Tisbury MA Impervious Cover Disconnection (ICD) Project

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

Task 3 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

A Technical Direct Assistance Project funded by the U.S. EPA Southern New England Program (SNEP)

Nov 29, 2018

Challenges and Practical Solutions to Managing Municipal Stormwater Systems

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Stories from the end of the pipe

Project Partners

- City of Dover, NH Staff
- UNH Stormwater Center
- NH Department of Environmental Services
- Environmental Protection Agency, Region 1

Berry Brook Watershed Management Plan –Implementation Projects Phase III

Final Report to
The New Hampshire Department of Environmental Services
Submitted by

The City of Dover and the UNH Stormwater Center
December, 2017

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https://www.unh.edu/unhsc/berry-brook-project

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BMPs

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Installations include:

- 12 bioretention systems,
- a tree filter,
- a subsurface gravel wetland,
- one acre of new wetland,
- daylighted and restored 1,100 linear feet of stream at the headwaters and restored 500 linear feet of stream at the confluence including two new geomorphically-designed stream crossings
- 3 grass-lined swales
- 2 subsurface gravel filters
- an infiltration trench system
- 3 innovative filtering catch basin designs

Funding and Results

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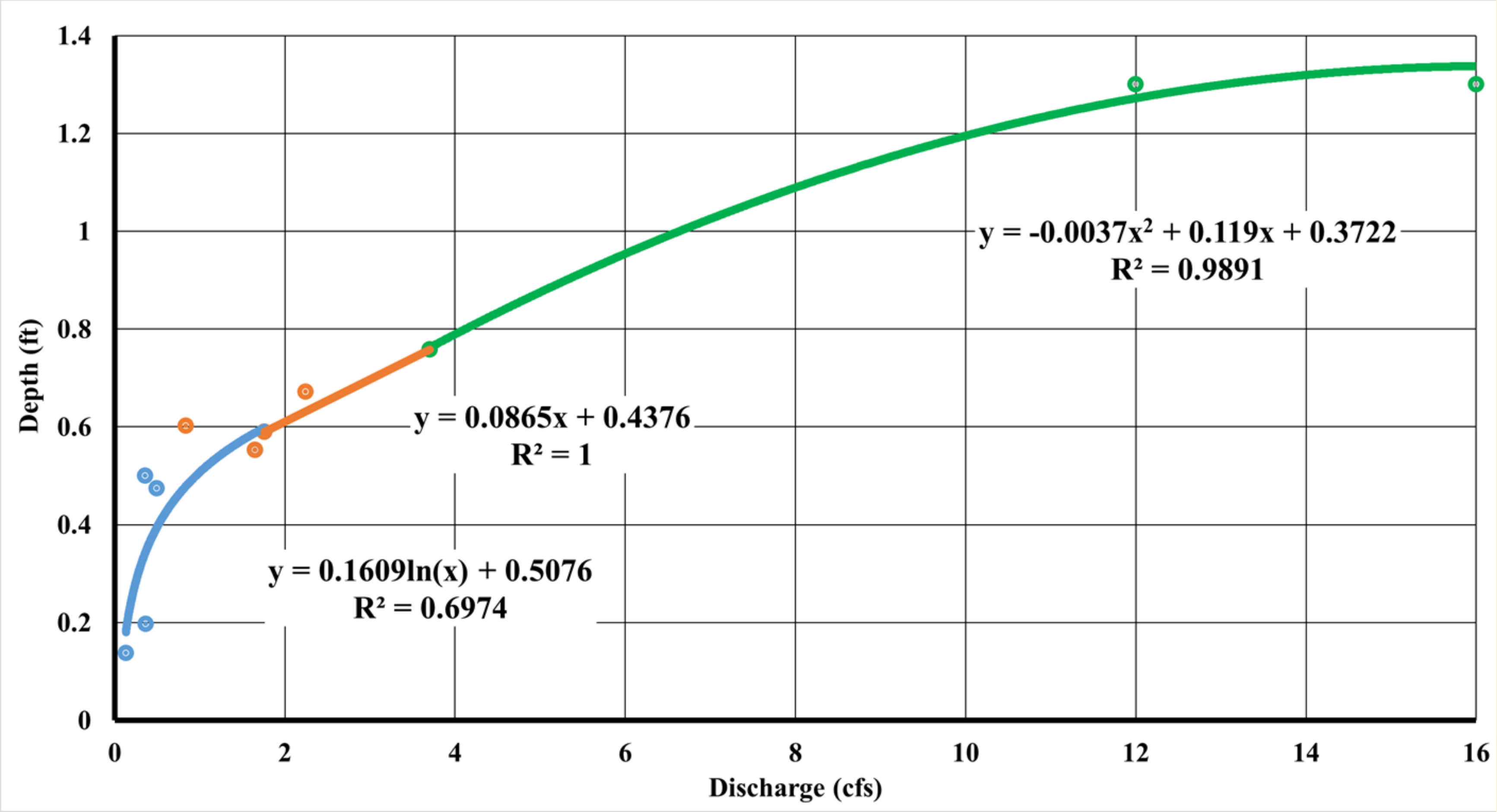
Funding: 3 watershed assistance grants (sec 319) and 1 aquatic resource mitigation grant, all with min 40% match from the city.

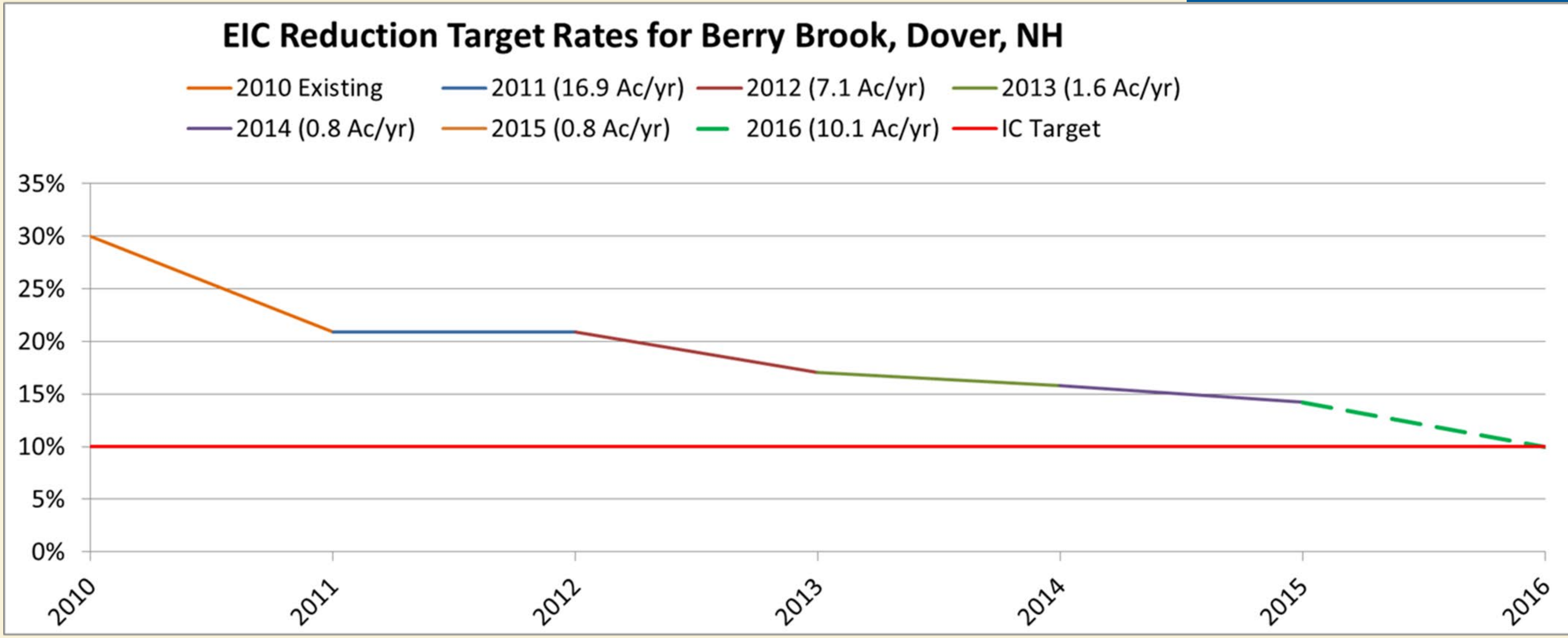
Berry Brook Project: Getting to 10%	
Cost	$1,322,000
Grant Funds	$793,000
Match (min estimate)	529,000
BMPs	26
DCIA Reduced	37 acres
TSS Reductions (lb./yr.)	57,223
TP Reductions (lb./yr.)	201
TN Reductions (lb./yr.)	1,127

Hydrology

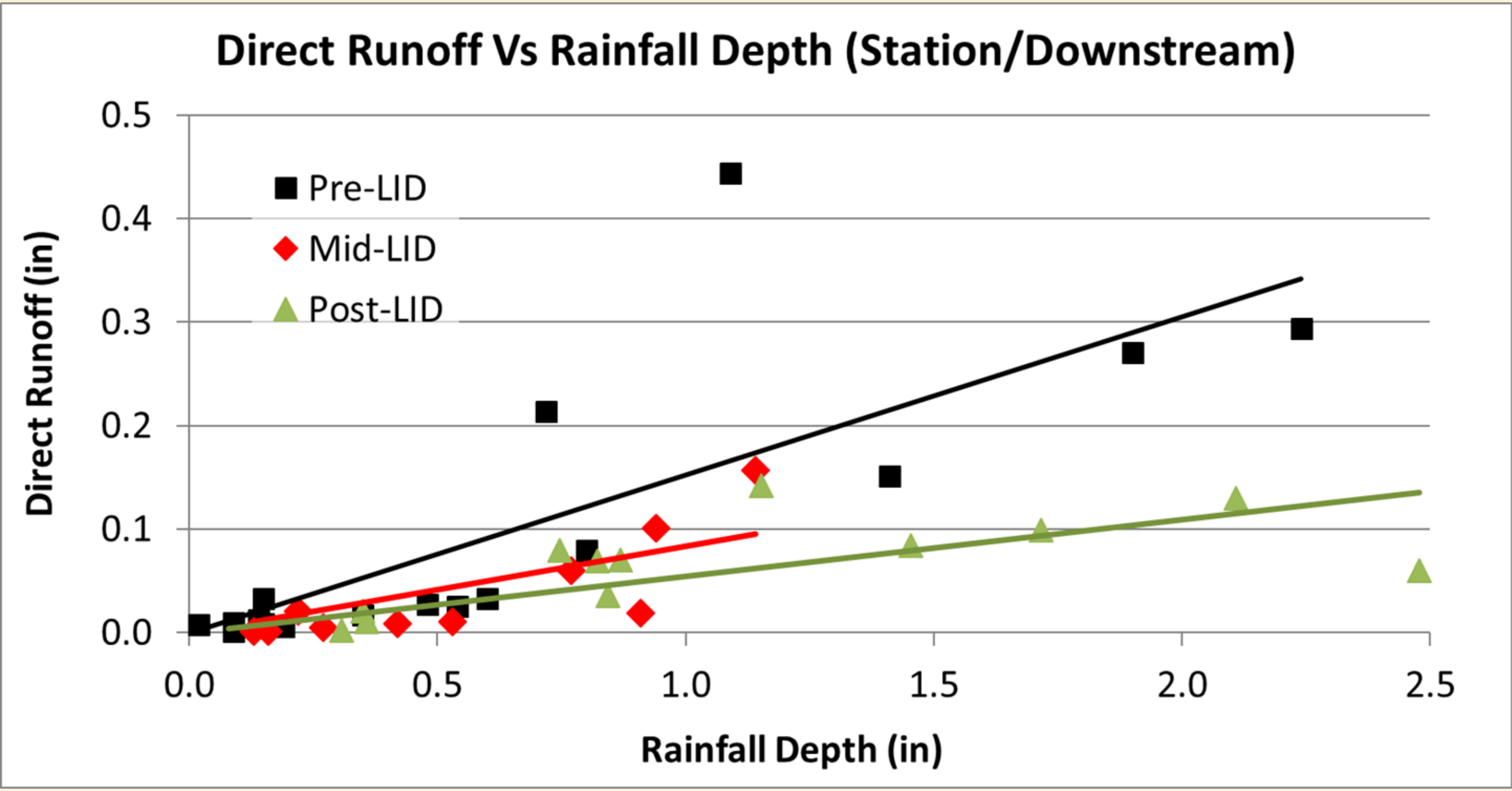


1.4
1.2
1
0.8
0.6
0.4
0.2
0
Depth (ft)
0
2
4
6
8
10
12
14
16
Discharge (cfs)
y = -0.0037x² + 0.119x + 0.3722
R² = 0.9891
y = 0.0865x + 0.4376
R² = 1
y = 0.1609ln(x) + 0.5076
R² = 0.6974

Berry Brook

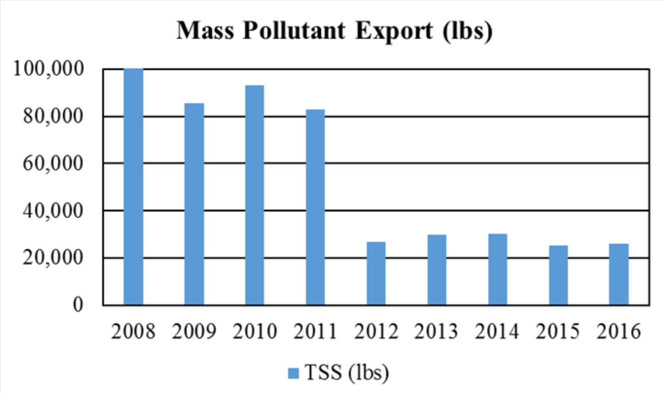

EIC Reduction Target Rates for Berry Brook, Dover, NH
2010 Existing
2011 (16.9 Ac/yr)
2012 (7.1 Ac/yr)
2013 (1.6 Ac/yr)
2014 (0.8 Ac/yr)
2015 (0.8 Ac/yr)
2016 (10.1 Ac/yr)
IC Target
35%
30%
25%
20%
15%
10%
5%
0%
2010
2011
2012
2013
2014
2015
2016

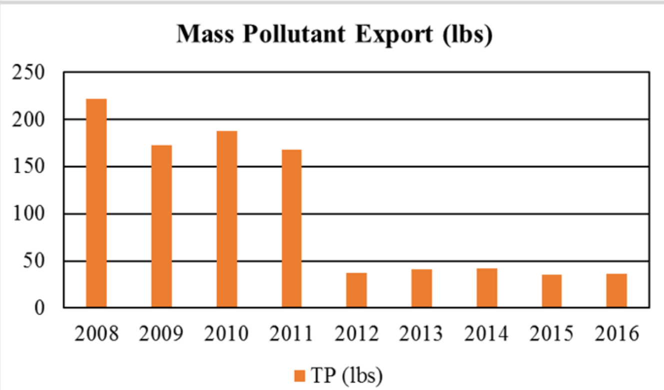
Hydrology

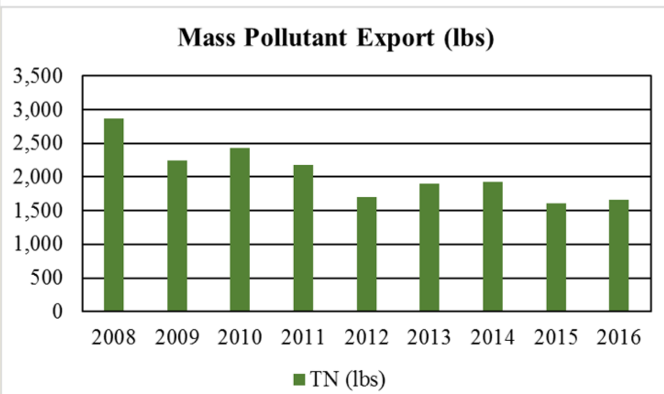


Direct Runoff Vs Rainfall Depth (Station/Downstream)
Pre-LID
Mid-LID
Post-LID
Direct Runoff (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.0
0.5
1.0
1.5
2.0
2.5
Rainfall Depth (in)

