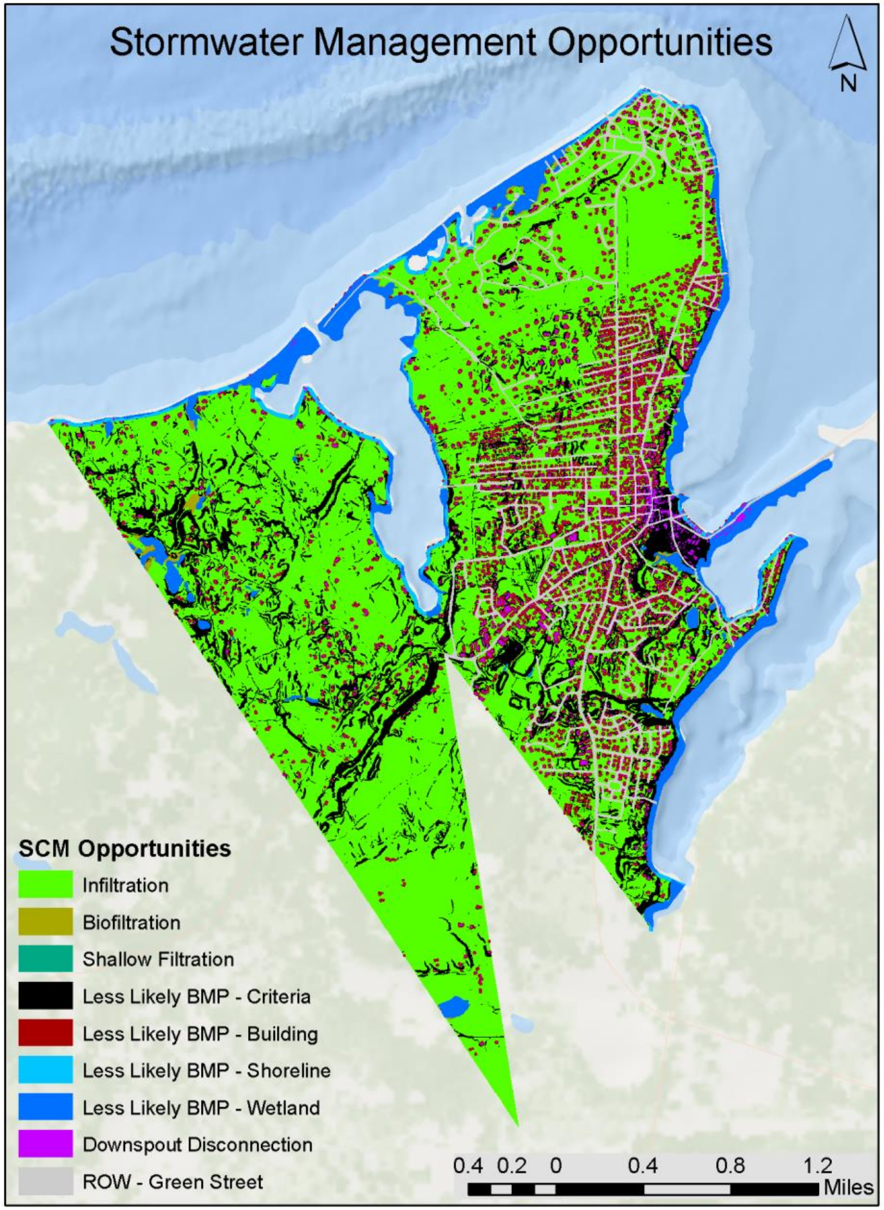
HRU Area Distribution



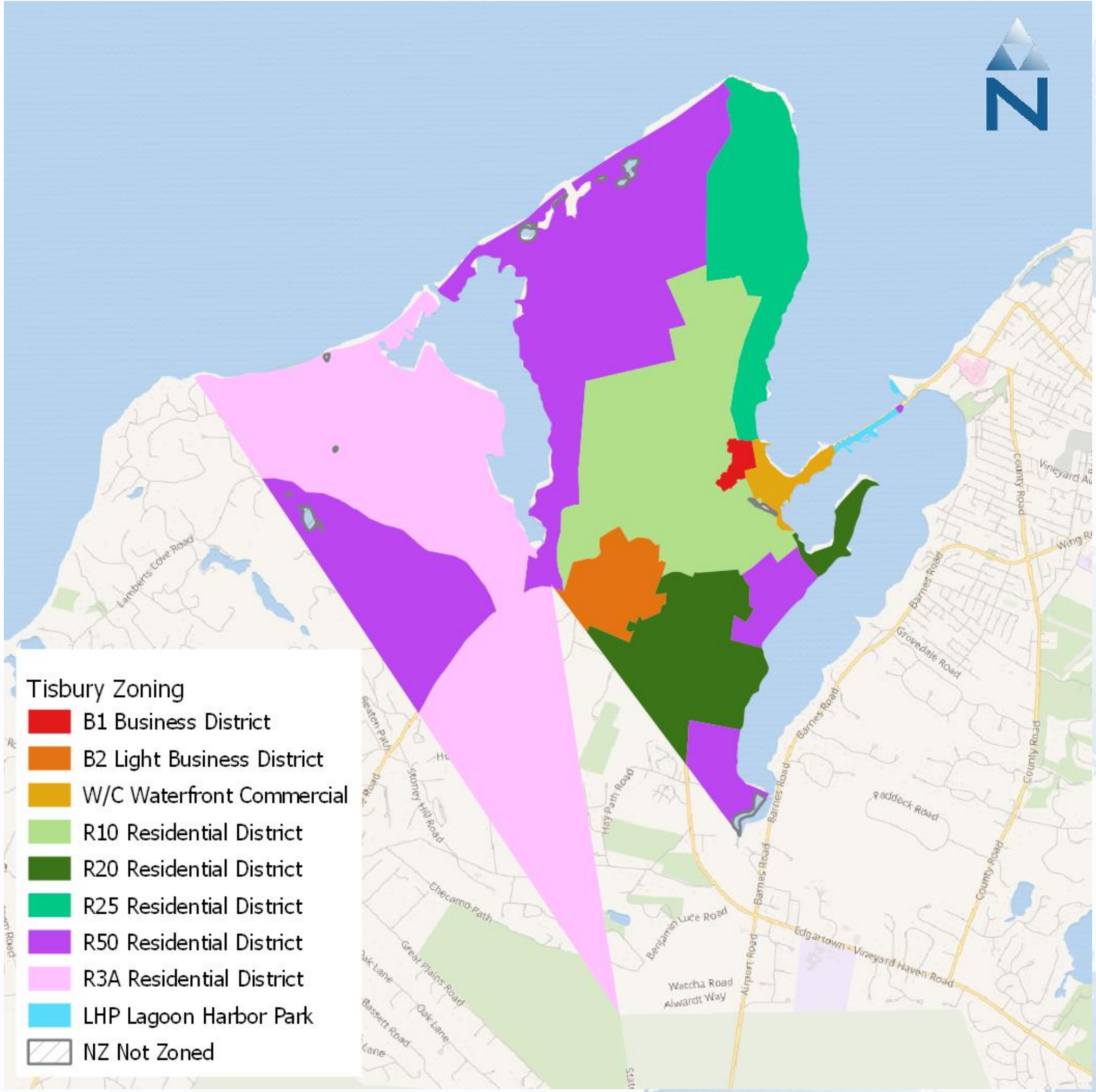
GI SCM Siting Criteria

Land Cover	Ground Slope (%)	Within 100 feet of Coastline?	Within 25 feet of Structure?	Hydrologic Soil Group	Management Category	BMP Type(s) in Opti-Tool
Pervious Area	<= 15	Yes	Yes	All	Less likely for onsite BMP	--
		No	No	A/B/C	Infiltration	Surface Infiltration Basin (e.g., Rain Garden)
				D	Biofiltration	Biofiltration (e.g., Enhanced Bioretention with ISR and underdrain option)
	> 15	--	--	--	Less likely for onsite BMP	--
Impervious Area	<= 5	Yes	Yes	All	Less likely for onsite BMP	--
		No	No	A/B/C	Infiltration	Infiltration Trench
				D	Shallow filtration	Porous Pavement
	> 5	--	--	--	Less likely for onsite BMP	--

GI SCM Opportunities All

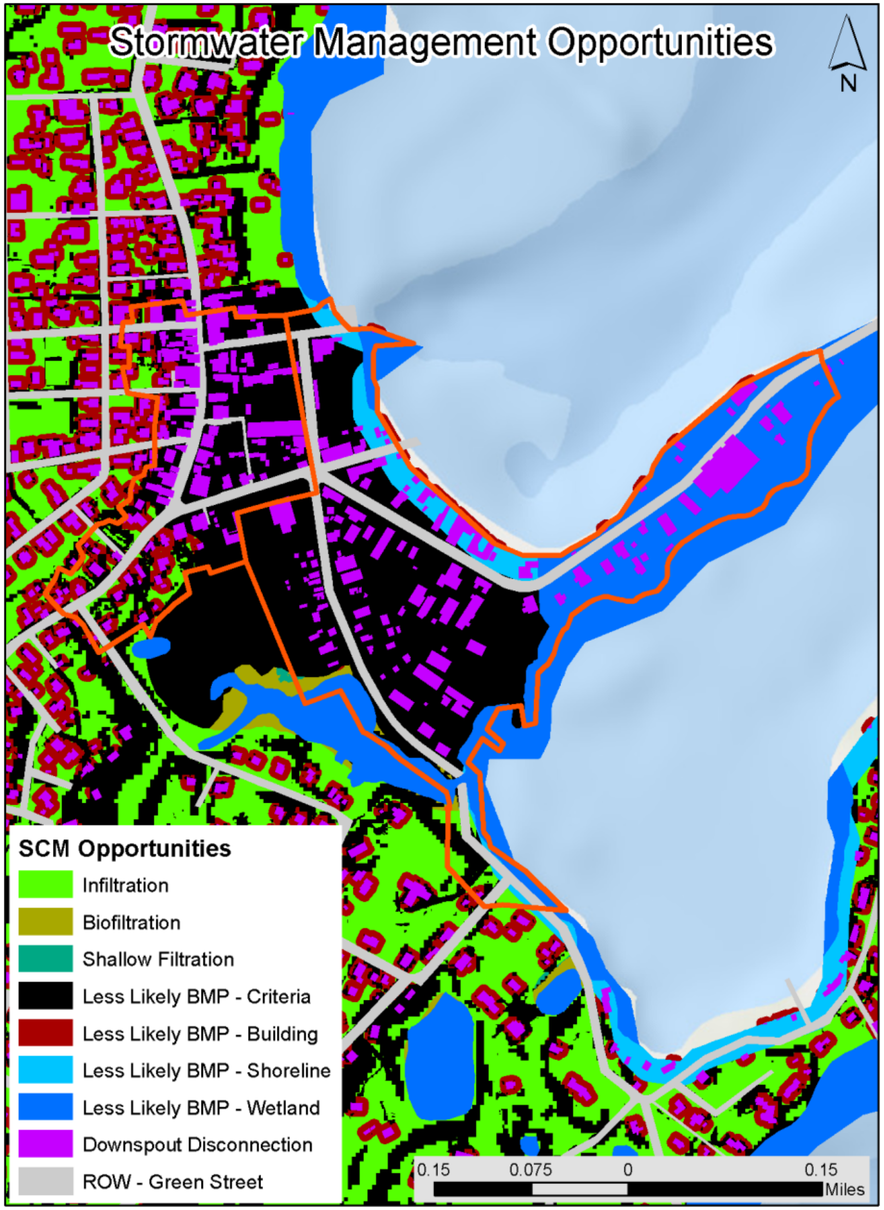


Zoning Map

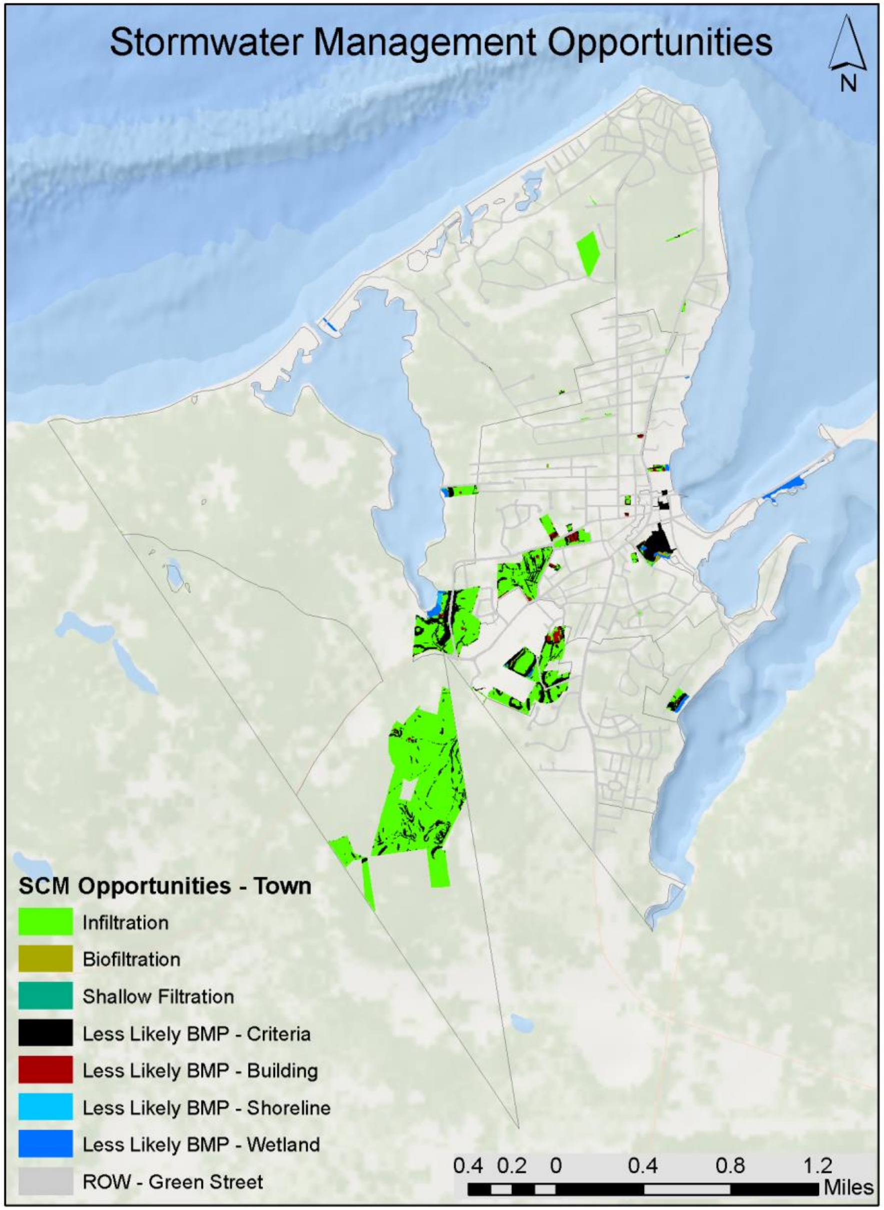


Tisbury Zoning
B1 Business District
B2 Light Business District
W/C Waterfront Commercial
R10 Residential District
R20 Residential District
R25 Residential District
R50 Residential District
R3A Residential District
LHP Lagoon Harbor Park
NZ Not Zoned

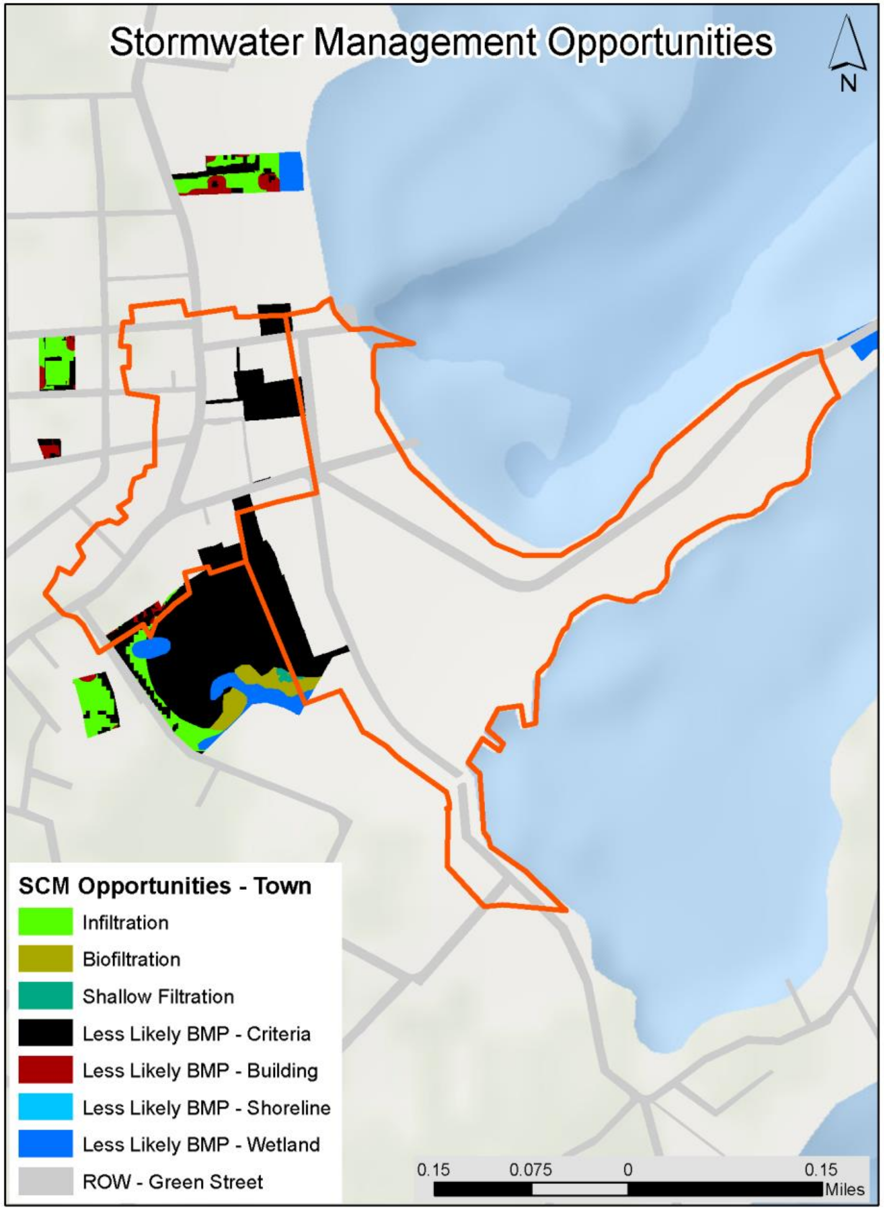
GI SCM Opportunities All B1/WC Districts



GI SCM Opportunities Town Ownership



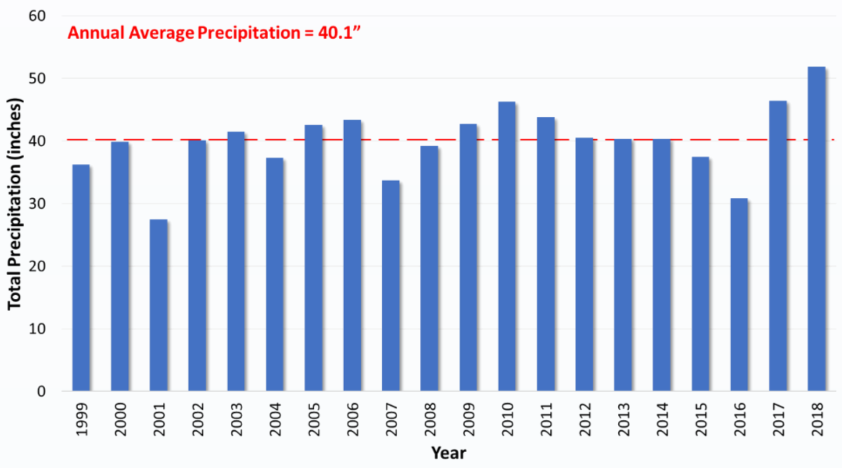
GI SCM Opportunities Town Ownership B1/WC Districts

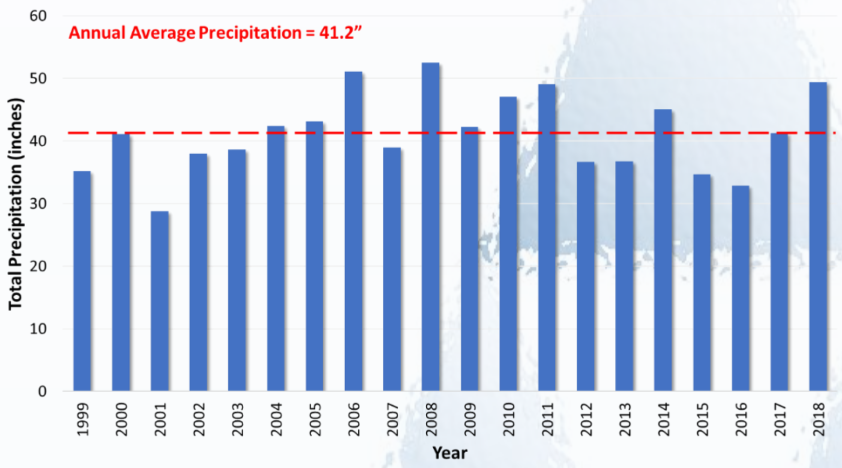


Task 4B. Current State Modeling (Baseline)