Modeled Water Quality







Results for Berry Brook at Station Drive

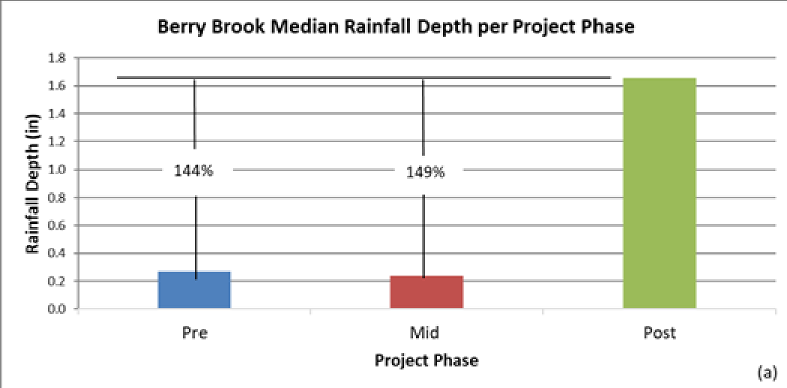
1-Inch Storm, Ia = 0.05 S[1]

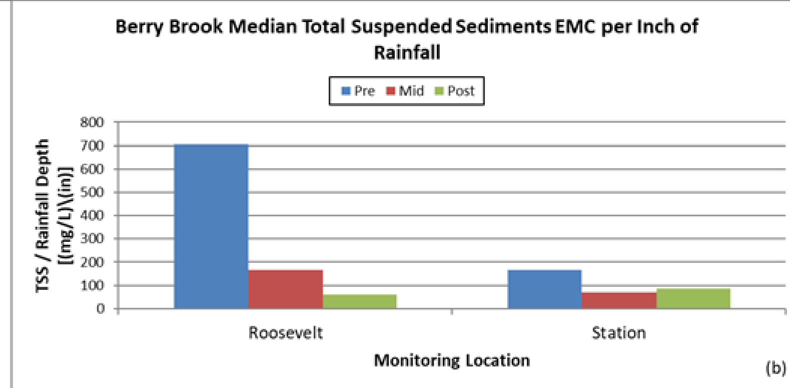
Year	% IC	P (in)	Q (in)	S (in)	CN	Q Reduction
2011	30	1.00	0.153	3.59	74	
2012	20	1.00	0.084	5.54	64	45.3%
2015	14	1.00	0.055	7.02	59	64.0%

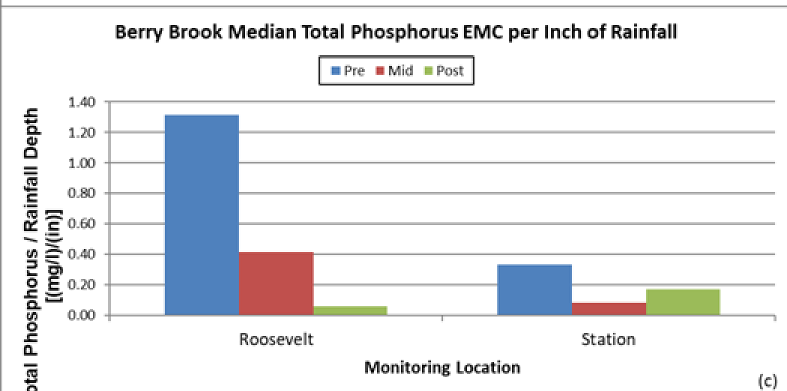
[1]*Hawkins, R.H.; Jiang, R.; Woodward, D.E.; Hjelmfelt, A.T.; Van Mullem, J.A. (2002). "Runoff Curve Number Method: Examination of the Initial Abstraction Ratio".*

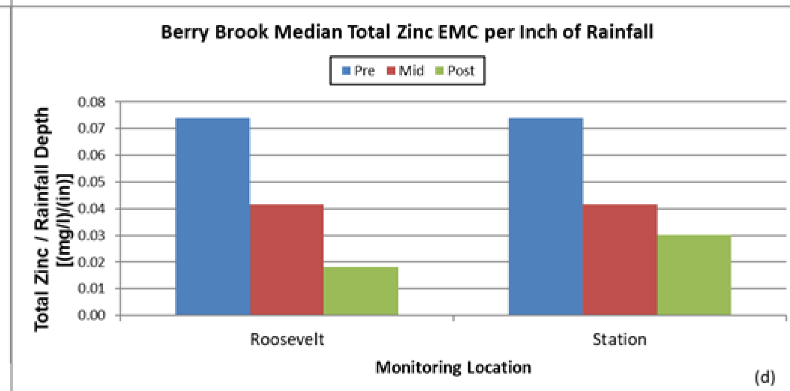
27

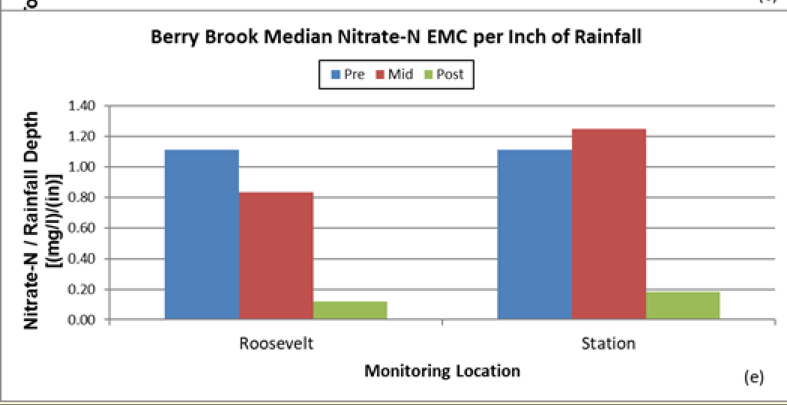
Year	A	P	CN	TSS (lbs)	TP (lbs)	TN (lbs)
2008-20011	185	56.14	74	92,719	188	2,428
20012-2016	185	42.20	62	27,575	38	1,762
Annual Reductions (lb./yr.)				65,144	149	667
Simple Method (lb./yr.)				57,223	201	1,127

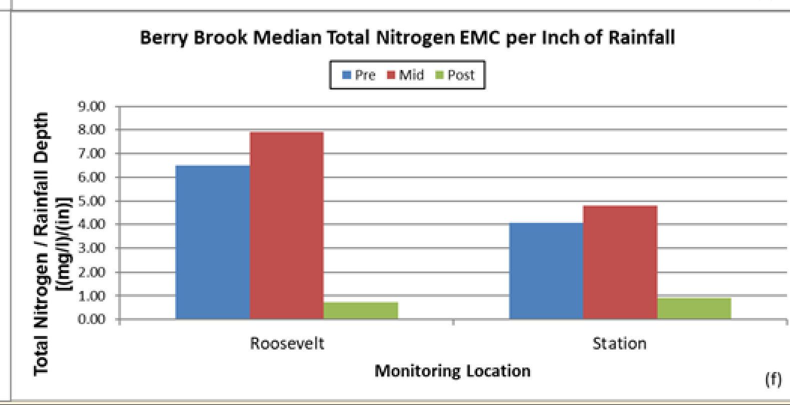






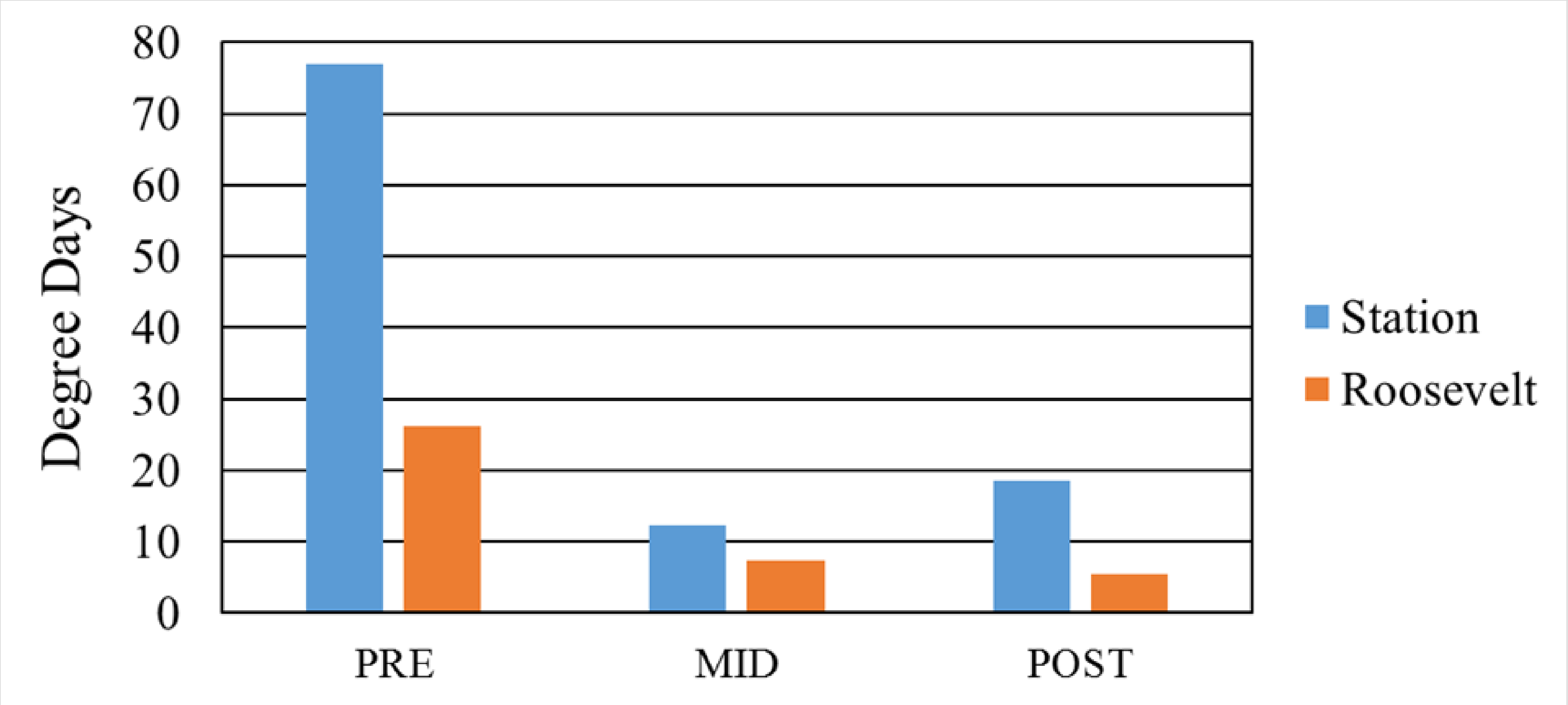






		TSS (mg/l) / (in)			Zinc (mg/l) / (in)			Nitrate-N (mg/l) / (in)			Total Nitrogen (mg/l) / (in)			Total Phosphorus (mg/l) / (in)		
		Pre	Mid	Post	Pre	Mid	Post	Pre	Mid	Post	Pre	Mid	Post	Pre	Mid	Post
Roosevelt	Weighted EMC	704	167	60	0.07	0.04	0.02	1.1	0.8	0.1	6.5	7.9	0.7	1.31	0.42	0.06
	% Difference		123%	168%		56%	121%		29%	161%		-20%	160%		104%	182%
Station	Weighted EMC	167	69	85	0.07	0.04	0.03	1.1	1.3	0.2	4.1	4.8	0.9	0.33	0.08	0.17
	% Difference		83%	65%		56%	84%		-12%	144%		-16%	127%		120%	65%
Average	% Difference		103%	117%		56%	103%		8%	152%		-18%	144%		112%	124%

Temperature Data



One degree day is a day when the average stream temperature is one degree Fahrenheit above 65 degrees F. This is important as the temperature that a Brook Trout begins to feel heat stress is 65 °F. Therefore a day with an average daily stream temperature of 71 degrees would represent 6 degree days.

Decadal Reflections: Cart Before the Horse

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The expression cart before the horse is an idiom or proverb used to suggest something is done contrary to a conventional or culturally expected order or relationship.

System Design

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Stormwater Runoff Modeling is historically simple

- Q=CiA
- SCS Method

There is a need for expansion

Yes, climate change gives us pause to think, but IC is the 800-pound gorilla

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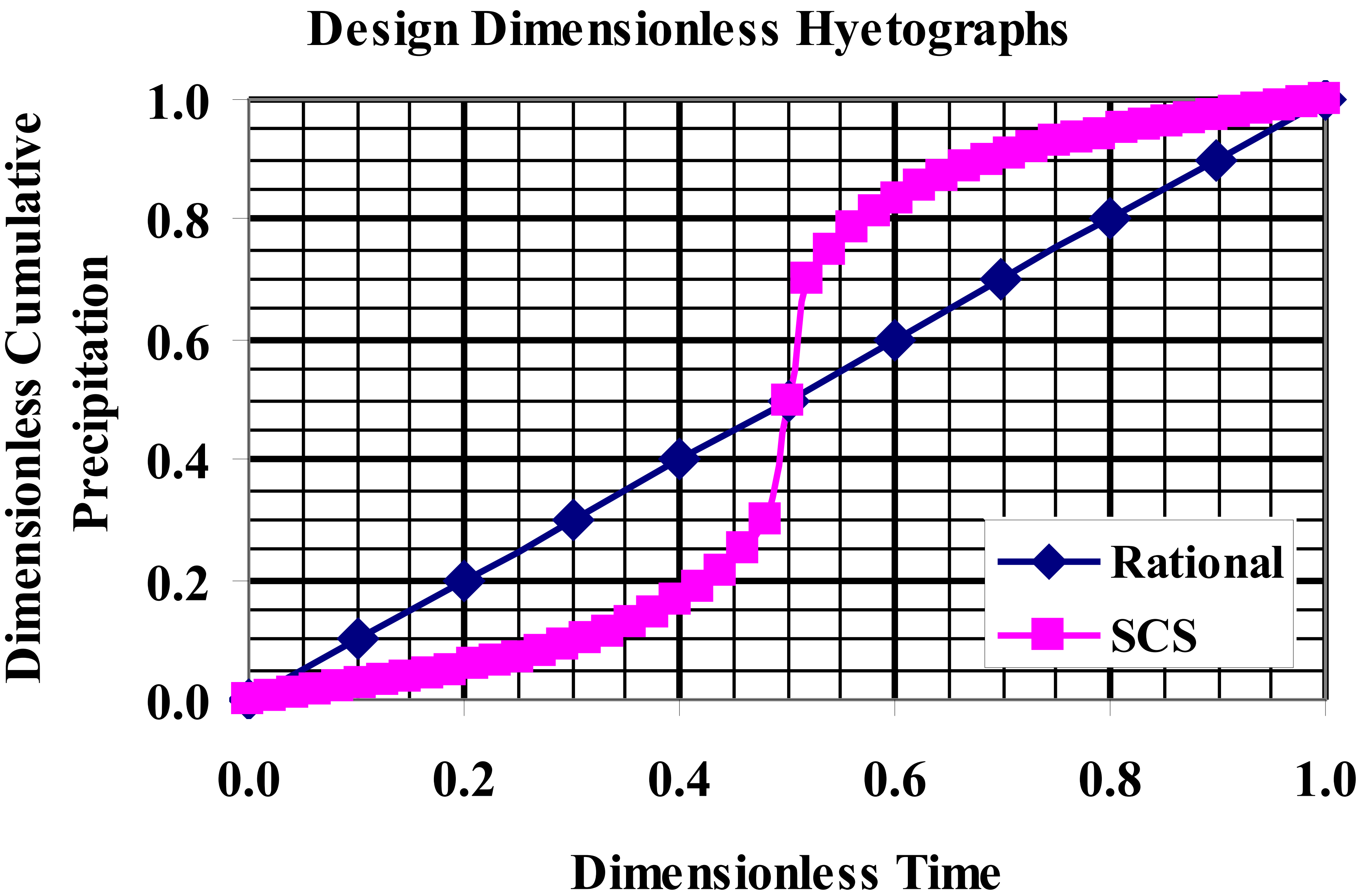
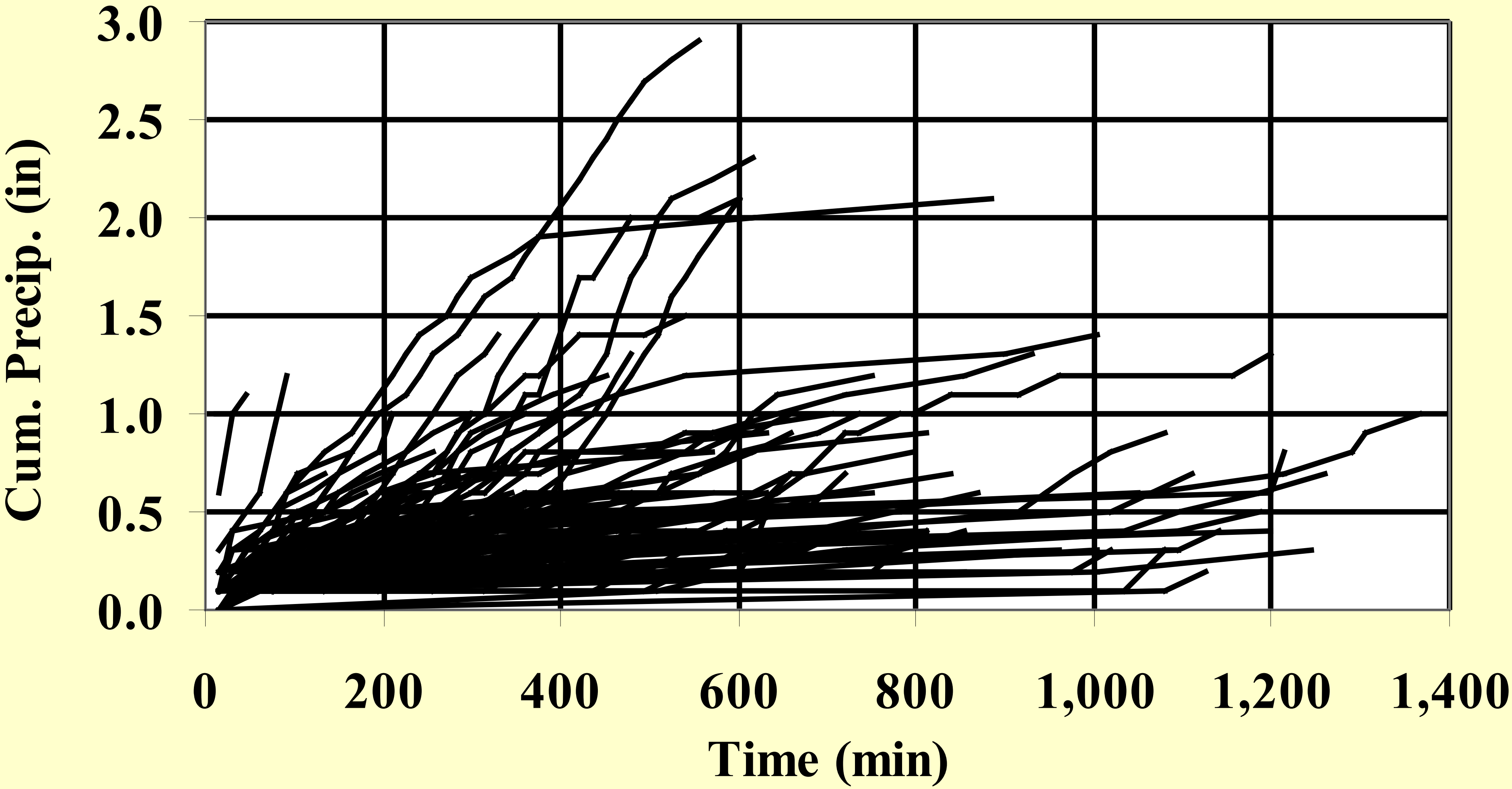

Design Dimensionless Hyetographs
Dimensionless Cumulative Precipitation
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
Dimensionless Time
Rational
SCS

Sampling of Observed Hyetographs Durham, NH NOAA Gage



Sizing for Performance

Sizing Details

System	WQV ft^3 (m^3)	Actual WQV ft^3 (m^3)	% of normal design	Rain Event in (mm)	Sizing Method
SGWSC	7,577 (214.6)	720 (20.4)	10%	0.10 (2.5)	Static
IBSCS	1,336 (37.8)	310 (8.8)	23%	0. 23 (5.8)	Dynamic

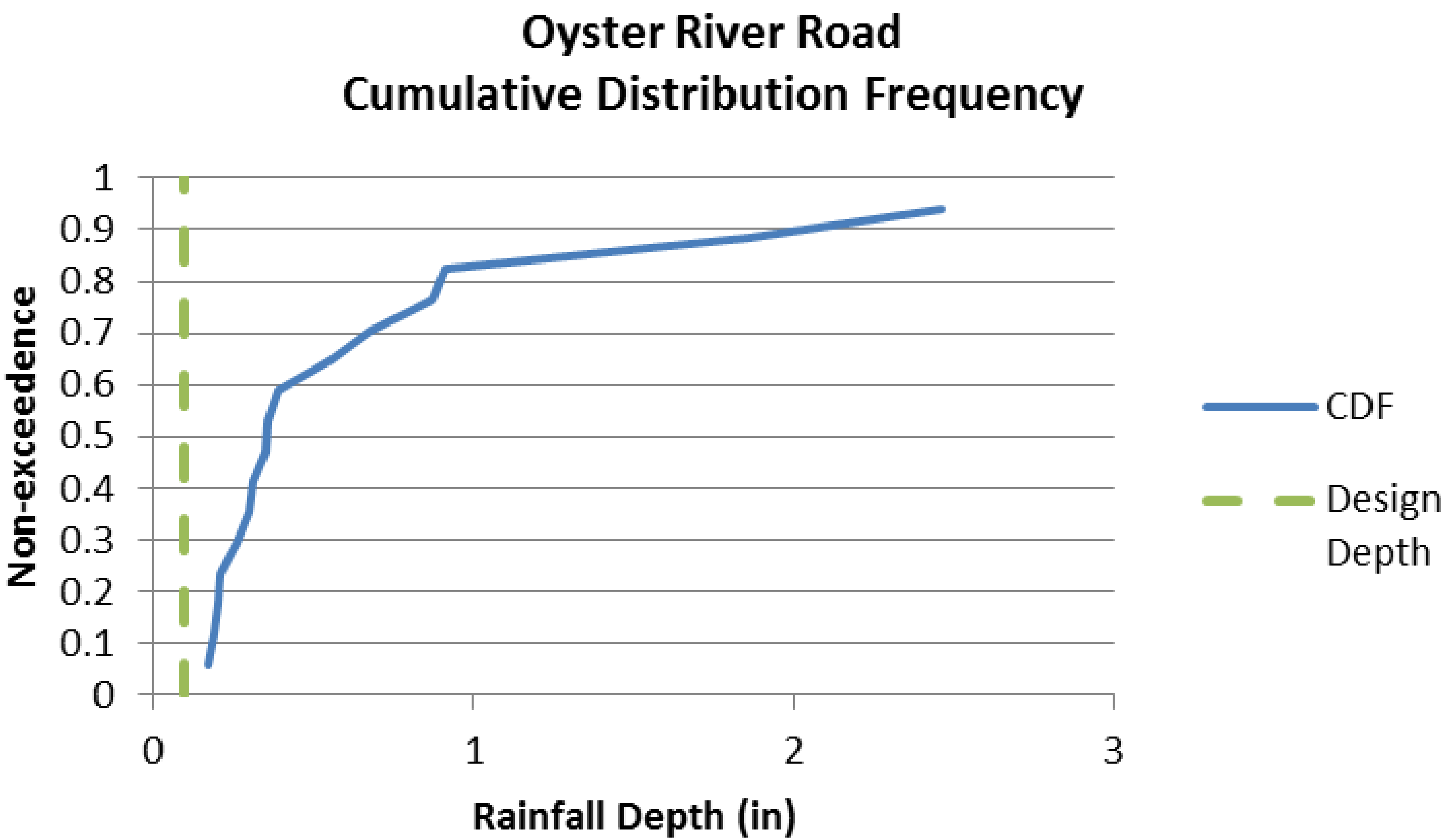
$$WQV = \left(\frac{P}{12}\right) x\ IA$$

Dynamic Bioretention Sizing

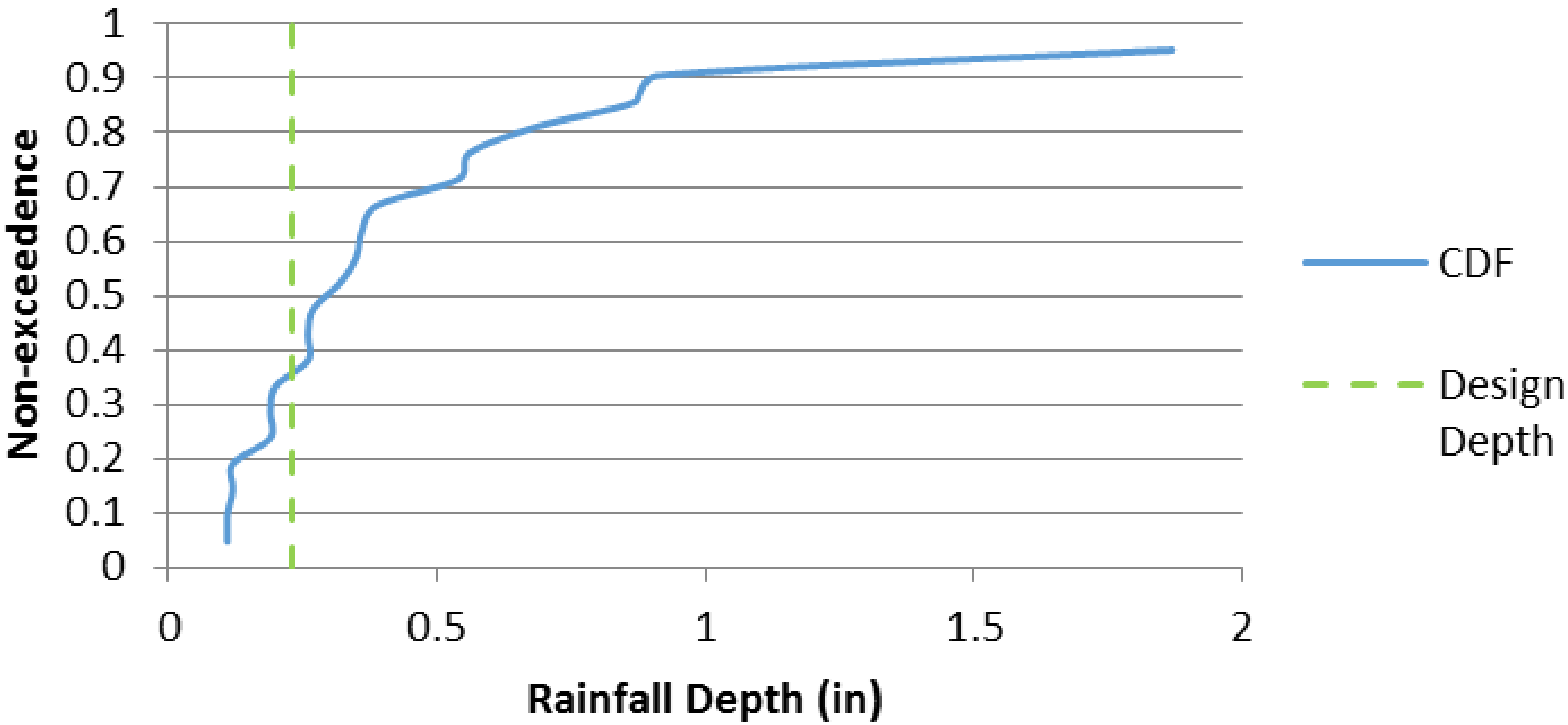
$$Af = Vwq * \frac{df}{(i(hf + df)tf)}$$

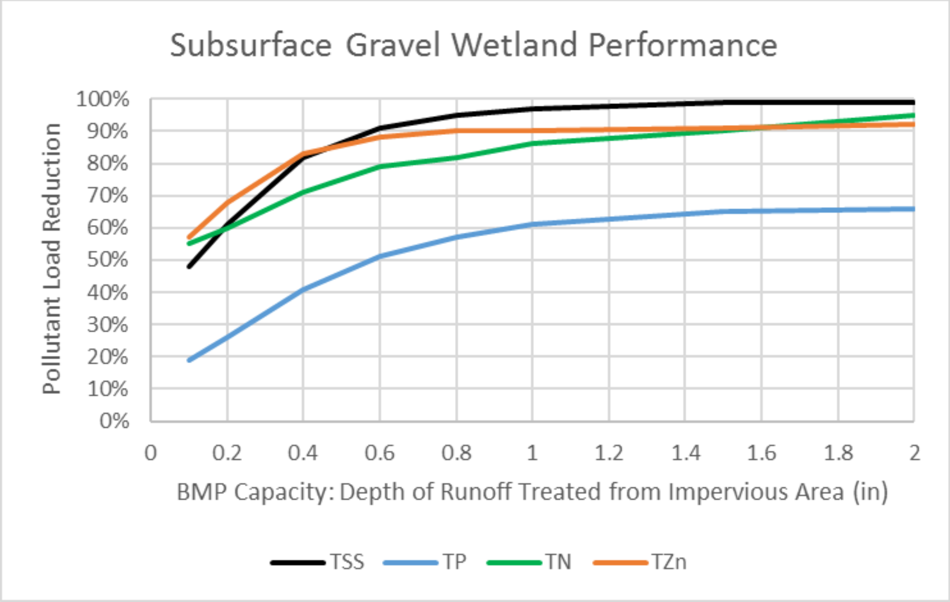
Static SGW System Sizing

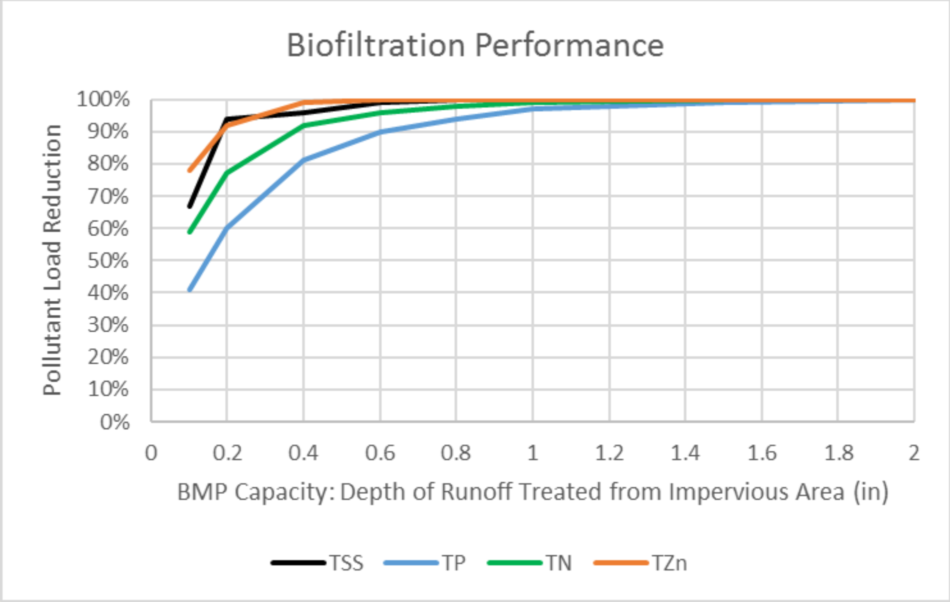
$$Q = CdA\sqrt{2gh}$$


Oyster River Road
Cumulative Distribution Frequency
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Non-exceedence
0
1
2
3
Rainfall Depth (in)
CDF
Design Depth

Durham Bio-5
Cumulative Distribution Frequency







Design Storage Volume (DSV) - runoff depth from IA (in)

Analyte	Depth txt	Modeled RE	Measured RE
TSS	0.1	48	75
TZn	0.1	57	75
TN	0.1	55	23
TP	0.1	19	53

Analyte	Depth txt	Modeled RE	Measured RE
TSS	0.23	70	81
TZn	0.23	88	86
TN	0.23	60	27
TP	0.23	35	45

Region 1 GI Cost Estimates

BMP (From Opti-Tool)	Cost ($/ft³) [1]	Cost ($/ft³) – 2016 dollars[6]
Bioretention (Includes rain garden)	13.37 [2,4]	15.46
Dry Pond or detention basin	5.88 [2,4]	6.80
Enhanced Bioretention (aka-Bio-filtration Practice)	13.5 [2,3]	15.61
Infiltration Basin (or other Surface Infiltration Practice)	5.4 [2,3]	6.24
Infiltration Trench	10.8 [2,3]	12.49
Porous Pavement - Porous Asphalt Pavement	4.60 [2,4]	5.32
Porous Pavement - Pervious Concrete	15.63 [2,4]	18.07
Sand Filter	15.51 [2,4]	17.94
Gravel Wetland System (aka-subsurface gravel wetland)	7.59 [2,4]	8.78
Wet Pond or wet detention basin	5.88 [2,4]	6.80
Subsurface Infiltration/Detention System (aka-Infiltration Chamber)	54.54[5]	67.85