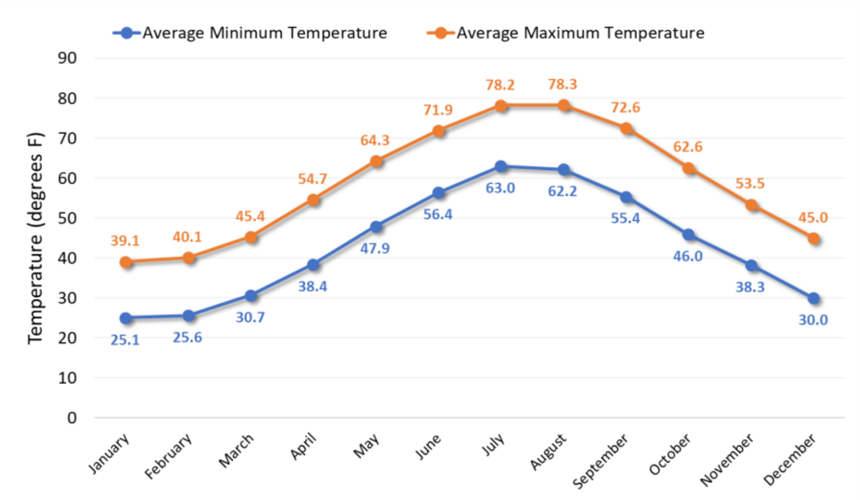
- Local Weather Data (1999 – 2018)
  - Hourly precipitation (in/hr)
  - Daily min/max temperature (^{0}F)
- Opti-Tool Setup
  - SWMM-HRU models (unit-area based)
  - Update weather data
  - Run SWMM models for 33 HRU categories
- Opti-Tool Results
  - SWMM output timeseries (Flow and TN)
  - Convert hourly HRU timeseries to Opti-Tool required format
  - Summary analysis (heat maps)

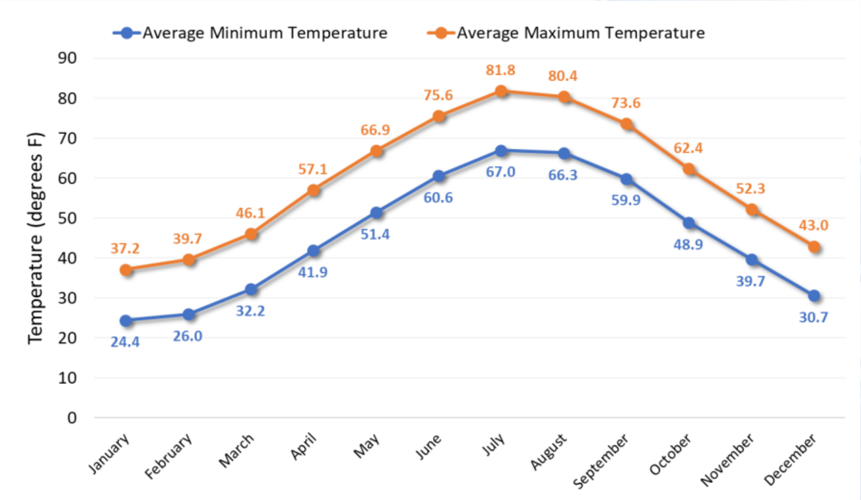
Martha’s Vineyard (left) vs Boston Logan (right)





Martha’s Vineyard (left) vs Boston Logan (right)





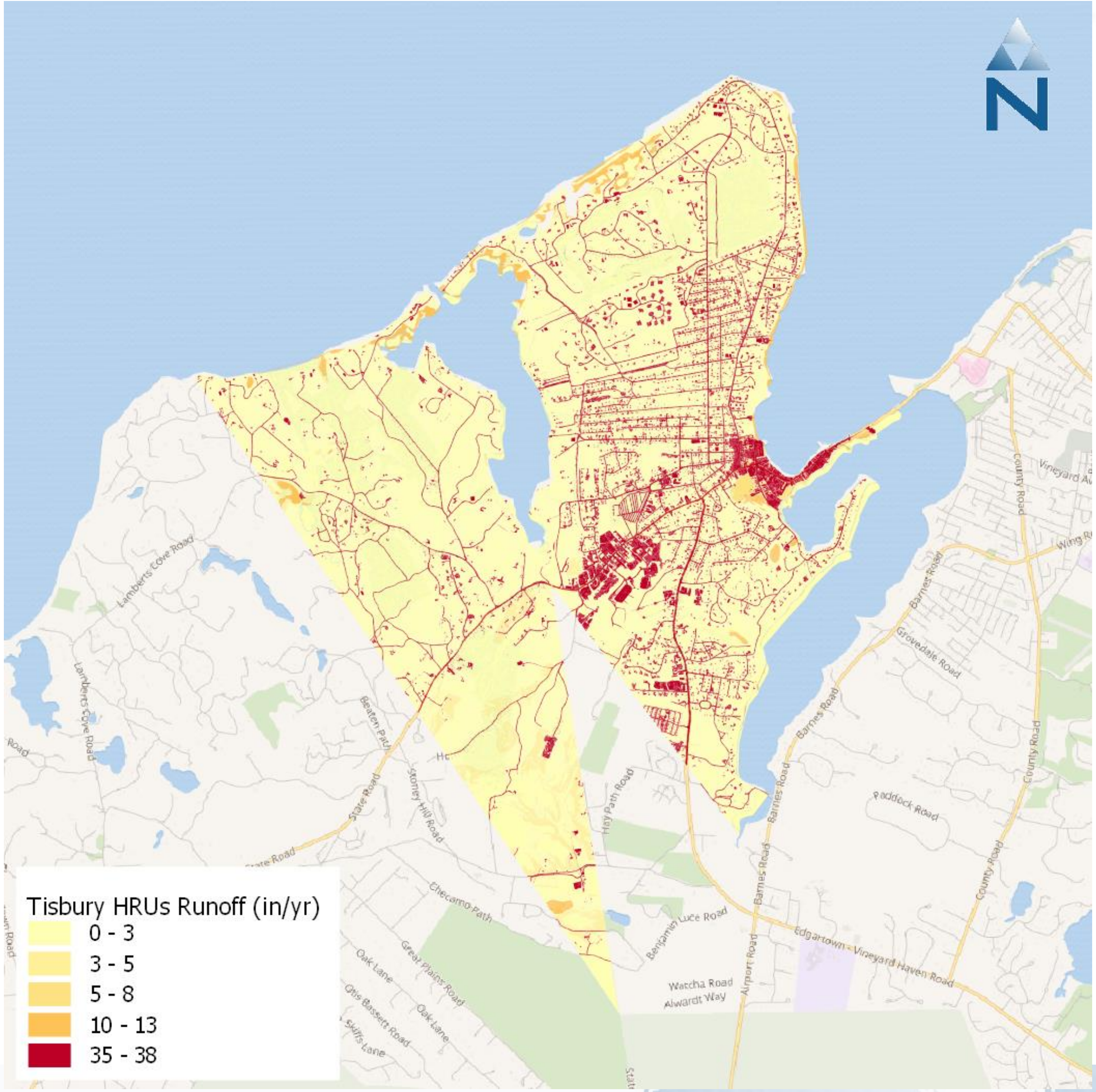
Daily Precipitation Percentile Depth (1999 - 2018)

Daily Precipitation Depth (in.)	Percentile Depth	
	Martha's Vineyard Airport	Boston Logan Airport
0.10	48.5%	42.1%
0.25	66.0%	61.7%
0.50	80.3%	77.7%
0.75	87.9%	87.1%
1.00	92.5%	92.4%
1.50	96.9%	97.0%
2.00	98.7%	98.6%
3.00	99.7%	99.7%

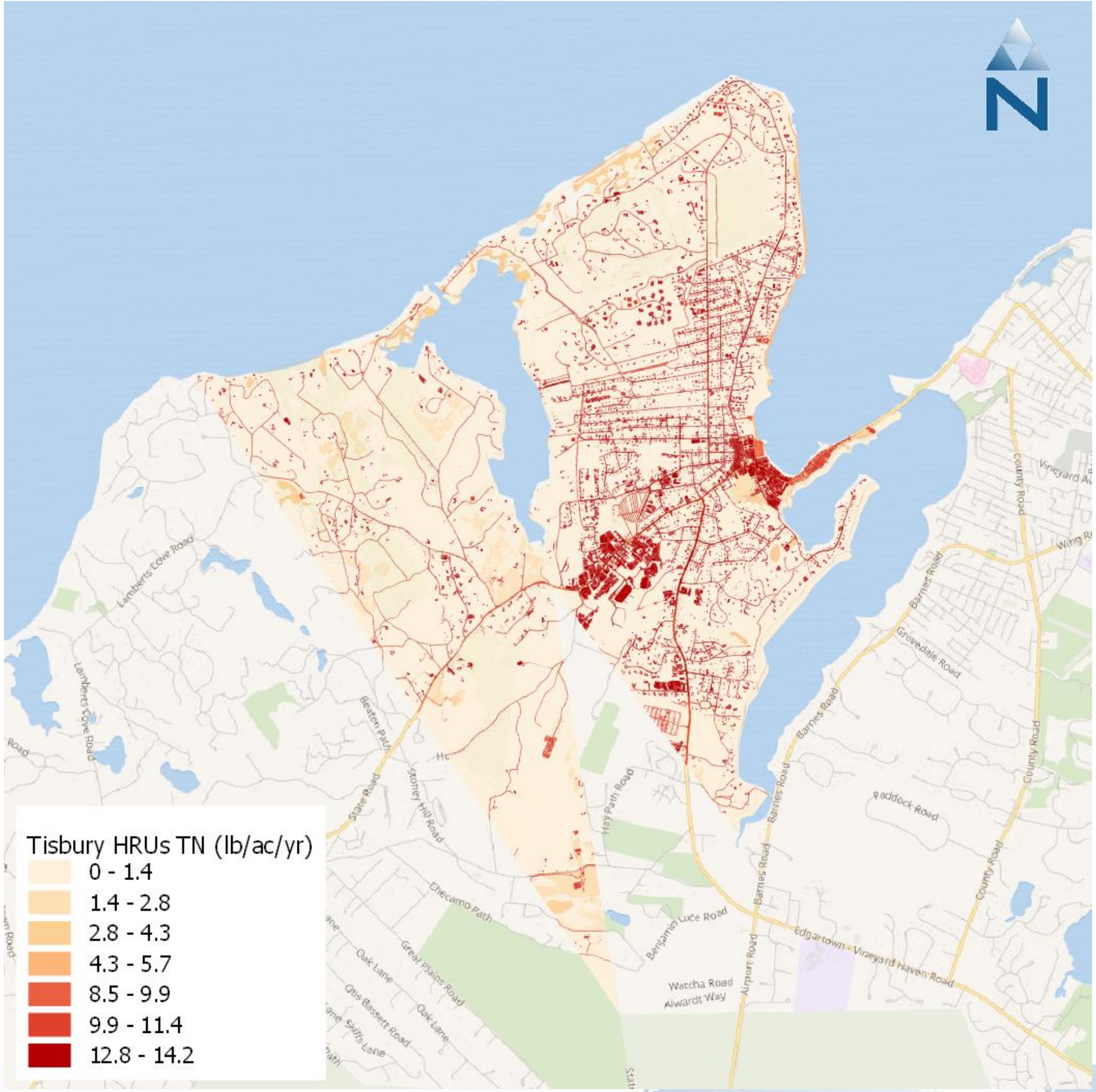
Opti-Tool HRUs

HRU ID	HRU CODE	HRU Description	Flow (in/yr)	TN (lb/ac/yr)
1	13110	Agriculture Pervious-A-Low	0.72	0.92
2	13120	Agriculture Pervious-A-Med	0.90	1.44
3	13130	Agriculture Pervious-A-High	0.97	1.66
4	13210	Agriculture Pervious-B-Low	2.30	2.82
5	13220	Agriculture Pervious-B-Med	2.70	3.77
6	13230	Agriculture Pervious-B-High	2.84	4.02
7	2001	Agriculture Impervious	37.53	10.65
8	12110	Forest Pervious-A-Low	0.72	0.19
9	12120	Forest Pervious-A-Med	0.90	0.28
10	12130	Forest Pervious-A-High	0.97	0.32
11	12210	Forest Pervious-B-Low	2.30	0.58
12	12220	Forest Pervious-B-Med	2.70	0.76
13	12230	Forest Pervious-B-High	2.84	0.81
14	1001	Forest Impervious	37.53	10.65
15	11110	Developed Pervious-A-Low	0.31	0.15
16	11120	Developed Pervious-A-Med	0.40	0.22
17	11130	Developed Pervious-A-High	0.44	0.25
18	11210	Developed Pervious-B-Low	2.30	1.23
19	11220	Developed Pervious-B-Med	2.70	1.63
20	11230	Developed Pervious-B-High	2.84	1.74
21	11310	Developed Pervious-C-Low	5.41	2.54
22	11320	Developed Pervious-C-Med	6.11	3.07
23	11330	Developed Pervious-C-High	6.39	3.23
24	11410	Developed Pervious-D-Low	10.25	3.94
25	11420	Developed Pervious-D-Med	11.15	4.56
26	11430	Developed Pervious-D-High	11.48	4.71
27	3001	Commercial	37.53	14.19
28	4001	Industrial	37.53	14.19
29	5001	Low Density Residential	37.53	13.26
30	6001	Medium Density Residential	37.53	13.26
31	7001	High Density Residential	37.53	13.26
32	8001	Highway	37.53	9.55
33	9001	Open Space	37.53	10.65

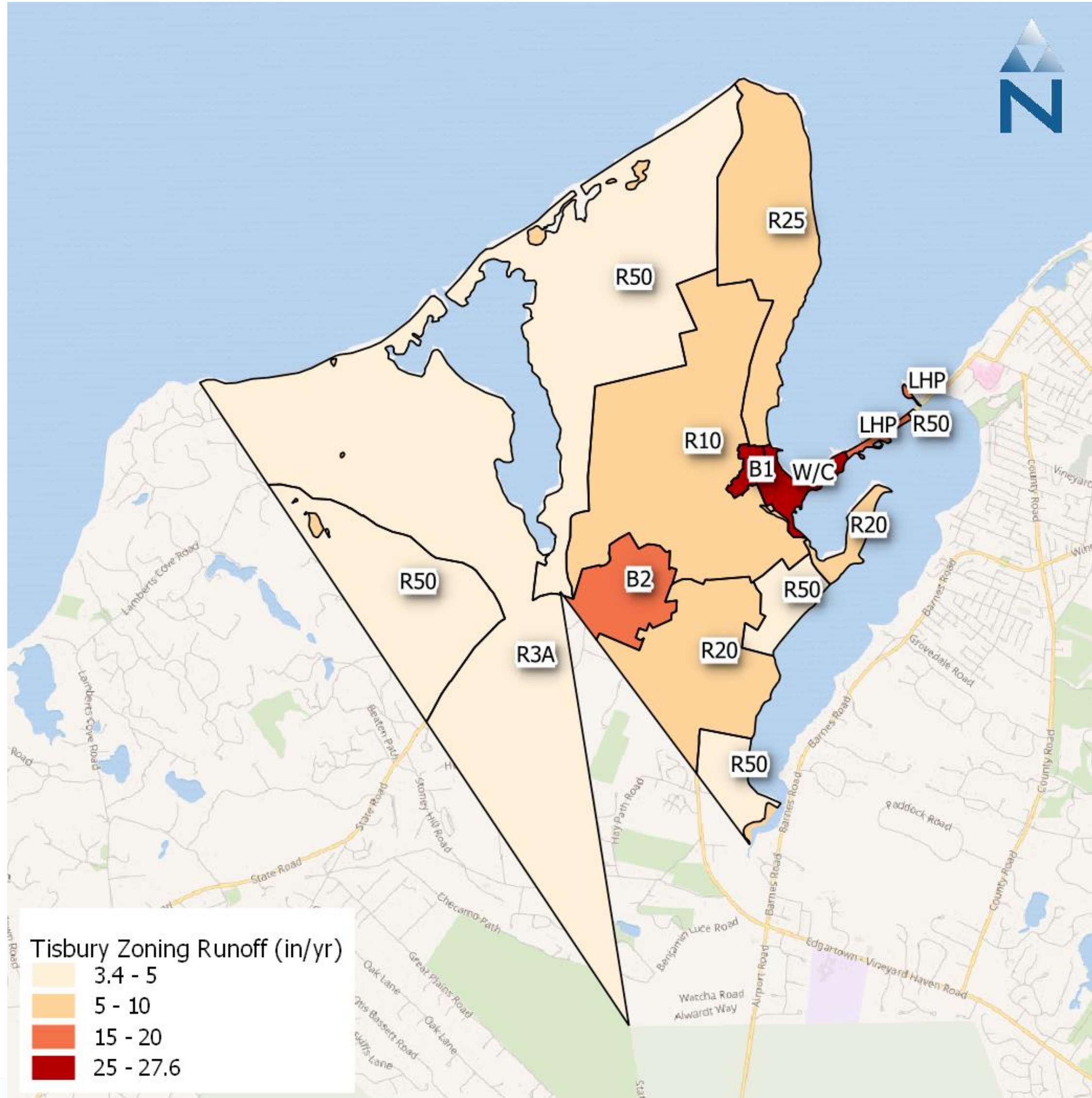
Runoff by HRU Category



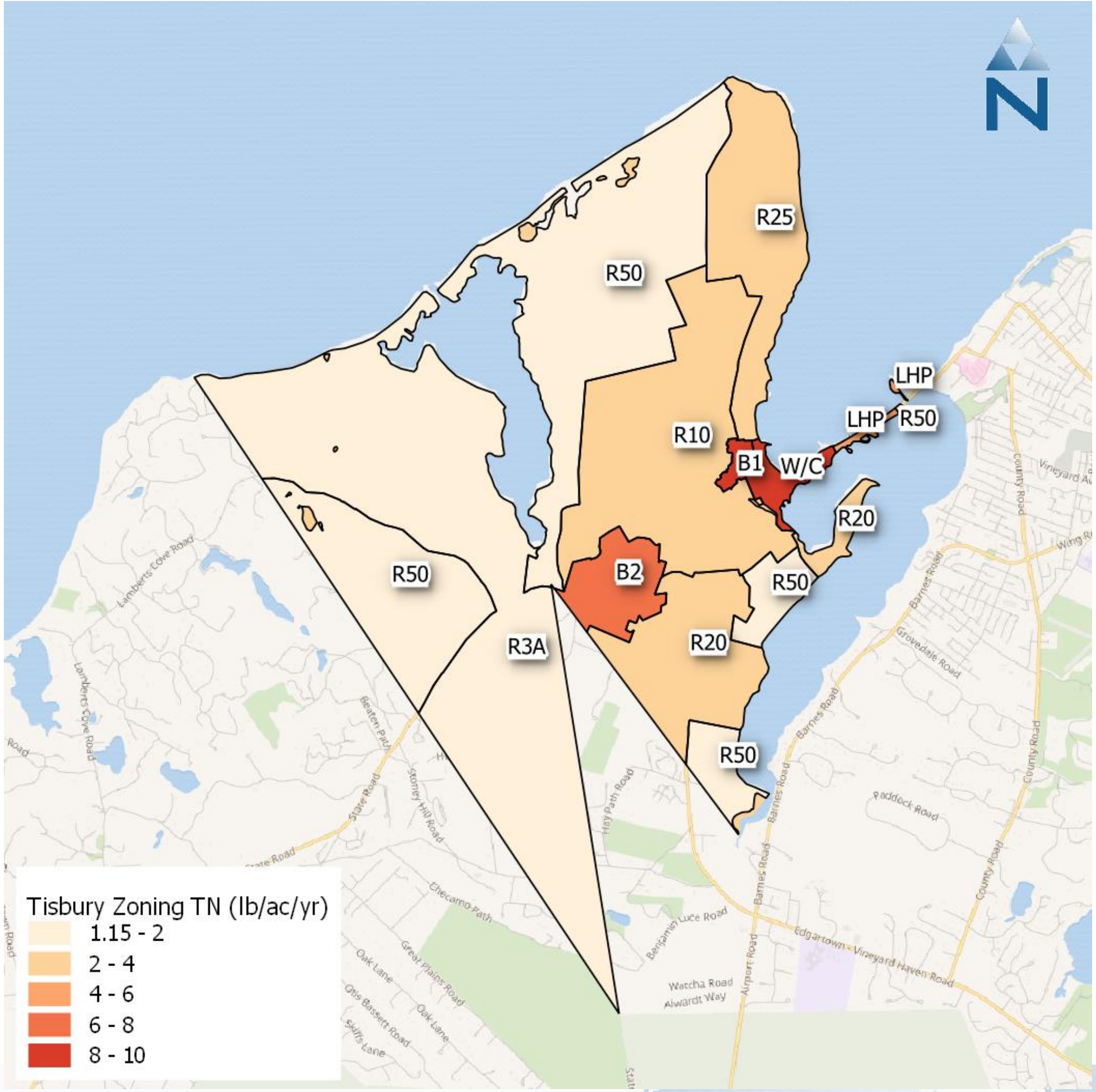
Total Nitrogen by HRU Category



Runoff by Zoning District



Total Nitrogen by Zoning District



Task 4C. Evaluate Source Area Contributions and GI SCM Reduction Benefits at Outfall #2 & #7