[1] **Footnote: Includes 35% add on for design engineering and contingencies**

https://www.unh.edu/unhsc/ms4-resources

https://www3.epa.gov/region1/npdes/stormwater/ma/green-infrastructure-stormwater-bmp-cost-estimation.pdf

GI Implementation Cost Comparisons

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Costs per disconnected acre of IC			
	PA	NY	NH
Actual	$250,000.00	$320,000.00	$30,000.00

Stormwater Management Design - 70.5 acre Ultra-Urban Drainage Area			
Sizing Comparison of Capital Costs and Relative Phosphorus Load Removal Efficiency			
Best Management Practice Size	Depth of Runoff Treated from Impervious Area (in)	*Storage Volume Cost ($/ft³)	**Total Phosphorus Removal Efficiency (%)
Subsurface Gravel Filter - Minimum Size	0.35	$1,016,912	62%
Subsurface Gravel Filter - Moderate Size	0.5	$1,452,732	80%
Subsurface Gravel Filter - Full Size	1.0	$2,905,463	96%
*Storage Volume Cost estimates provided by EPA-Region 1 for Opti-Tool methodology, 2015-Draft			
**Total Phosphorus %RE based on Appendix F Massachusetts MS4 Permit			

Project Approach

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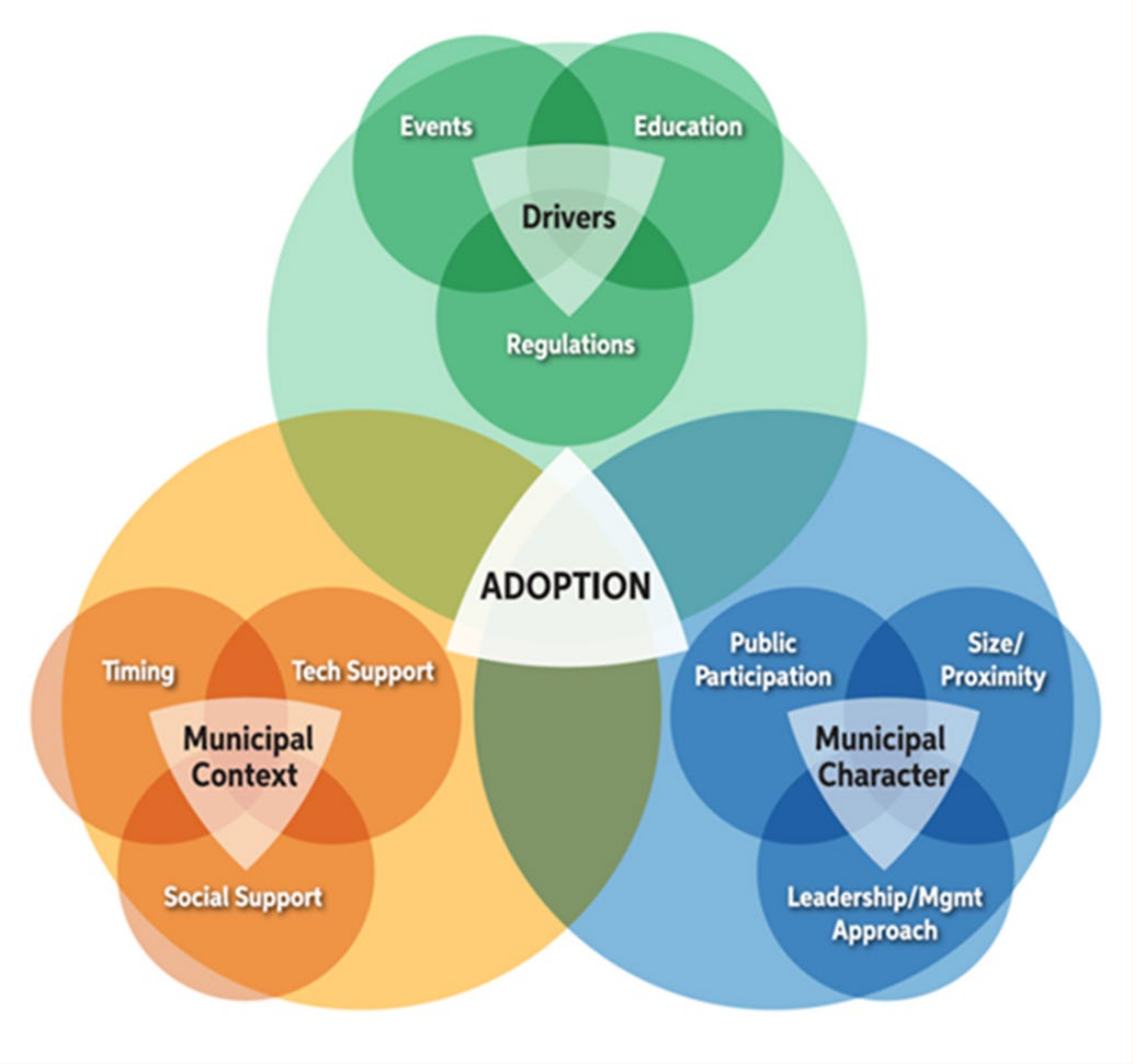

Typical Project Approach

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Develop a watershed management plan (a-i)

Optimize placement of BMPs for maximum gain

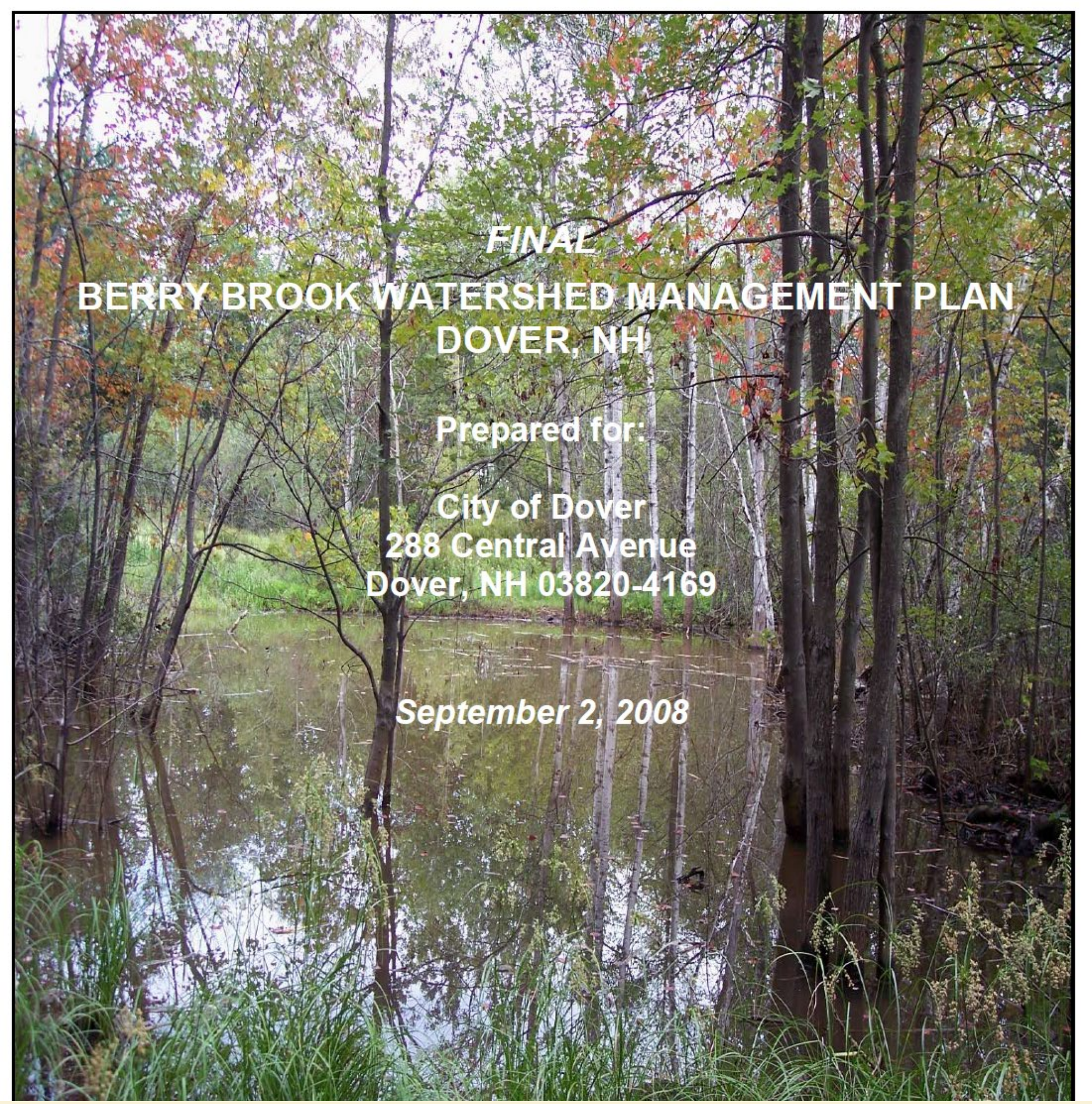
Implement

Model

Outreach and education on project results

Report

Typical Project Approach



Optimize Again…

2011 Watershed Restoration Grants for Impaired Waters

Section B: PRE-PROPOSAL APPLICATION FORM

Watershed Restoration Grants for Impaired Waters

I. Proposal Title

Berry Brook Watershed Restoration through Low Impact Development Retrofits in an Urban Environment

II. Contact Information

Primary contact person: Dean Peschel
Organization: Environmental Project Manager, City of Dover DPW
Street address: 288 Central Avenue
City, State, ZIP: Dover, NH, 03820-4169
Day phone: (603) 516-6094 Fax: ( ) Email: dean.peschel@ci.dover.nh.us

Secondary contact person: Robert M. Roseen, Ph.D., D.WRE, P.E.
Organization: Director, The UNH Stormwater Center
Street address: 35 Colovos Road
City, State, ZIP: Durham, NH, 03824
Day phone: (603)862-4024 Fax: (603)862-3957 Email: robert.roseen@unh.edu

Signature of Applicant: ______________________

Date of signature: 9/2/10

III. Project Summary

Berry Brook is a highly urbanized 1st order stream located in Dover, NH, that is classified as Class B waters. . The Brook is located in a built-out, 164-acre watershed with 25% impervious cover (IC) and includes medium-density housing with commercial and industrial uses. The stream has been placed on the NHDES 2006 Section 303(d) list and is impaired for primary recreation and for aquatic life. The source of this impairment includes urbanization resulting in an increase of pollutant mass and runoff volumes from stormwater.

And then you implement – Inside a historic 40,000 sf slow sand filter

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National Historic Preservation Act Section 106 Compliance for the Regulatory Program

And more implementation…

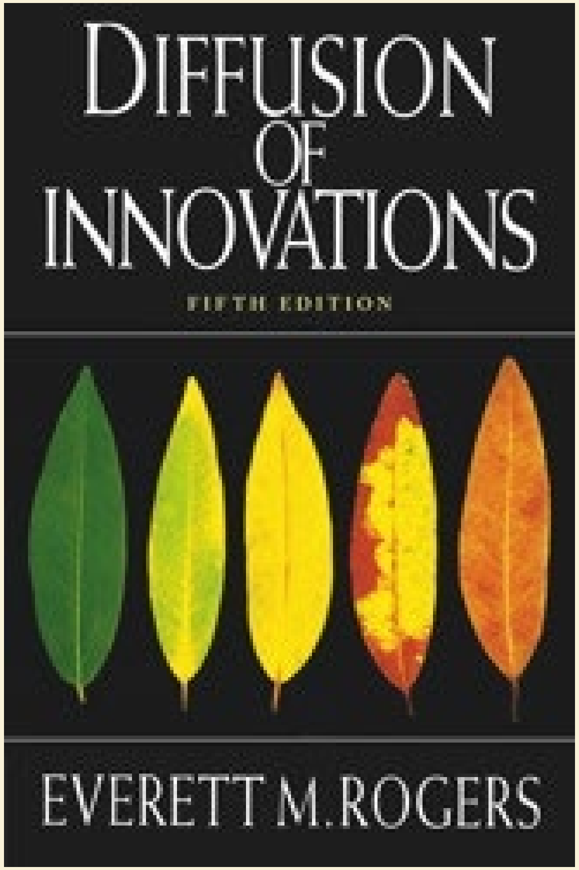
Every Day Counts

There is a second approach that implements no-regrets stormwater improvements opportunistically as infrastructure is routinely upgraded.

This is a behavioral change toward developing long-term comprehensive and affordable SW management strategies for achieving water resource goals.

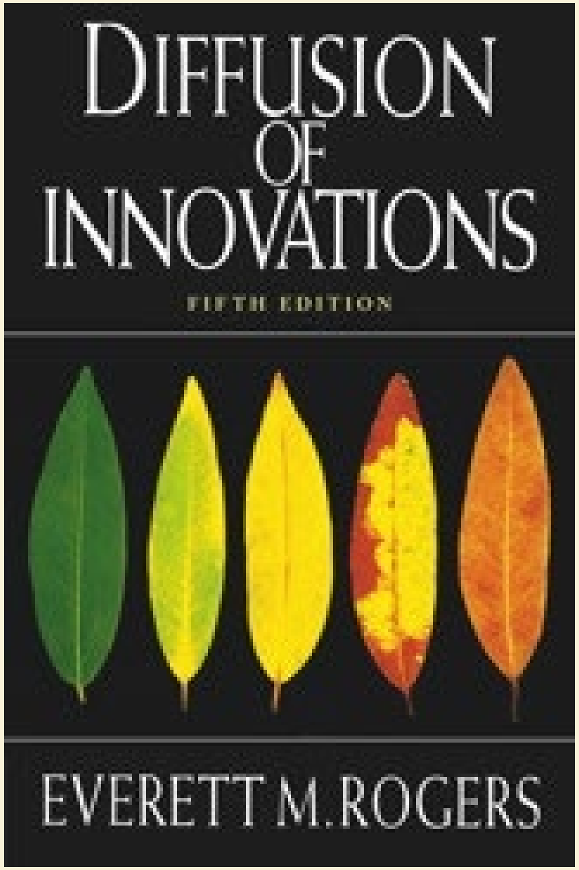
Diffusion of Innovation

Diffusion of innovation is the process by which an innovation is communicated through certain channels over time among the members of a social system (Rogers, 2003)