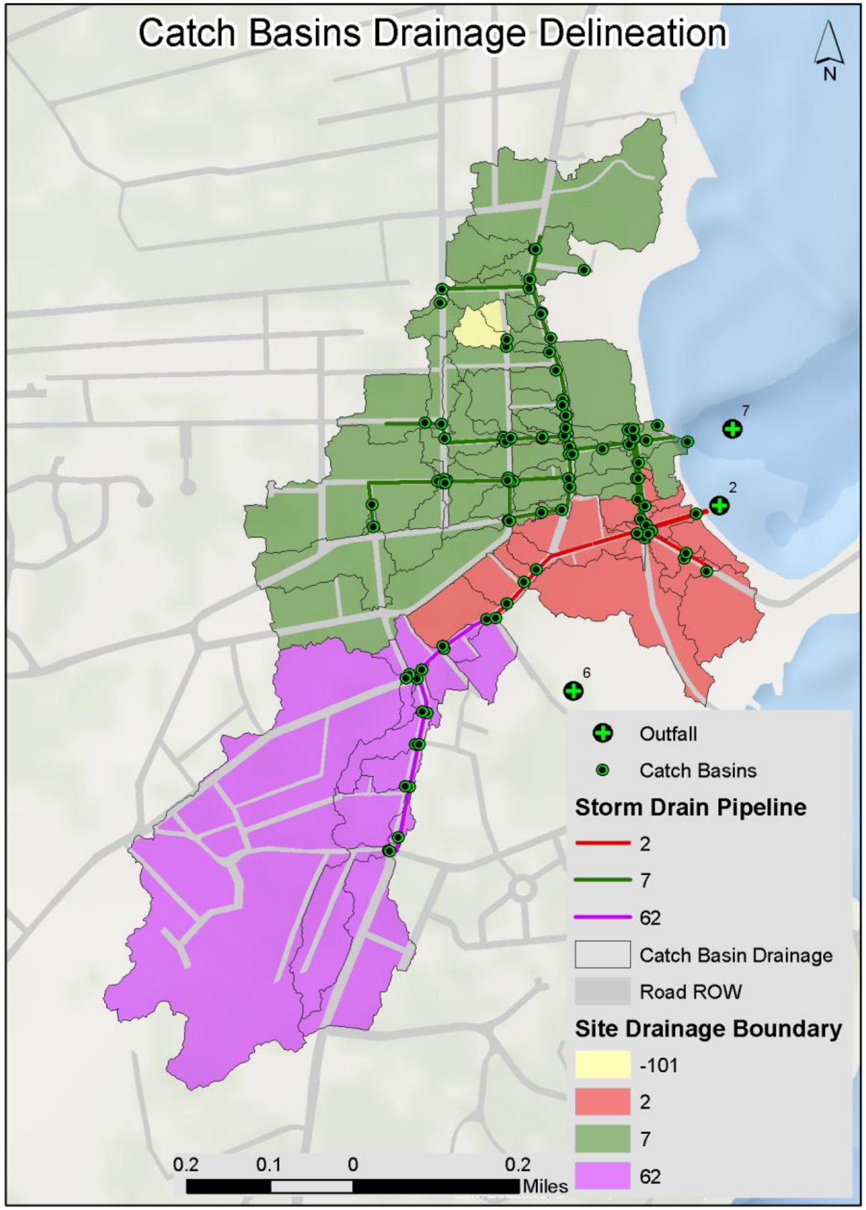
Opti-Tool Application
- Outfall #2 and #7 assessment points

Establish Baseline Condition
- Stormwater pipe routing network
- Catch basins delineation
- HRU area tabulation

Run GI SCM Scenarios
- Identify GI SCM opportunities
- GI SCM concept designs
- SCM treated areas

Evaluate the effectiveness of GI SCM (annual based)
- Groundwater recharge
- Flow volume reduction
- TN load reduction

Catch Basins Drainage Delineation



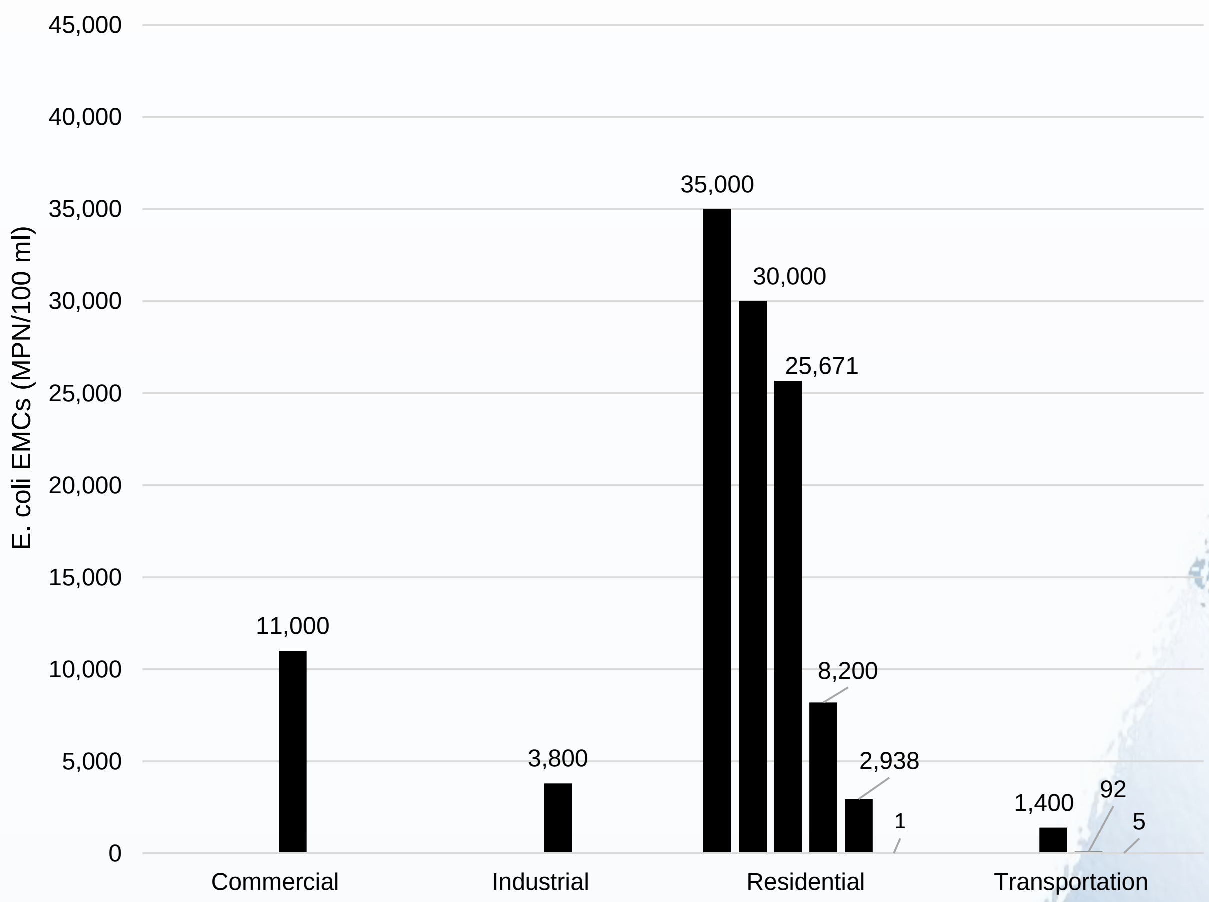
Next Steps

- Finalize the catchment boundaries
- Identify GI SCM opportunities and treatment sub-areas in each catchment
- Tabulate HRU area distribution in each catchment and GI SCM sub-areas
- Analyze catch basins and storm drainage pipes specification (size, invert level, diversion)
- Develop flow routing network
- Setup and run Opti-Tool model with and without GI SCM.
- Summarize Opti-Tool results

Task 4D. SCM Performance Curves for Bacteria

- Review Literature
  - Event Mean Concentrations
  - Export Rates
  - Buildup/Washoff Values
  - SCM efficiencies
- Run SWMM with Buildup/Washoff Values for Bacteria
- Compare Simulated Concentrations and Loads to Literature Values
- Use Opti-Tool to develop performance curves based on SWMM timeseries and published SCM efficiencies

Observed EMCs



Locations include: CA,NC,MA,TN,TX,WA,WI,MD

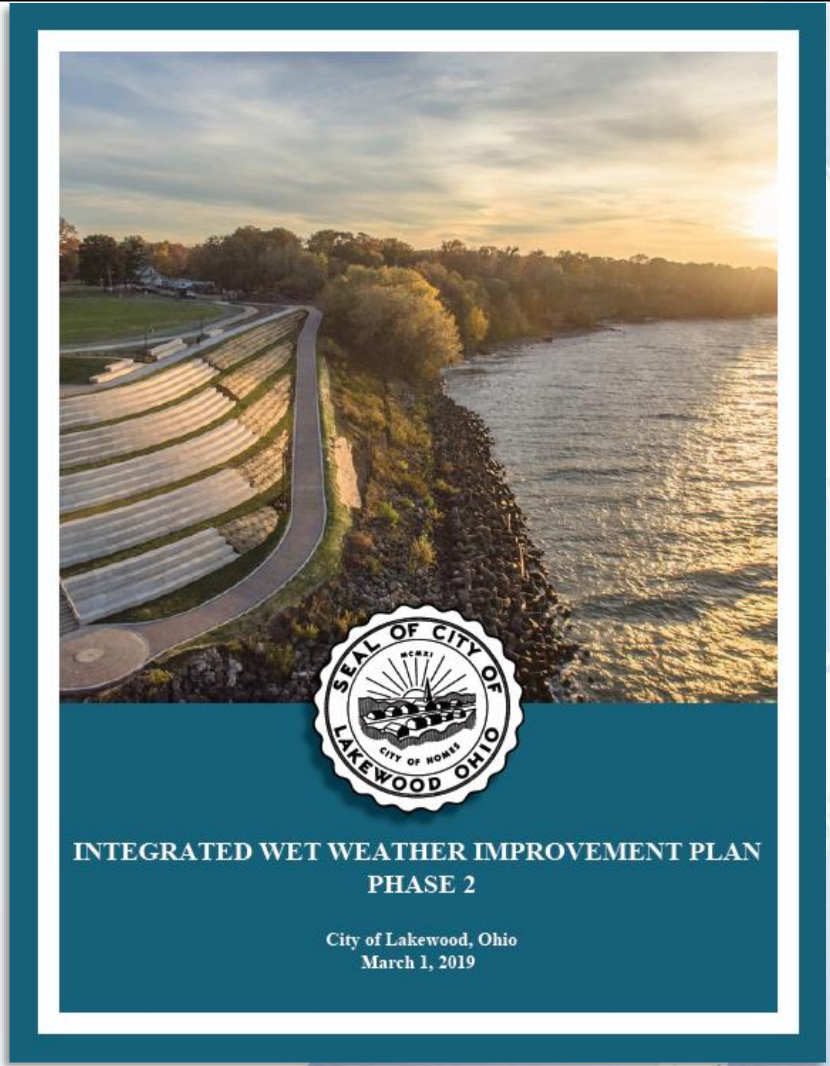
Sources: Stein, 2008; Krometis et al.,2009; NSQD; Hathaway and Hunt, 2010; Schueler, 2000, McCarthy et al., 2012; Li and Davis, 2009

Observed Loadings

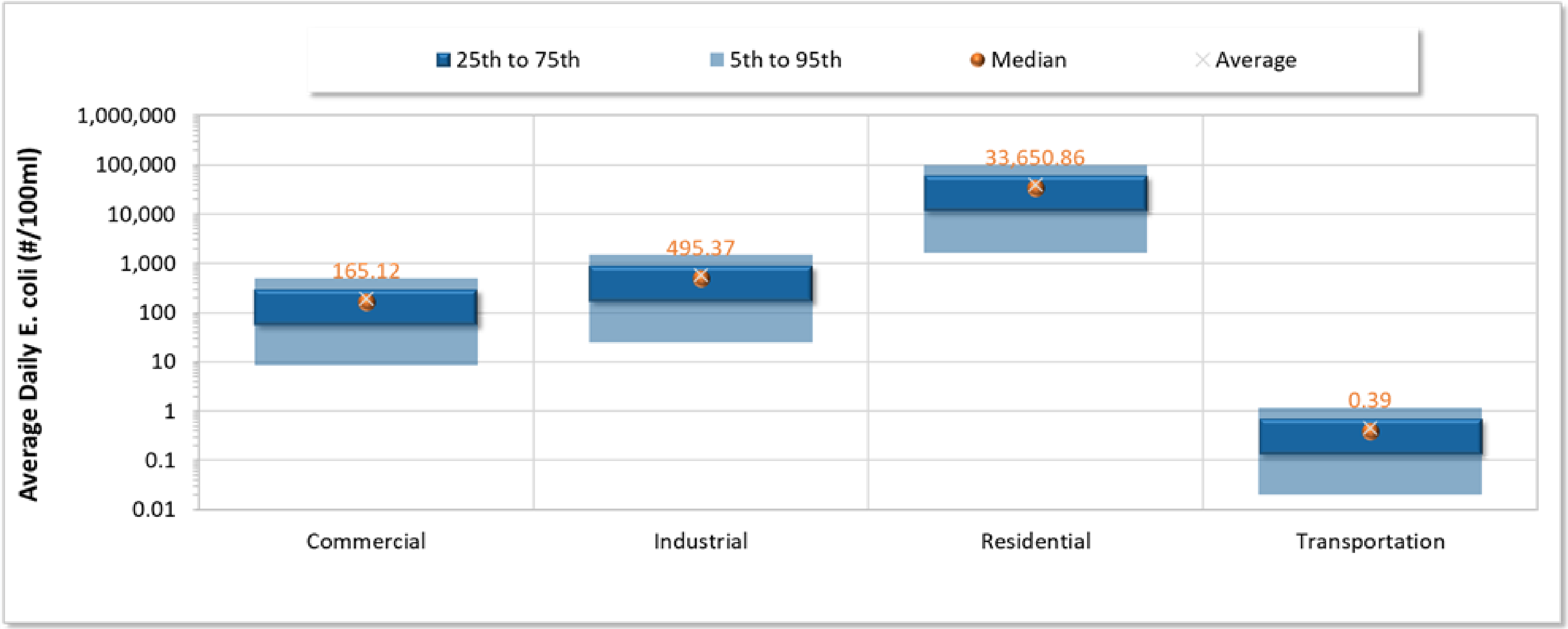
	Land use	Billion MPN/ac/yr	Source
Fecal Coliform	Urban	190.024 – 477.654	(Line et al, 2008)
E. coli	Open Urban	13.789 – 60.482	(EA Engineering, 2010)
	Residential/Commercial	9.00 – 3.80	
	Various	22 - 1,397	CDM Smith, 2012*

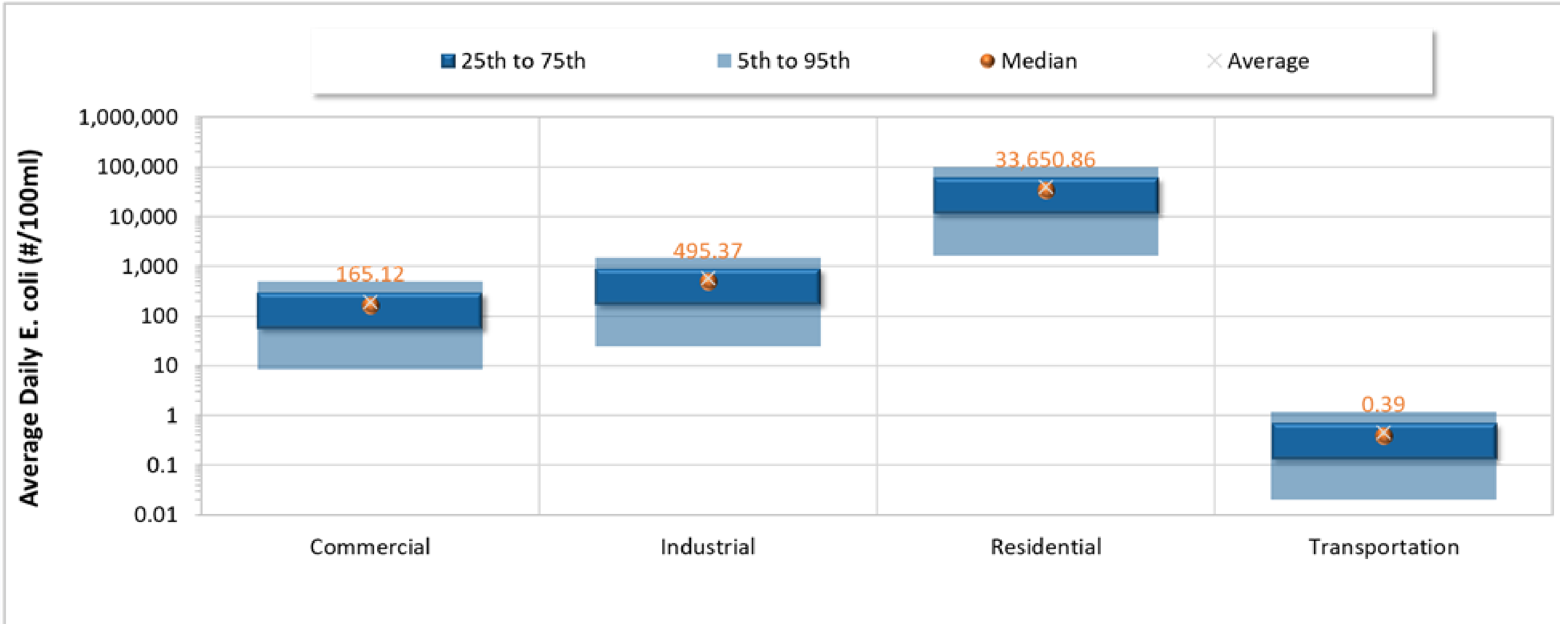
* Units in CFUs, not MPN

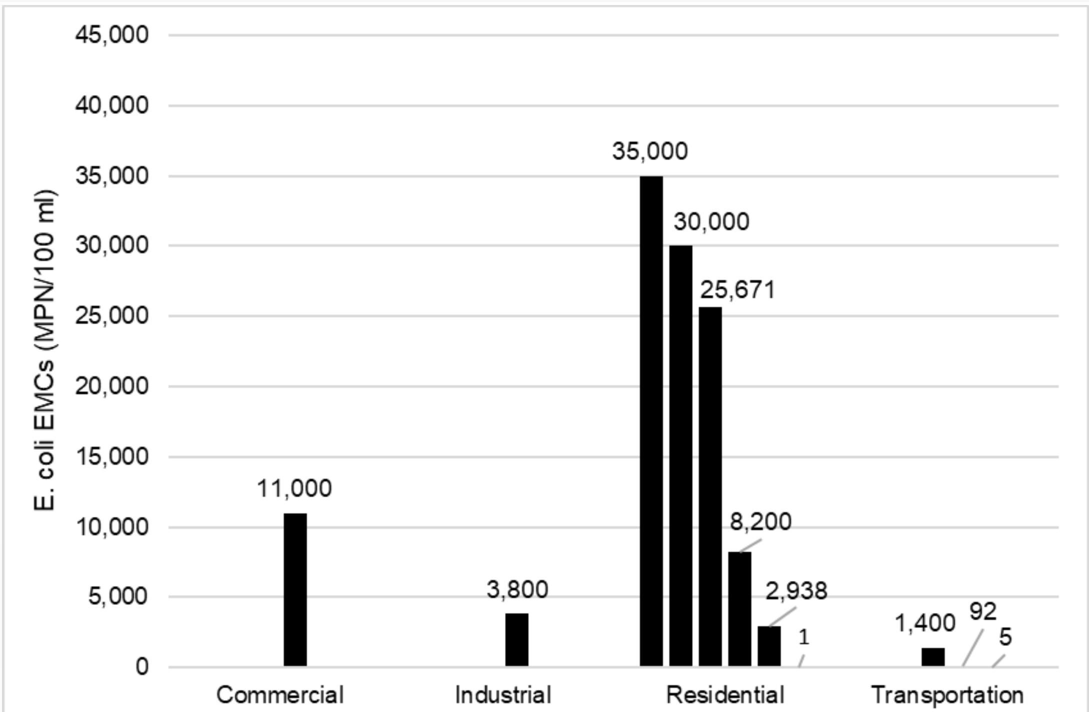
Previous applications of SWMM studies for bacteria