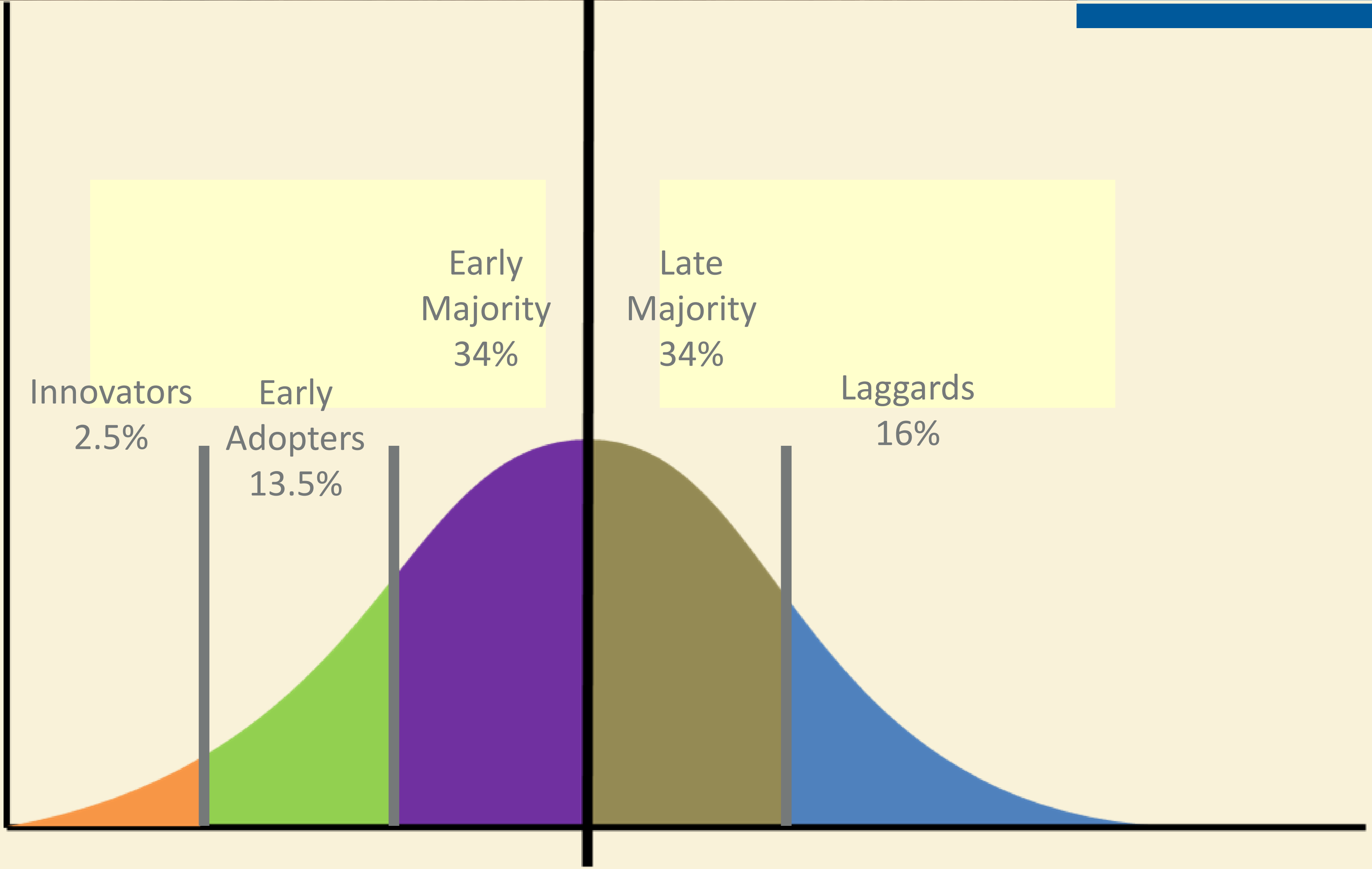


Innovation

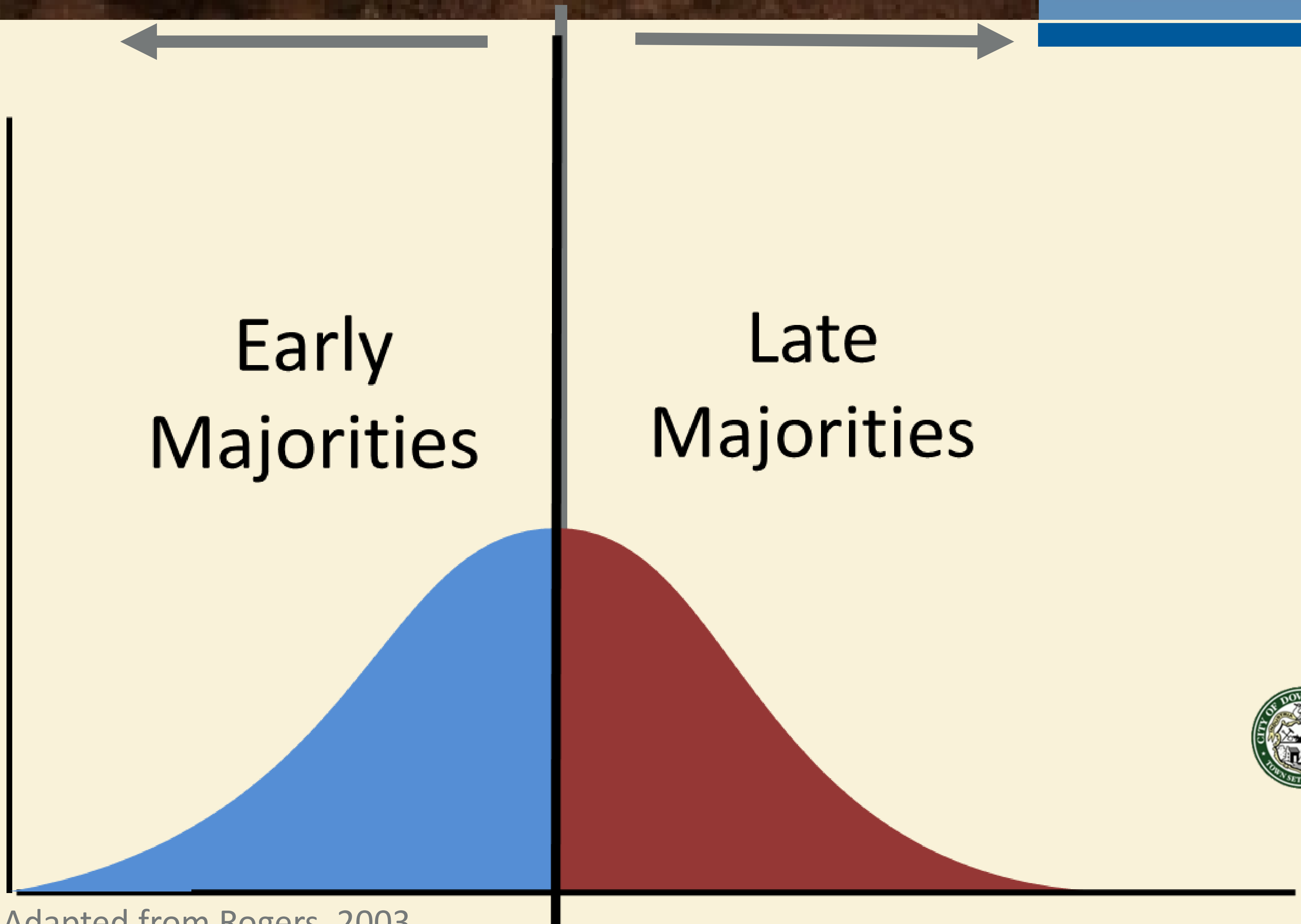
An idea, practice, or object that is perceived as new by an individual or other unit of adoption (Rogers, 2003).



DOI Adopter Categories

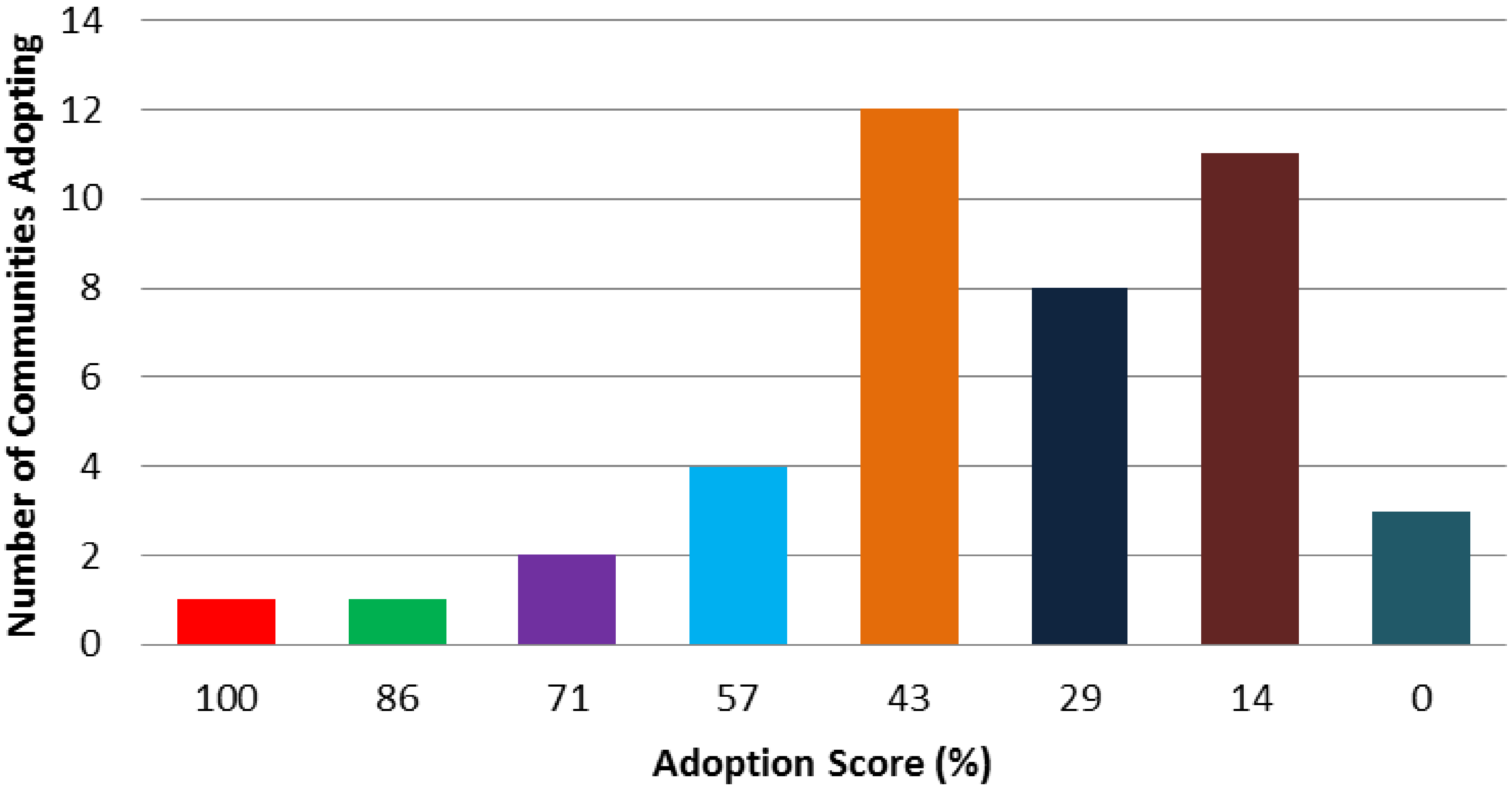


Adapted from Rogers, 2003



Adapted from Rogers, 2003

NH Great Bay Communities (n=42)



Pragmatic Herd

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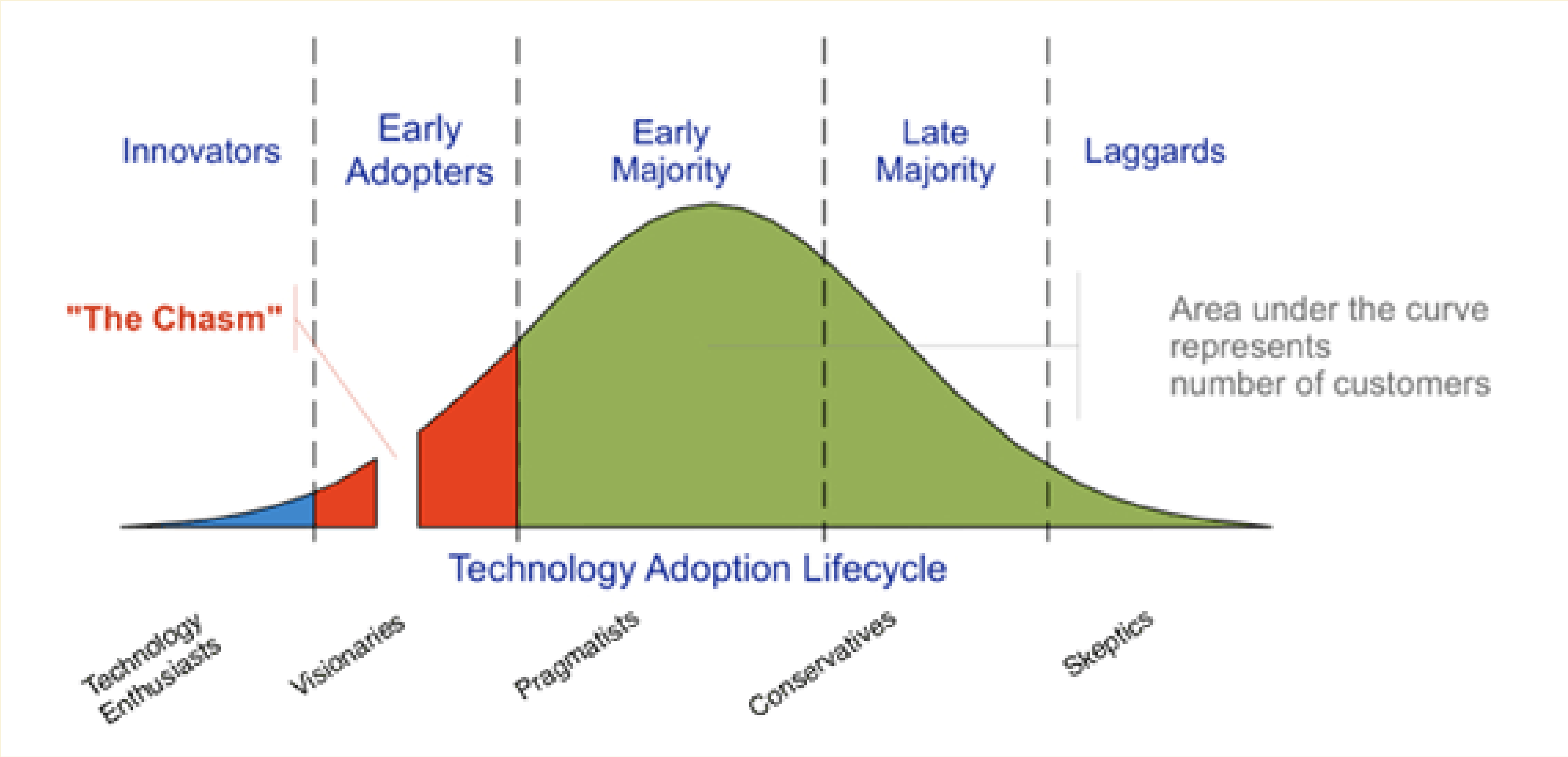
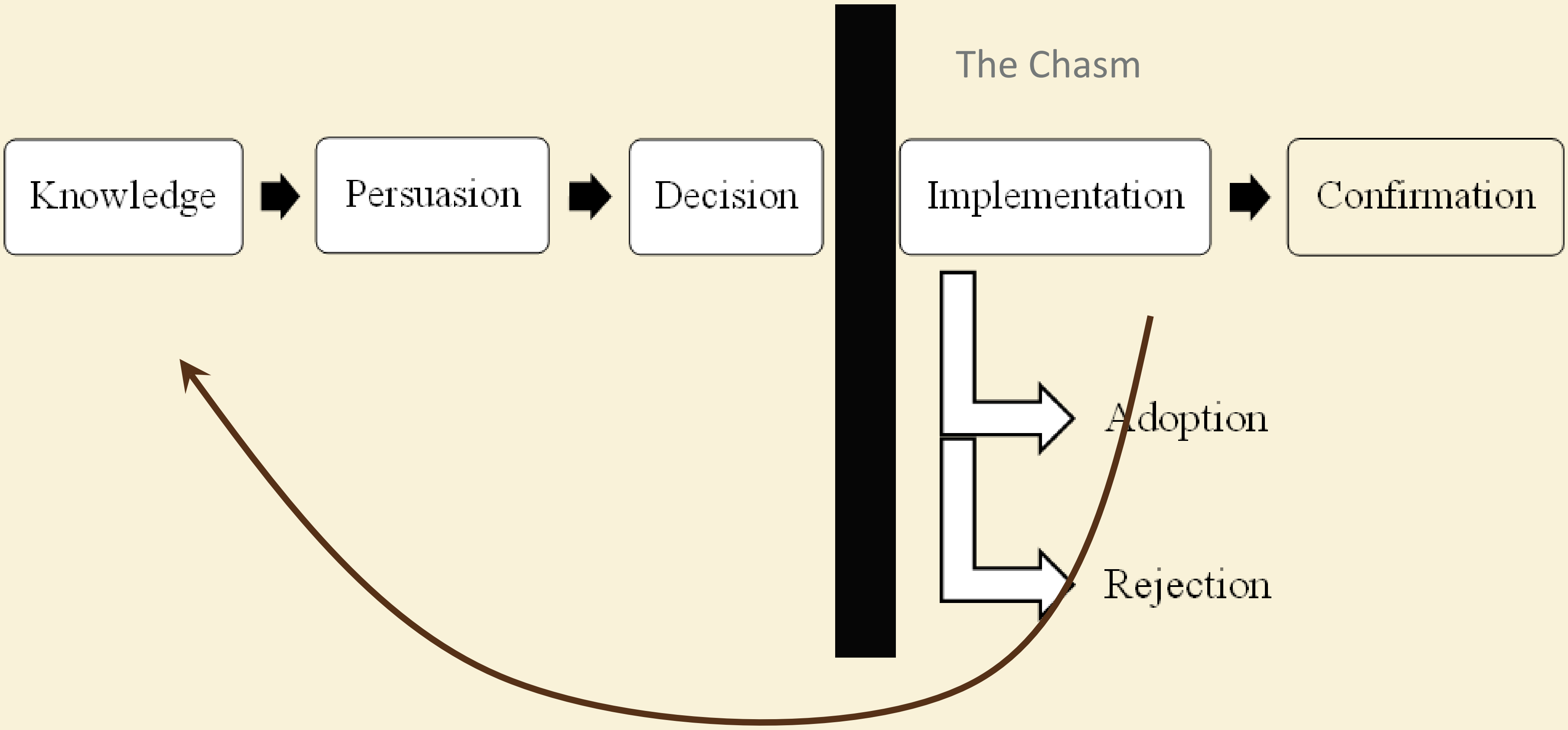