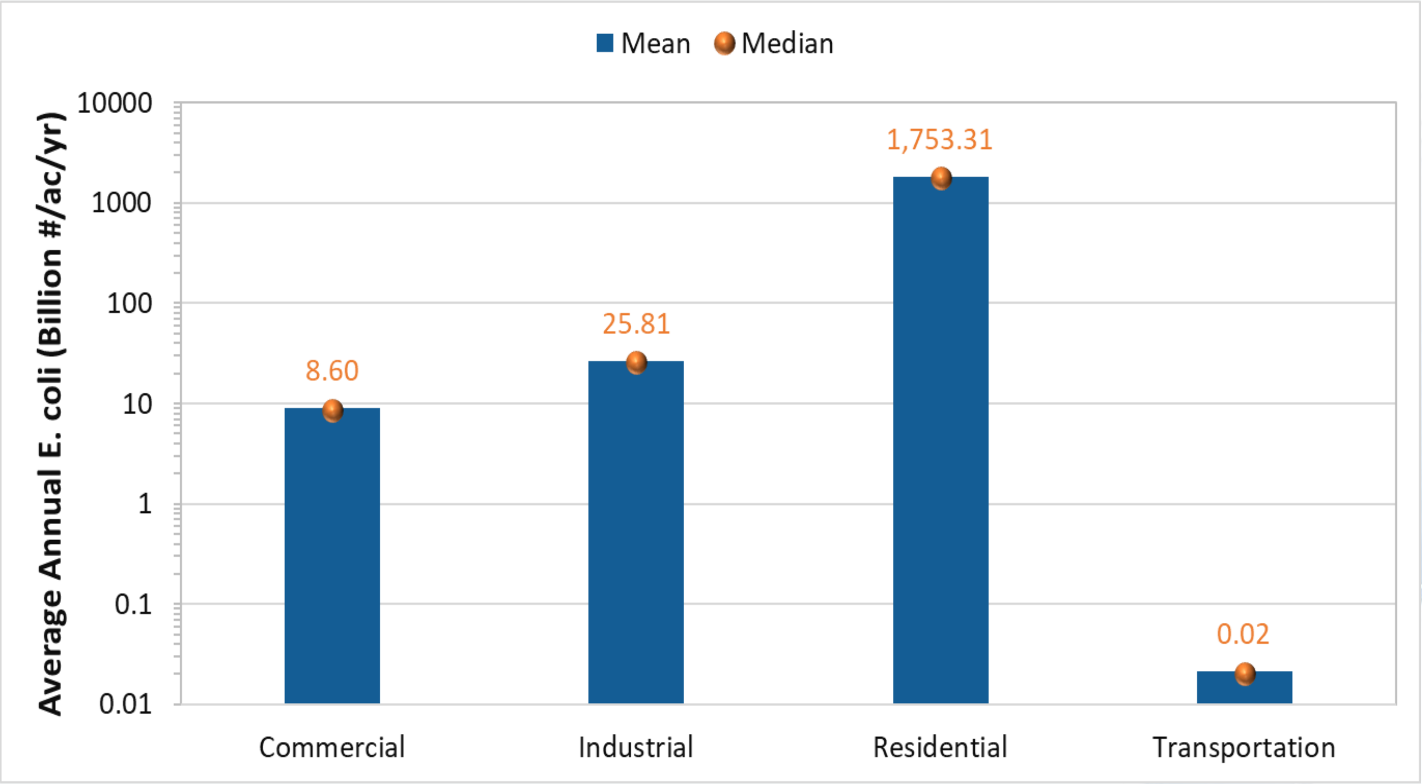
Simulated EMCs




25th to 75th
5th to 95th
Median
Average
Average Daily E. coli (#/100ml)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
165.12
495.37
33,650.86
0.39
Commercial
Industrial
Residential
Transportation


E. coli EMCs (MPN/100 ml)
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
11,000
3,800
35,000
30,000
25,671
8,200
2,938
1
1,400
92
5
Commercial
Industrial
Residential
Transportation

Simulated Loading

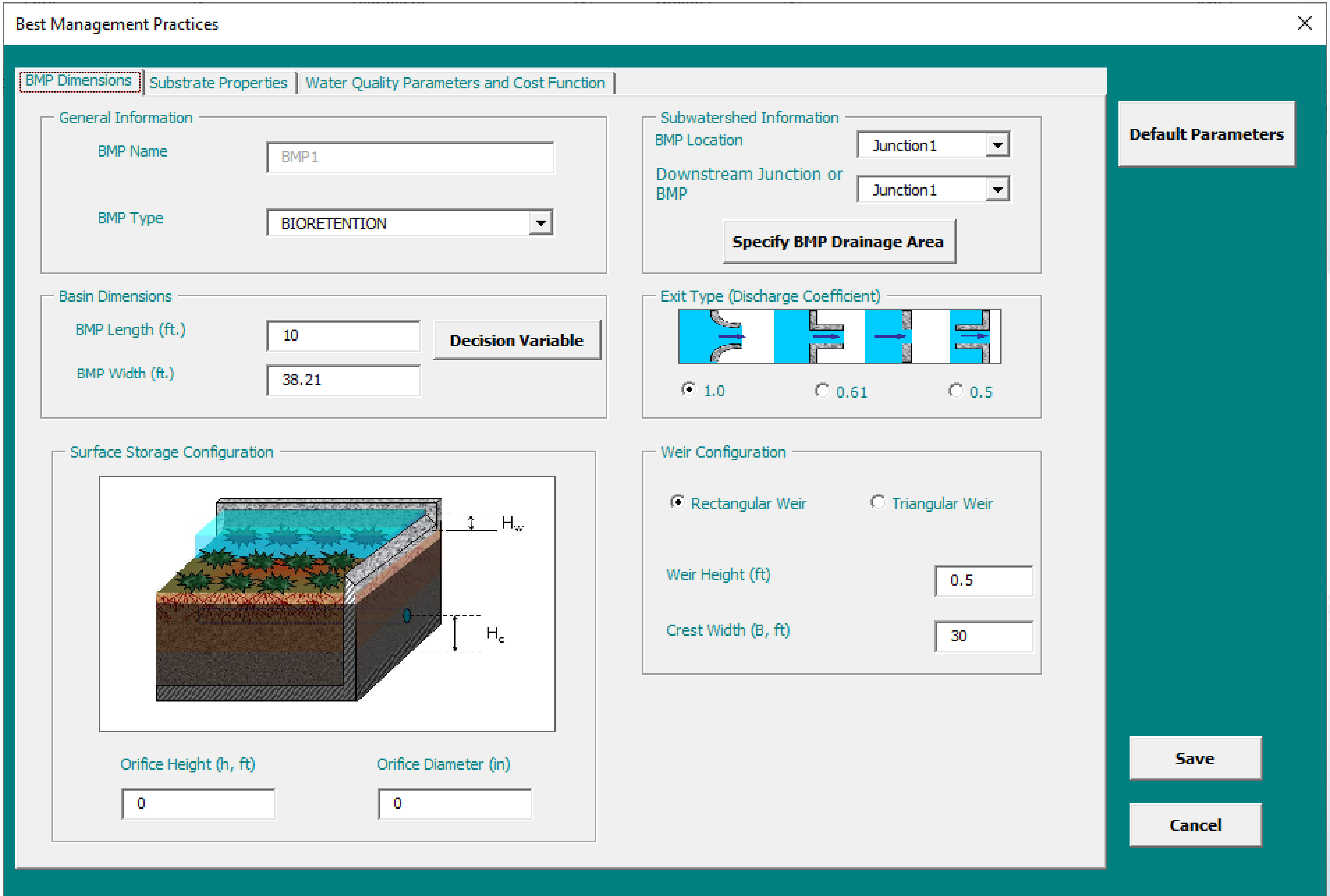


Observed range: 9 – 1,397 Billion/ac/yr

	SCM with published efficiency data							Location	Source
	Bioretention	Grass swale	Dry detention	Media Filter	Wet Pond	Wetland	Wetland/ Retention Pond		
	Opti-Tool equivalent								
	Biofiltration Biofiltration with ISR	NA	Dry Pond	Infiltration Basin/Trench, Sand Filter	Wet Pond	Subsurface gravel wetland	Wet Pond		
E. coli	0.71							NC	Hunt et al., 2008
	0.48 – 0.97							TX	Kim et al., 2012
	0.72 – 0.97							Laboratory & synthetic stormwater	Zhang et al., 2011
	0.71		0.05 - 0.14		0.18	0.22-0.92		North Carolina	Hathaway et al. 2008
	0.80	-0.26	0.64*	0.76*	0.96	0.64	0.80 – 0.96	National	Clary et al., 2017

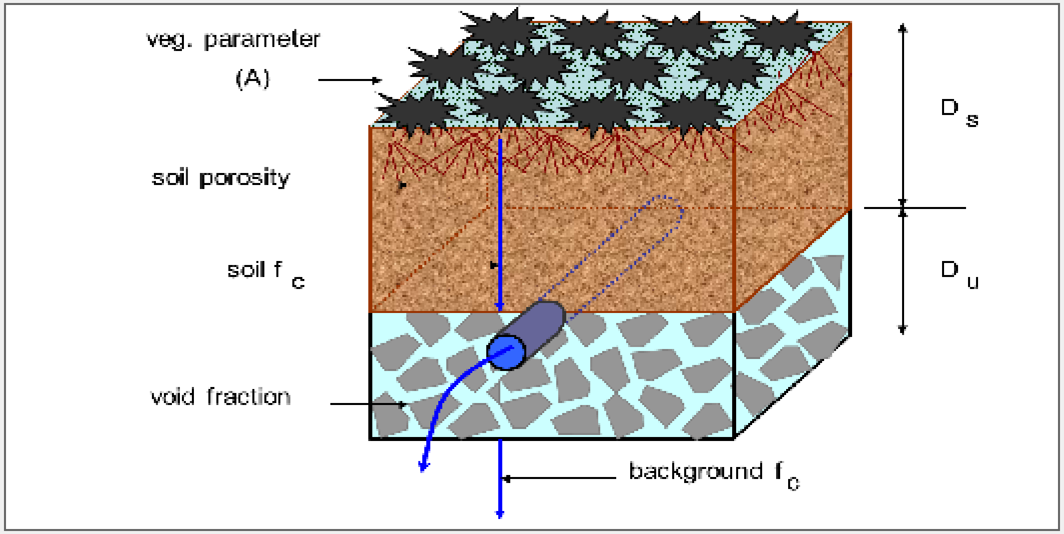
*Data for fecal coliform

- Major mechanisms for bacteria removal
  - Sorption
  - Sedimentation
  - Filtration
- Several factors impact bacteria removal in SCMs
  - Holding time
  - Sunlight
  - Salinity
  - Temperature
  - Predation
- SCMs can be a *source* of bacteria
- SMCs that use filtration and infiltration may perform better than those relying on settling processes


Best Management Practices
BMP Dimensions
Substrate Properties
Water Quality Parameters and Cost Function
General Information
BMP Name
BMP1
BMP Type
BIORETENTION
Subwatershed Information
BMP Location
Junction1
Downstream Junction or BMP
Junction1
Specify BMP Drainage Area
Default Parameters
Basin Dimensions
BMP Length (ft.)
10
Decision Variable
BMP Width (ft.)
38.21
Exit Type (Discharge Coefficient)
1.0
0.61
0.5
Surface Storage Configuration
H_w
H_c
Weir Configuration
Rectangular Weir
Triangular Weir
Weir Height (ft)
0.5
Crest Width (B, ft)
30
Orifice Height (h, ft)
0
Orifice Diameter (in)
0
Save
Cancel

Best Management Practices

BMP Dimensions | Substrate Properties | Water Quality Parameters and Cost Function



Default Parameters

Soil Properties

DS - Depth of Soil (ft)	2.5
Soil Porosity (0-1)	0.2
Vegetative Parameter A	0.9
FC - Soil Infiltration (in/hr)	2.5

If underdrain is off, then the FC - Soil Infiltration (in/hr) is the FC - Background Infiltration (in/hr).