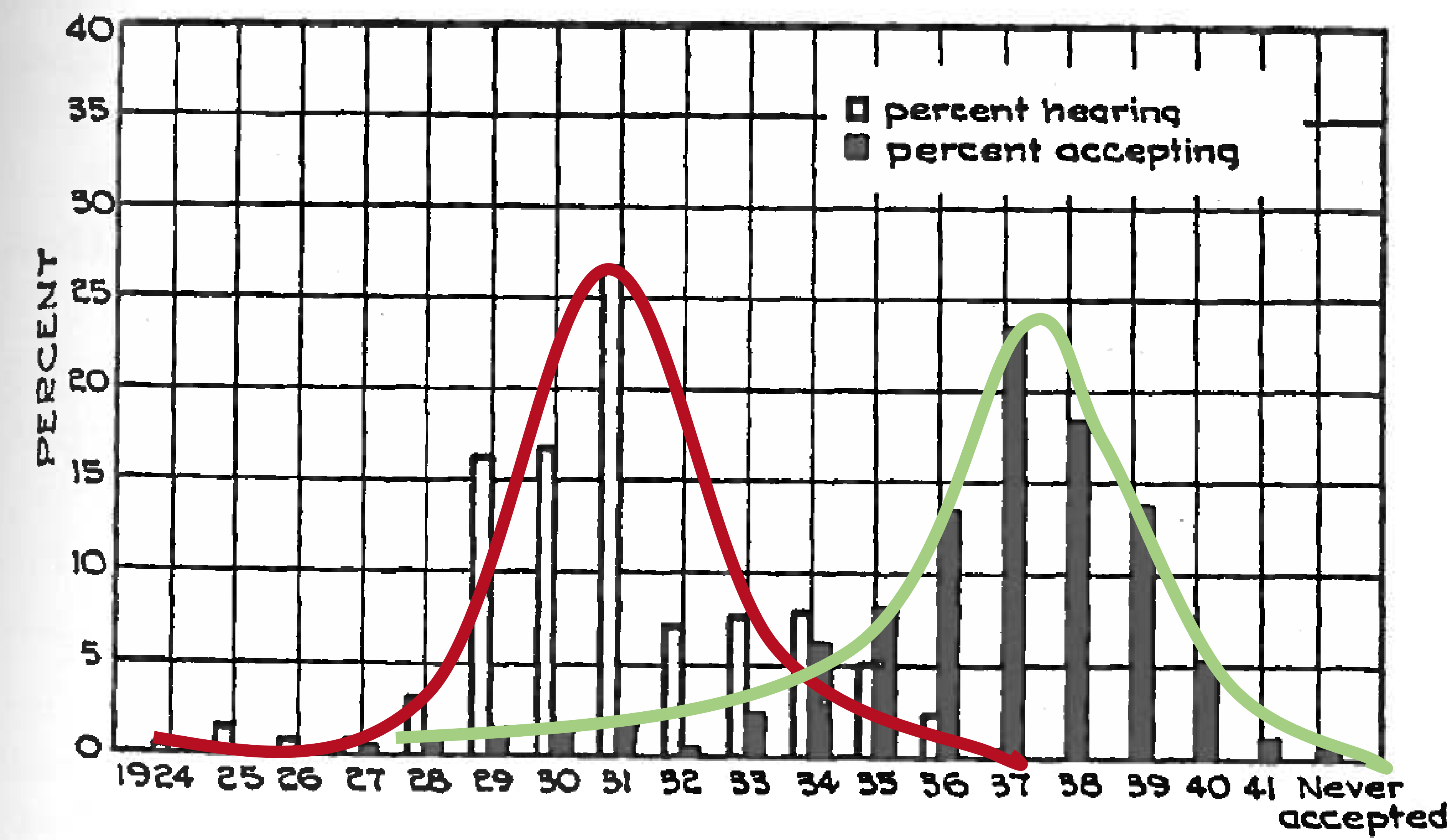
Innovation Decision Process



Ability to reinvent to reflect local needs and foster ownership

Rogers, 2003

Results from Ryan and Gross on farmer adoption patterns of hybrid corn.



Source: Ryan & Gross (1943), "The Diffusion of Hybrid Seed Corn in Two Iowa Communities," *Rural Sociology 8* (March): 15.

Are we at the finish line or the starting line?

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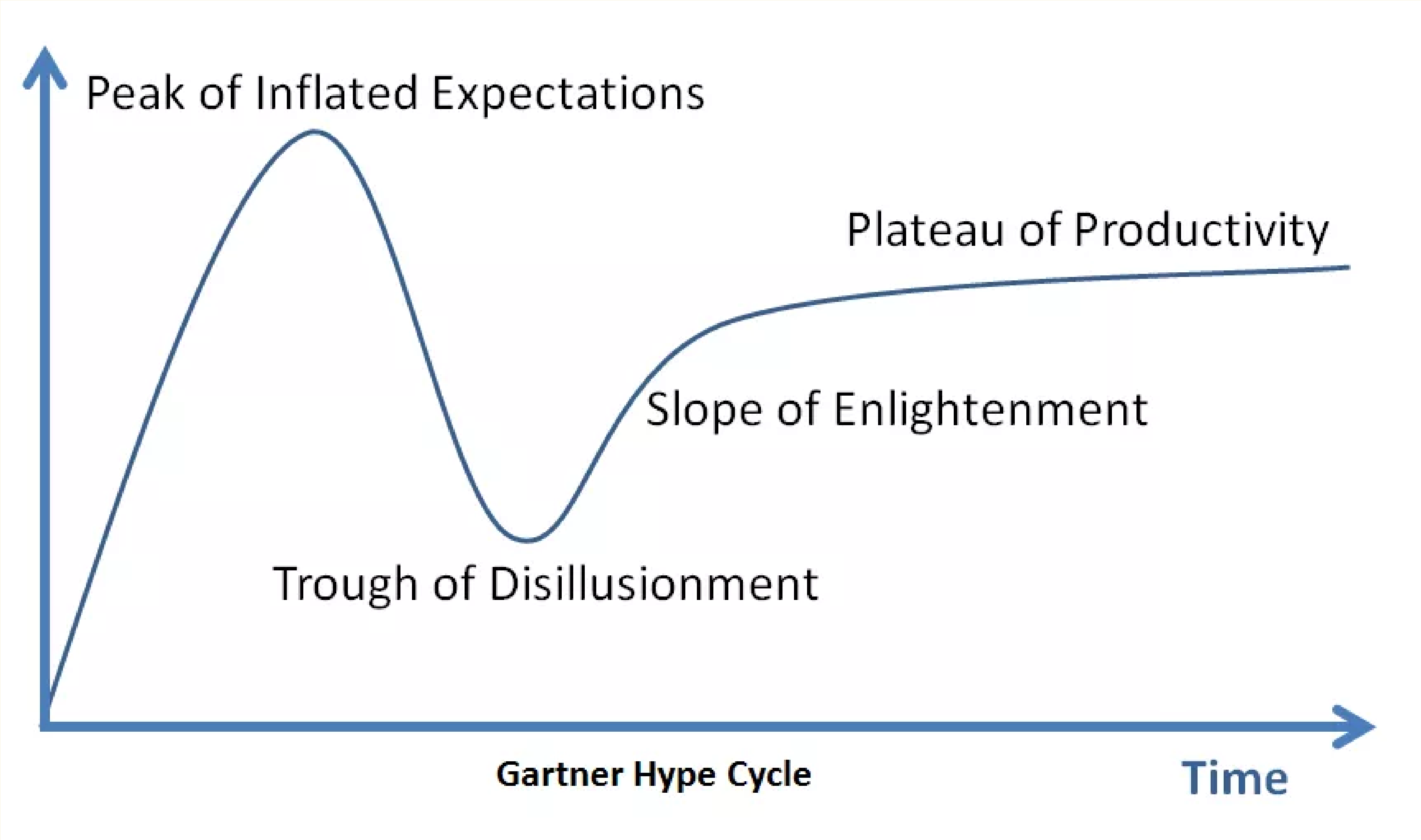

Peak of Inflated Expectations
Plateau of Productivity
Slope of Enlightenment
Trough of Disillusionment
Gartner Hype Cycle
Time

Project Milestone & Timeline

Project Task	Delivery Date	Status
Task 0: Work Plan	Oct 12, 2018	Complete
Task 1: Quality Assurance Project Plan (QAPP)	Oct 12, 2018	Complete
Task 2: Kickoff **Meeting at Boston MA**	Oct 24, 2018	Complete
Task 3: Municipal Coordination **Meeting at Tisbury MA**	Nov 29, 2018	Current
Task 4A: GIS Analysis: Watershed Characterization and GI SCM Opportunity Area Screening	Dec 15, 2018	In Progress
Task 4B: Opti-Tool Analyses for Quantifying Stormwater Runoff Volume, High-Flow Rates and Pollutant Loadings from Watershed Source Areas	Dec 31, 2018	In Progress
Task 4C: Develop High Runoff Flow Rate Metric(s) to Evaluate Source Area Contributions and GI SCM Reduction Benefits	Feb 1, 2019*	-
Task 4D: Develop Planning Level GI SCM Performance Curves for Estimating Cumulative Reductions in SW-Related Indicator Bacteria	Feb 15, 2019	-
Task 4E: Identify Green Infrastructure Stormwater Control Opportunities and Potential Management Strategies for Tisbury (**Meeting at Tisbury MA**)	Mar 7, 2019	-

Project Milestone & Timeline

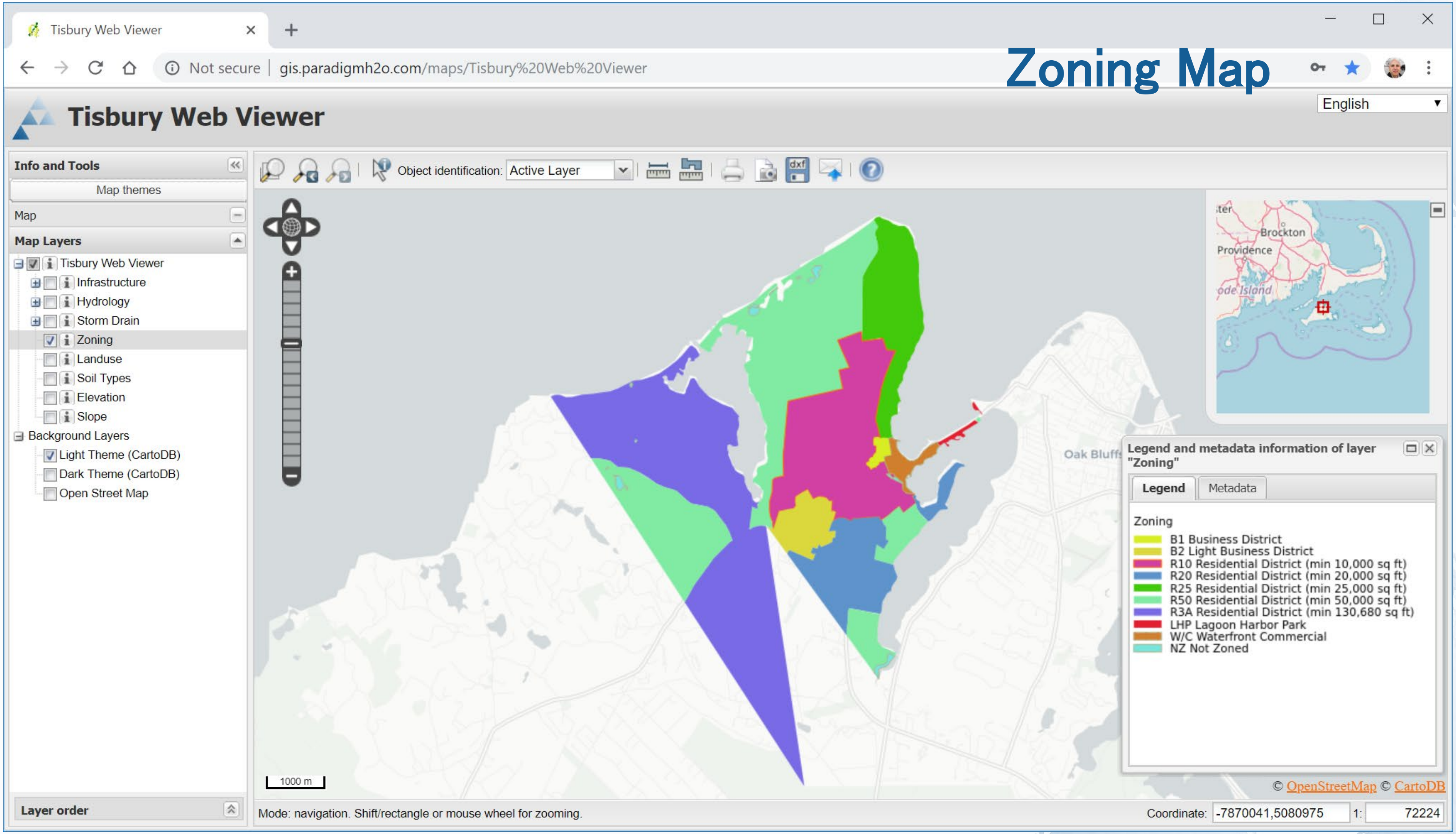
Project Task	Delivery Date	Status
Task 4F: Conduct Field Investigations to Further Evaluate Community GI SCM Opportunities and Strategies	June 15, 2019	-
Task 4G: Develop GI SCM Conceptual Designs	July 15, 2019	-
Task 4H: Quantify Benefits for Municipal Long-Term GI SCMs Implementation Strategies	Aug 15, 2019	-
Task 4I: Develop Streamlined Technical Support Document to Quantify Benefits of GI SCMs for IC Disconnection	Aug 15, 2019	-
Task 4J: Final Project **Meeting at Tisbury MA** and Final Project Report	Aug 30, 2019 Sep 15, 2019	-
Task 5: Develop Streamlined Technical Support Document for Developing Long-Term Community SCM IC Disconnection Strategies	Sep 15, 2019	-
Task 2: Conduct a webinar	Sep 15, 2019	-

GIS Data Inventory

- MassGIS (Massachusetts Bureau of Geographic information Systems)
- Martha Vineyard Commission
- gSSURGO (Soil Survey Staff. Gridded Soil Survey Geographic)