Underdrain Properties

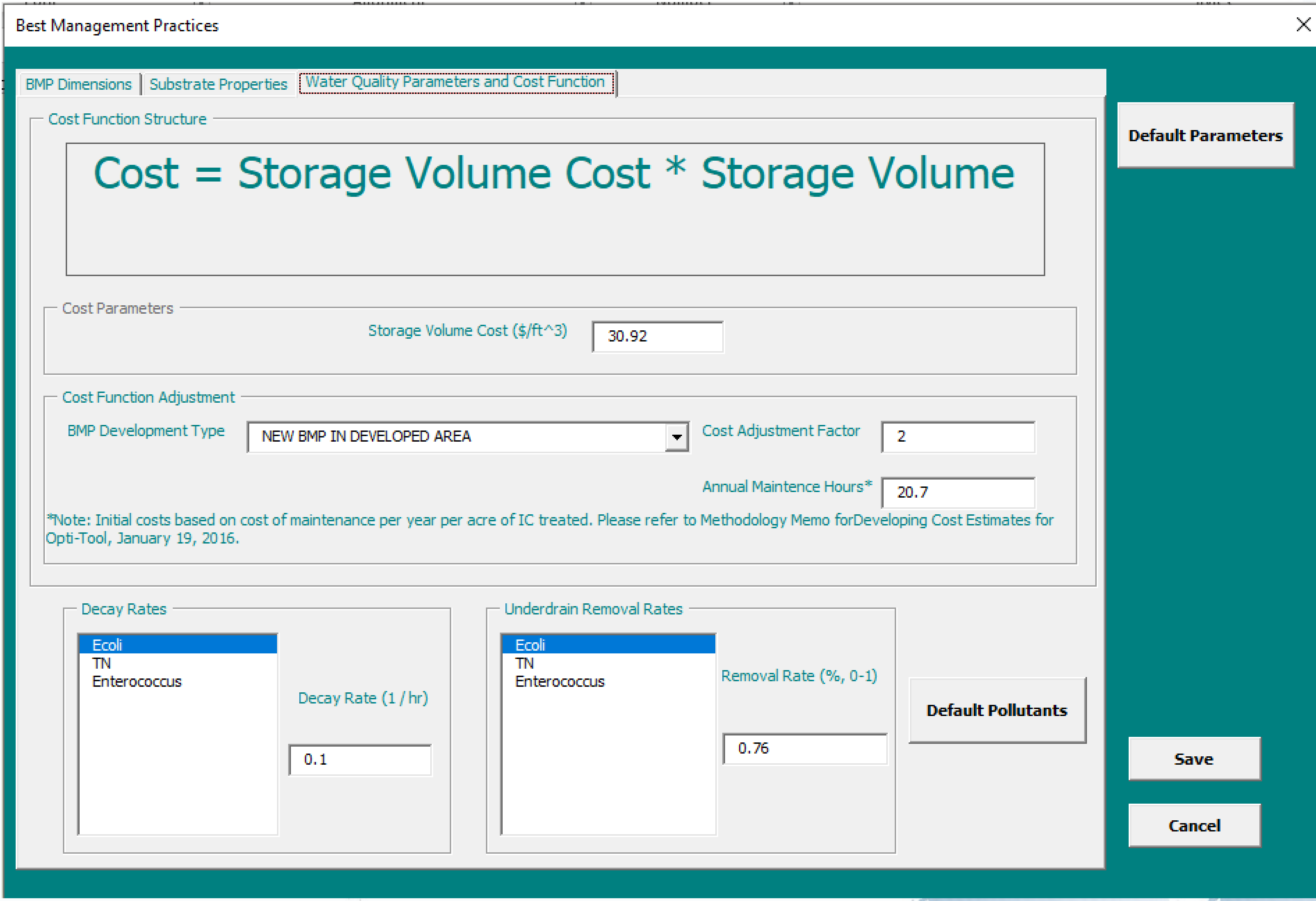
☑ Condiser Underdrain Structure?

Update Eff. Depth

DU - Storage Depth (ft)	1
Media Void Fraction (0-1)	0.4
FC - Background Infiltration (in/hr)	0

Save

Cancel


Best Management Practices
BMP Dimensions
Substrate Properties
Water Quality Parameters and Cost Function
Cost Function Structure
Cost = Storage Volume Cost * Storage Volume
Cost Parameters
Storage Volume Cost ($/ft^3)
30.92
Cost Function Adjustment
BMP Development Type
NEW BMP IN DEVELOPED AREA
Cost Adjustment Factor
2
Annual Maintence Hours*
20.7
*Note: Initial costs based on cost of maintenance per year per acre of IC treated. Please refer to Methodology Memo forDeveloping Cost Estimates for Opti-Tool, January 19, 2016.
Decay Rates
Ecoli
TN
Enterococcus
Decay Rate (1 / hr)
0.1
Underdrain Removal Rates
Ecoli
TN
Enterococcus
Removal Rate (%, 0-1)
0.76
Default Parameters
Default Pollutants
Save
Cancel

- 400 simulations later…

Photo credit: Minnesota Pollution Control Agency

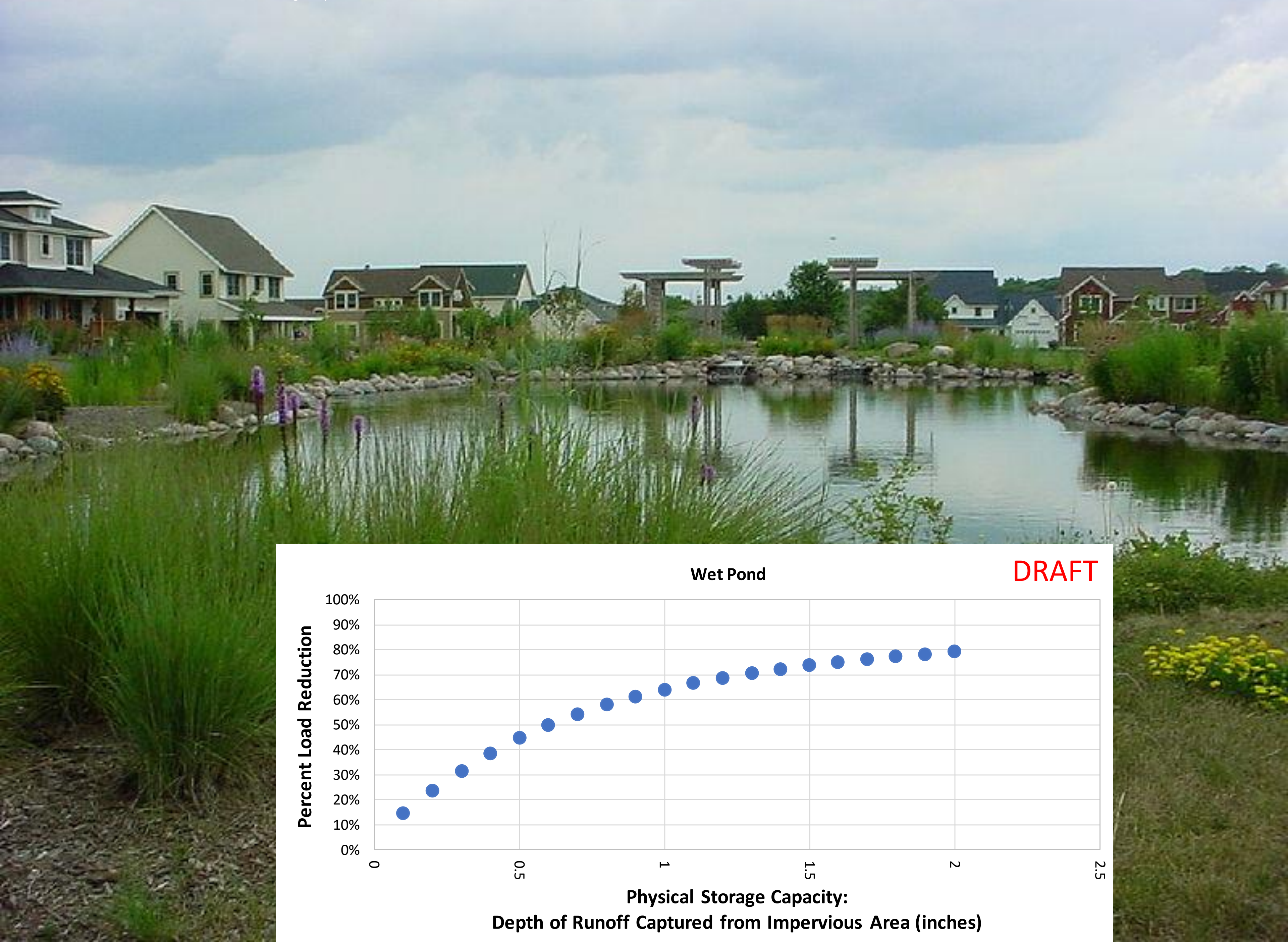


Photo credit: Minnesota Pollution Control Agency

Feasible SCM Controls and Management Strategies

Additional Field Investigations / Concept Designs

Lunch Break

Watershed Tour

An Integrated Stormwater Management Approach for Promoting Urban Community Sustainability and Resilience