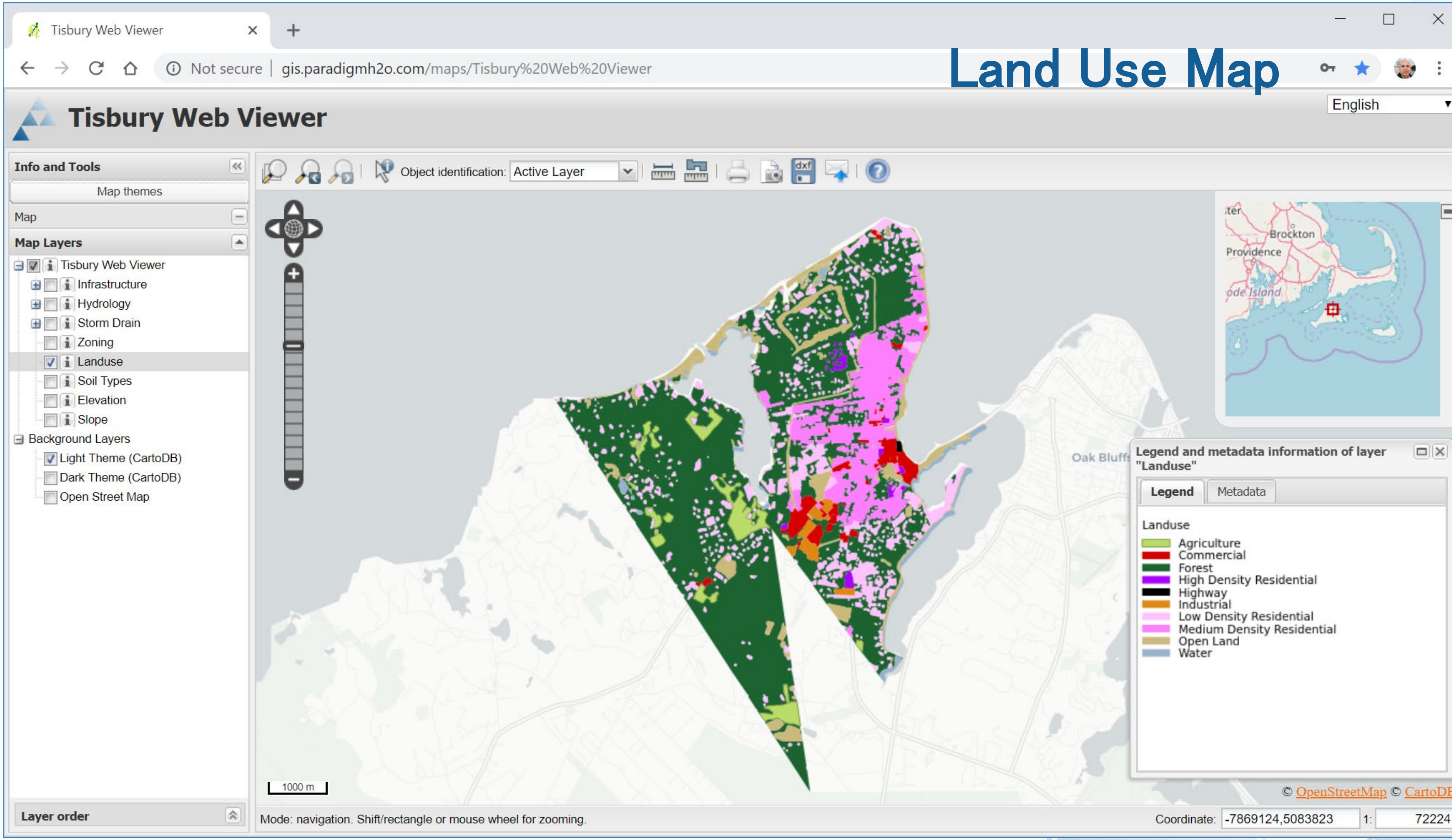
GIS Layer	Description	Raw File Name
Digital Elevation Model	2005 – 5 x 5 meters	Elevation_hillshade_5k.zip
LiDAR Terrain	2014 – 1 x 1 meter	MV_Lidar.zip
Building Structures	2017 – polygon layer	Structures_poly.zip
Impervious Surface	2005 – 1 x 1 meter	Imp_mvin.zip
Land Use	2017 – polygon layer	Landuse2005_poly.zip
USGS Drainage Sub-basins	2008 – polygon layer	Subbas.zip
NRCS HUC12 Subwatersheds	2017 – polygon layer	Nrcshuc.zip
MassDEP Hydrogeography	2017 – polygon layer	Hydro100k.zip
MassDEP Wetlands	2017 – polygon layer	Wetlands.zip
MassDEP CWA Regulated Receiving Waters and Attainment Classes	2014 – polygon layer	Wbs2014_shp.zip
FEMA National Flood Hazard Layer (50 + 100 Year Flood Zones)	2017 – polygon layer	Nfhl.zip
NRCS SSURGO-Certified Soils	2012 – polygon layer	Soi_dukes.zip
Standardized Assessors' Parcels	2018 – polygon layer	L3_SHP_M296_TISBURY.zip
Department of Transportation (MassDOT) Roads	2014 – line layer	MassDOT_Roads_SHP.zip
MassDEP Oil and/or Hazardous Material Sites with AUL	2018 – point layer	Aul_pt.zip
Aquifers	2007 – polygon layer	Aquifers.zip
Surficial Geology	2014 – polygon layer	Surfgeo250k.zip
Tisbury City Boundary	2014 – polygon layer	Towns.zip
Tisbury Zoning	2004 – polygon layer	tis_wastewater_request.mpk
Storm Drain System	2003 – polygon layer	tis_wastewater_request.mpk
Major and Coastal H2osheds	2009 – polygon layer	tis_wastewater_request.mpk

Zoning Map



Tisbury Web Viewer
Not secure | gis.paradigmh2o.com/maps/Tisbury%20Web%20Viewer
Tisbury Web Viewer
English
Info and Tools
Map themes
Map
Map Layers
Tisbury Web Viewer
Infrastructure
Hydrology
Storm Drain
Zoning
Landuse
Soil Types
Elevation
Slope
Background Layers
Light Theme (CartoDB)
Dark Theme (CartoDB)
Open Street Map
Layer order
Object identification: Active Layer
Oak Bluffs
Brockton
Providence
Legend and metadata information of layer "Zoning"
Legend
Metadata
Zoning
B1 Business District
B2 Light Business District
R10 Residential District (min 10,000 sq ft)
R20 Residential District (min 20,000 sq ft)
R25 Residential District (min 25,000 sq ft)
R50 Residential District (min 50,000 sq ft)
R3A Residential District (min 130,680 sq ft)
LHP Lagoon Harbor Park
W/C Waterfront Commercial
NZ Not Zoned
1000 m
© OpenStreetMap © CartoDB
Mode: navigation. Shift/rectangle or mouse wheel for zooming.
Coordinate: -7870041,5080975 1: 72224

Land Use Map


Tisbury Web Viewer
Not secure | gis.paradigmh2o.com/maps/Tisbury%20Web%20Viewer
Tisbury Web Viewer
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Light Theme (CartoDB)
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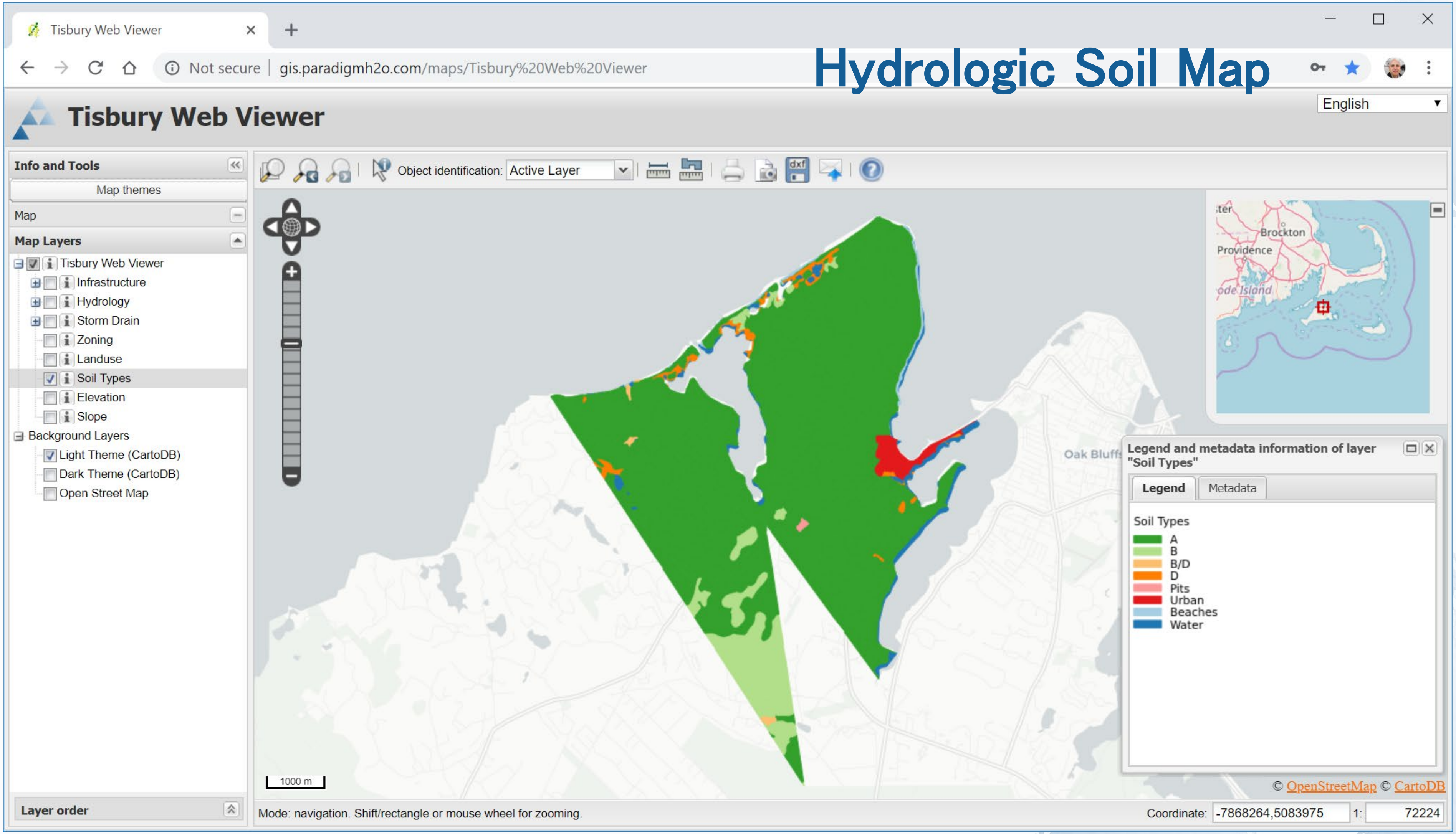
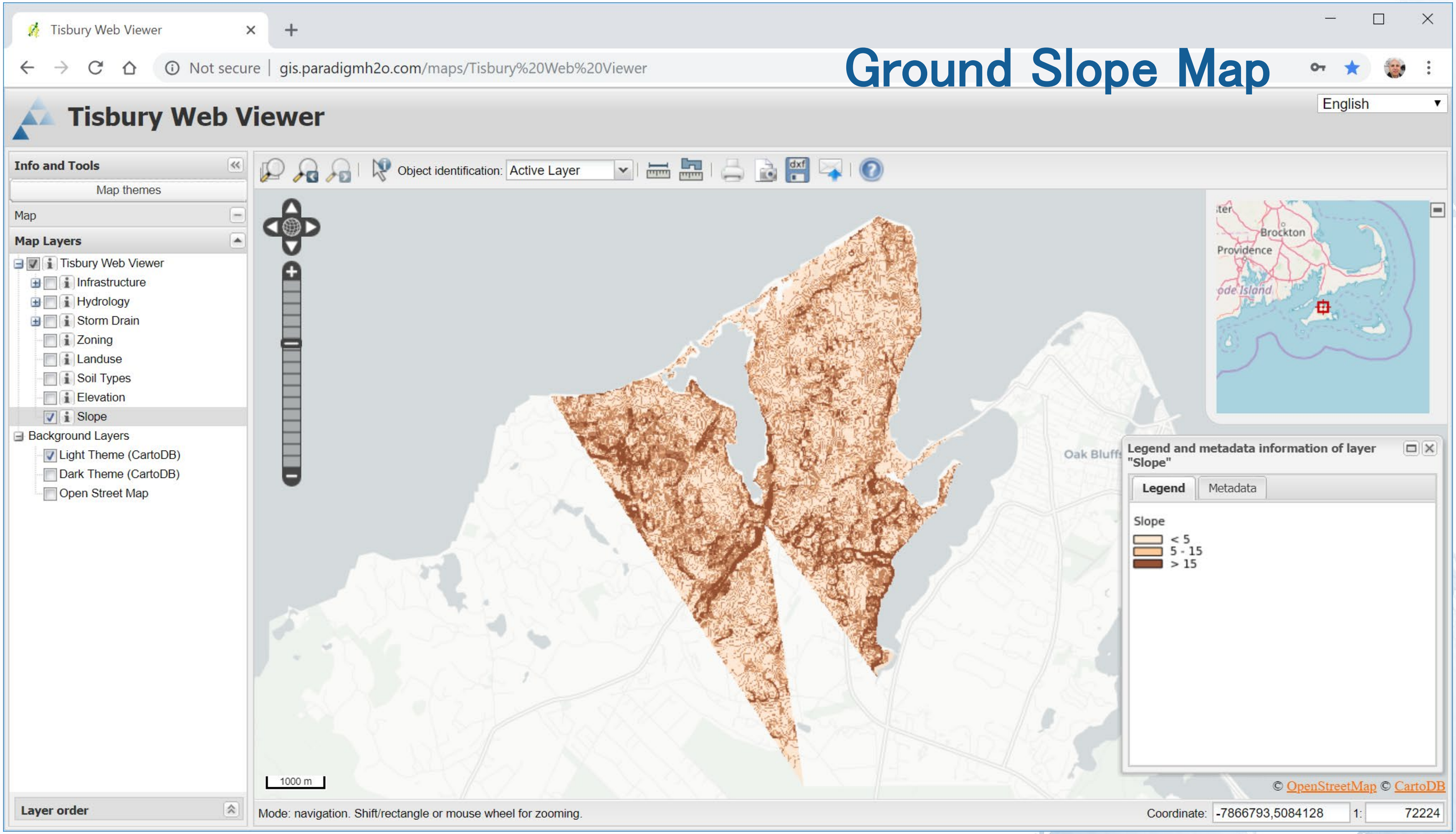
Open Street Map
Layer order
Object identification: Active Layer
Brockton
Providence
Oak Bluffs
Legend and metadata information of layer "Landuse"
Legend
Metadata
Landuse
Agriculture
Commercial
Forest
High Density Residential
Highway
Industrial
Low Density Residential
Medium Density Residential
Open Land
Water
1000 m
© OpenStreetMap © CartoDB
Mode: navigation. Shift/rectangle or mouse wheel for zooming.
Coordinate: -7869124,5083823 1: 72224

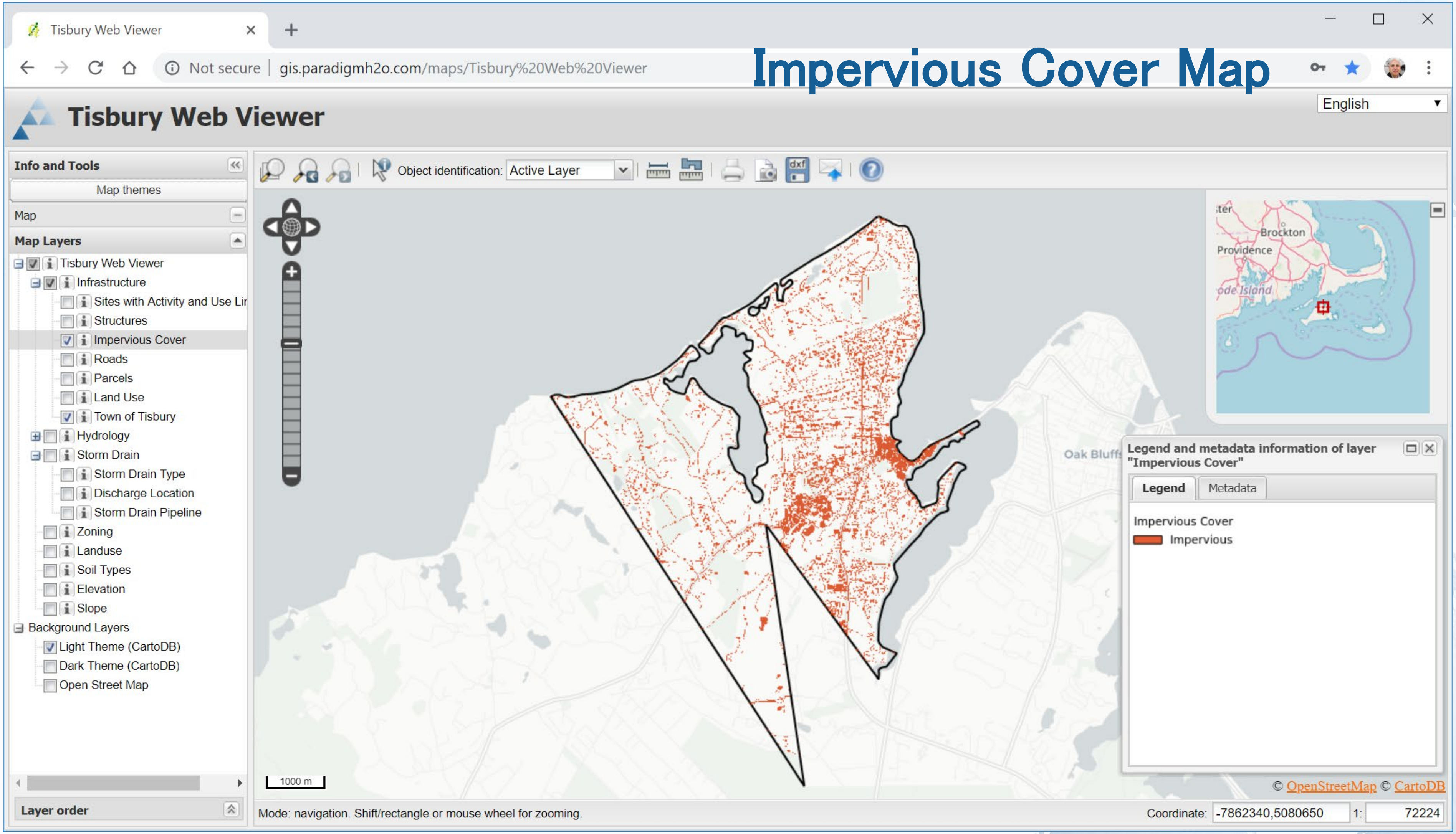
Hydrologic Soil Map



Ground Slope Map



Impervious Cover Map



Hydrologic Response Units (HRUs)

- Intersect land use, land cover, soil, and slope
- Tabulate area distribution

Land Use	Total Area (acre)	Soil					Slope			Cover	
		A	B	C	D	NoData	Low	Med	High	Impervious	Pervious
Forest	2,393.19	50.8%	6.0%	0.0%	0.4%	0.0%	17.5%	28.4%	11.4%	3.1%	54.1%
Agriculture	147.03	2.7%	0.7%	0.0%	0.0%	0.0%	1.5%	1.6%	0.4%	0.2%	3.3%
Commercial	112.83	1.9%	0.0%	0.8%	0.0%	0.0%	1.5%	0.9%	0.3%	1.8%	0.9%
Industrial	41.68	1.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.3%	0.2%	0.5%	0.5%
Low Density Residential	551.76	12.8%	0.4%	0.0%	0.0%	0.0%	4.5%	6.3%	2.4%	3.3%	9.9%
Medium Density Residential	478.14	11.4%	0.0%	0.0%	0.0%	0.0%	4.6%	5.3%	1.5%	3.3%	8.1%
High Density Residential	27.50	0.6%	0.0%	0.0%	0.0%	0.0%	0.2%	0.3%	0.1%	0.3%	0.4%
Highway	2.74	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%
Open Land	334.78	5.1%	0.6%	0.5%	1.8%	0.0%	3.7%	3.2%	1.1%	1.1%	6.9%
Water	84.43	0.2%	0.0%	0.0%	1.8%	0.0%	1.7%	0.1%	0.2%	0.0%	2.0%
No Data	13.20	0.0%	0.0%	0.0%	0.3%	0.1%	0.2%	0.0%	0.0%	0.0%	0.3%
Total	**4,187.28**	**86.4%**	**7.8%**	**1.4%**	**4.3%**	**0.1%**	**35.9%**	**46.5%**	**17.7%**	**13.6%**	**86.4%**

Hydrologic Response Units (HRUs) – Impervious

Impervious Land Use	Total Area (acre)	Soil Group					Slope		
		A	B	C	D	NoData	Low	Med	High
Forest	129.51	21.3%	1.4%	0.0%	0.1%	0.0%	9.4%	10.0%	3.3%
Agriculture	8.55	0.9%	0.6%	0.0%	0.0%	0.0%	0.8%	0.5%	0.1%
Commercial	75.02	8.7%	0.0%	4.4%	0.0%	0.0%	8.6%	3.6%	1.0%
Industrial	20.05	3.5%	0.0%	0.0%	0.0%	0.0%	2.0%	1.1%	0.4%
Low Density Residential	138.06	23.6%	0.6%	0.0%	0.0%	0.0%	11.1%	9.8%	3.3%
Medium Density Residential	137.38	24.0%	0.0%	0.1%	0.0%	0.0%	12.1%	9.8%	2.2%
High Density Residential	12.53	2.1%	0.0%	0.1%	0.0%	0.0%	1.0%	0.9%	0.3%
Highway	2.43	0.0%	0.0%	0.4%	0.0%	0.0%	0.4%	0.1%	0.0%
Open Land	45.31	5.8%	0.5%	1.6%	0.1%	0.0%	4.5%	2.9%	0.6%
Water	0.61	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%
No Data	0.58	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
Total	**570.04**	**89.8%**	**3.1%**	**6.8%**	**0.3%**	**0.1%**	**50.1%**	**38.8%**	**11.1%**

Hydrologic Response Units (HRUs) – Pervious

Pervious Land Use	Total Area (acre)	Soil Group					Slope		
		A	B	C	D	NoData	Low	Med	High
Forest	2,263.68	55.4%	6.7%	0.0%	0.4%	0.0%	18.7%	31.3%	12.7%
Agriculture	138.47	3.0%	0.8%	0.0%	0.0%	0.0%	1.6%	1.8%	0.4%
Commercial	37.80	0.8%	0.0%	0.2%	0.0%	0.0%	0.4%	0.4%	0.2%
Industrial	21.64	0.6%	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%	0.2%
Low Density Residential	413.70	11.0%	0.4%	0.0%	0.0%	0.0%	3.5%	5.7%	2.2%
Medium Density Residential	340.77	9.4%	0.0%	0.0%	0.0%	0.0%	3.4%	4.6%	1.4%
High Density Residential	14.97	0.4%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.1%
Highway	0.31	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Open Land	289.47	5.0%	0.6%	0.3%	2.1%	0.0%	3.6%	3.3%	1.2%
Water	83.82	0.2%	0.0%	0.0%	2.1%	0.0%	1.9%	0.2%	0.2%
No Data	12.61	0.0%	0.0%	0.0%	0.3%	0.1%	0.2%	0.0%	0.0%
Total	**3,617.24**	**85.9%**	**8.5%**	**0.6%**	**4.9%**	**0.1%**	**33.6%**	**47.7%**	**18.7%**

Hydrologic Response Units (HRUs) – Slope by Dev. Pervious

Land Cover	Total Area (acre)	Slope		
		Low	Med	High
Pervious A	986.28	29.3%	42.1%	16.1%
Pervious B	36.70	1.7%	1.3%	0.2%
Pervious C	19.58	1.1%	0.5%	0.1%
Pervious D	84.53	4.4%	2.2%	0.8%
NoData	0.00			
Impervious	568.76			
Pervious Forest	2,263.68			
Pervious Agriculture	138.47			
Water	84.43			
Total	**4,182.42**	**36.5%**	**46.2%**	**17.3%**

Hydrologic Response Units (HRUs)

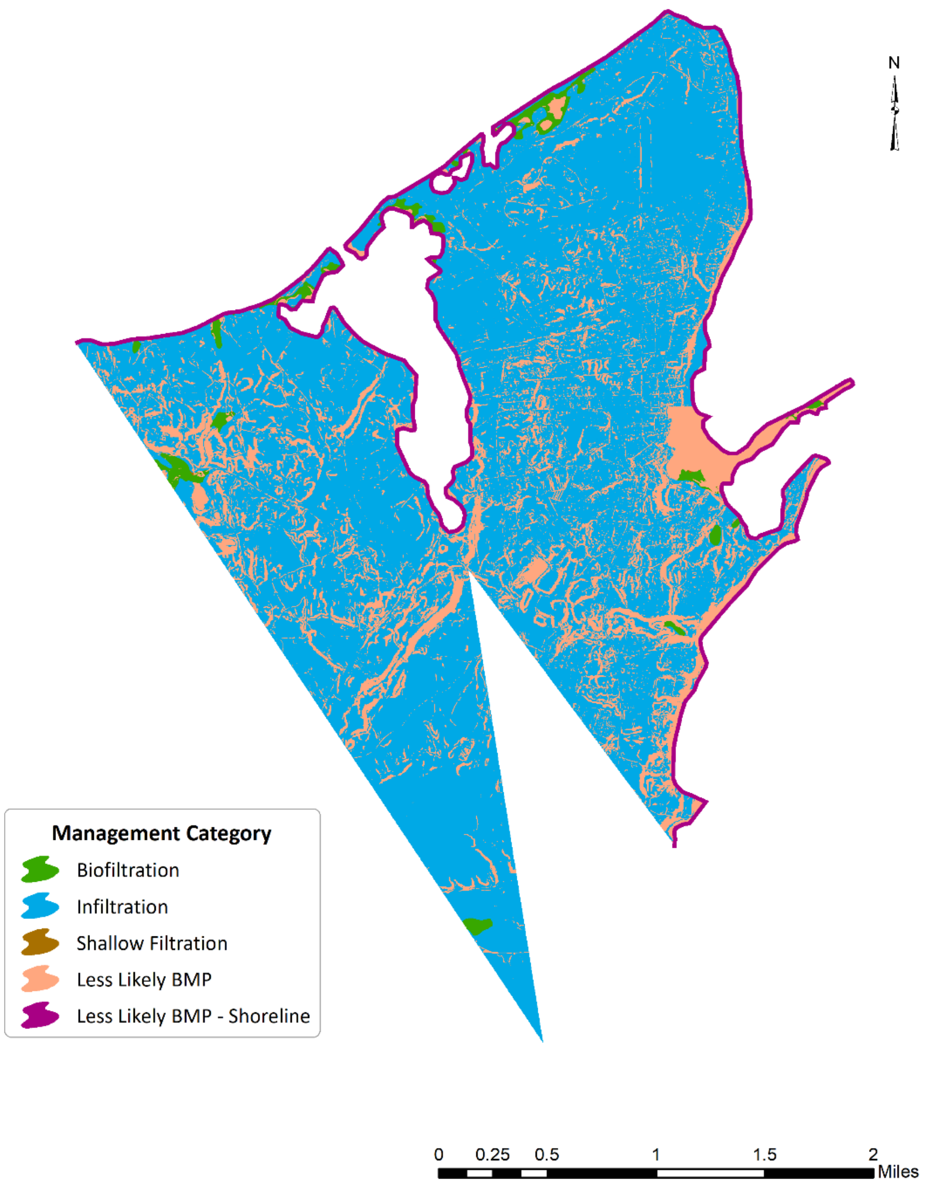
- Unique combinations of land use, land cover, soil, and slope
- Basic building blocks of the watershed model
- Boundary condition to the Opti-Tool

HRU	Land Use	Land Cover	Hydrologic Soil Group	Slope
1	Agriculture	Pervious	A	Low
2	Agriculture	Pervious	A	Med
3	Agriculture	Pervious	B	Low
4	Agriculture	Pervious	B	Med
5	Agriculture	Impervious	n/a	n/a
6	Forest	Pervious	A	Low
7	Forest	Pervious	A	Med
8	Forest	Pervious	A	High
9	Forest	Pervious	B	Low
10	Forest	Pervious	B	Med
11	Forest	Pervious	B	High
12	Forest	Impervious	n/a	n/a
13	Developed	Pervious	A	Low
14	Developed	Pervious	A	Med
15	Developed	Pervious	A	High
16	Developed	Pervious	B	Low
17	Developed	Pervious	B	Med
18	Developed	Pervious	C	Low
19	Developed	Pervious	C	Med
20	Developed	Pervious	D	Low
21	Developed	Pervious	D	Med
22	Open Space	Impervious	n/a	n/a
23	Commercial/Industrial	Impervious	n/a	n/a
24	Low Density Residential	Impervious	n/a	n/a
25	Medium Density Residential	Impervious	n/a	n/a
26	High Density Residential	Impervious	n/a	n/a
27	Highway/Roads	Impervious	n/a	n/a

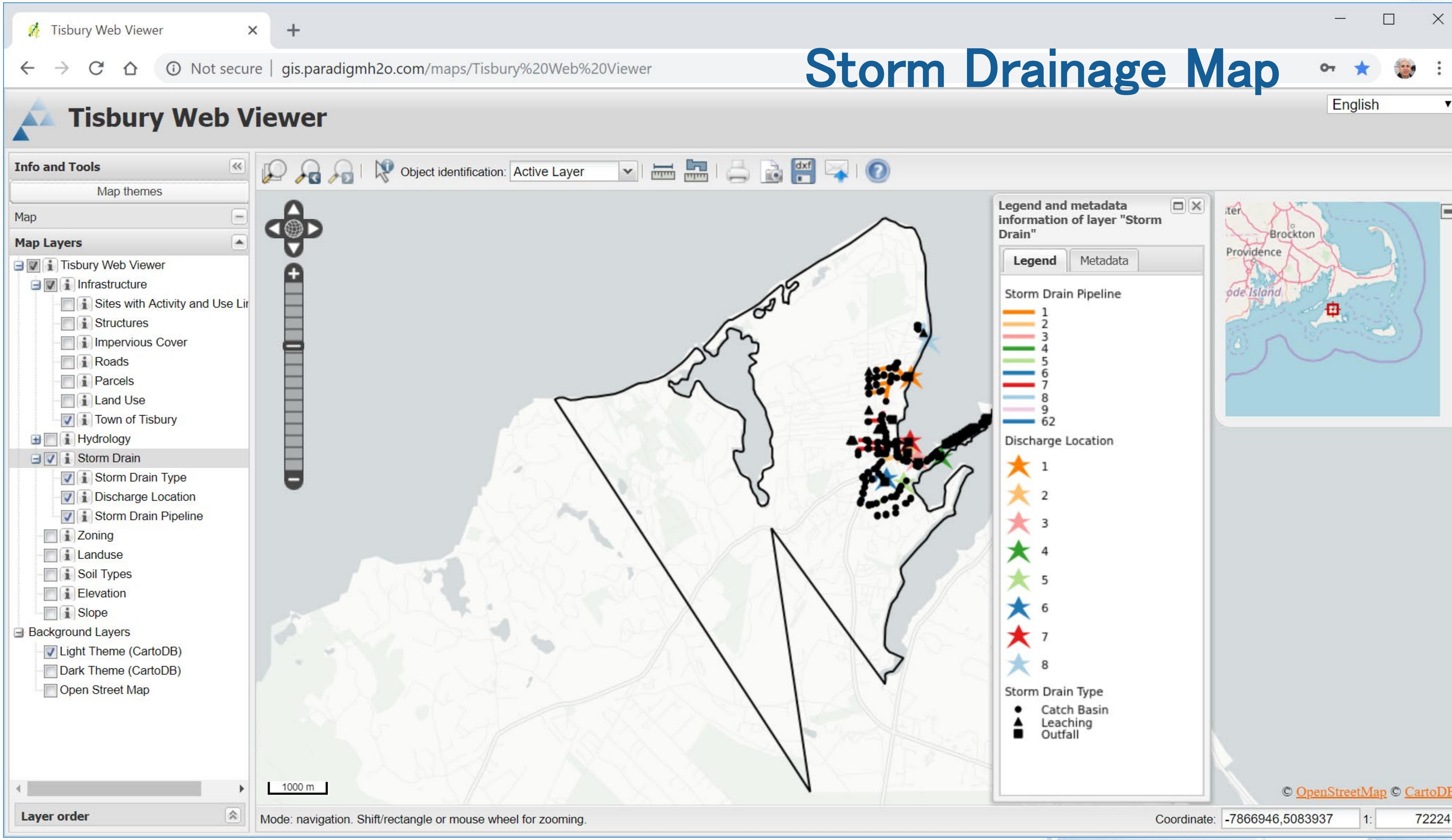
GI SCM Siting Criteria

Land Use	Landscape Slope (%)	Within 100 feet of Coastline?	Soil Group	Management Category	BMP Type(s) in Opti-Tool
Pervious Area	<= 15	Yes	All	Less likely for onsite BMP	--
		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	All	Less likely for onsite BMP	--
		No	A/B/C	Infiltration	Infiltration Trench
			D	Shallow filtration	Porous Pavement
	> 5	--	--	Less likely for onsite BMP	--

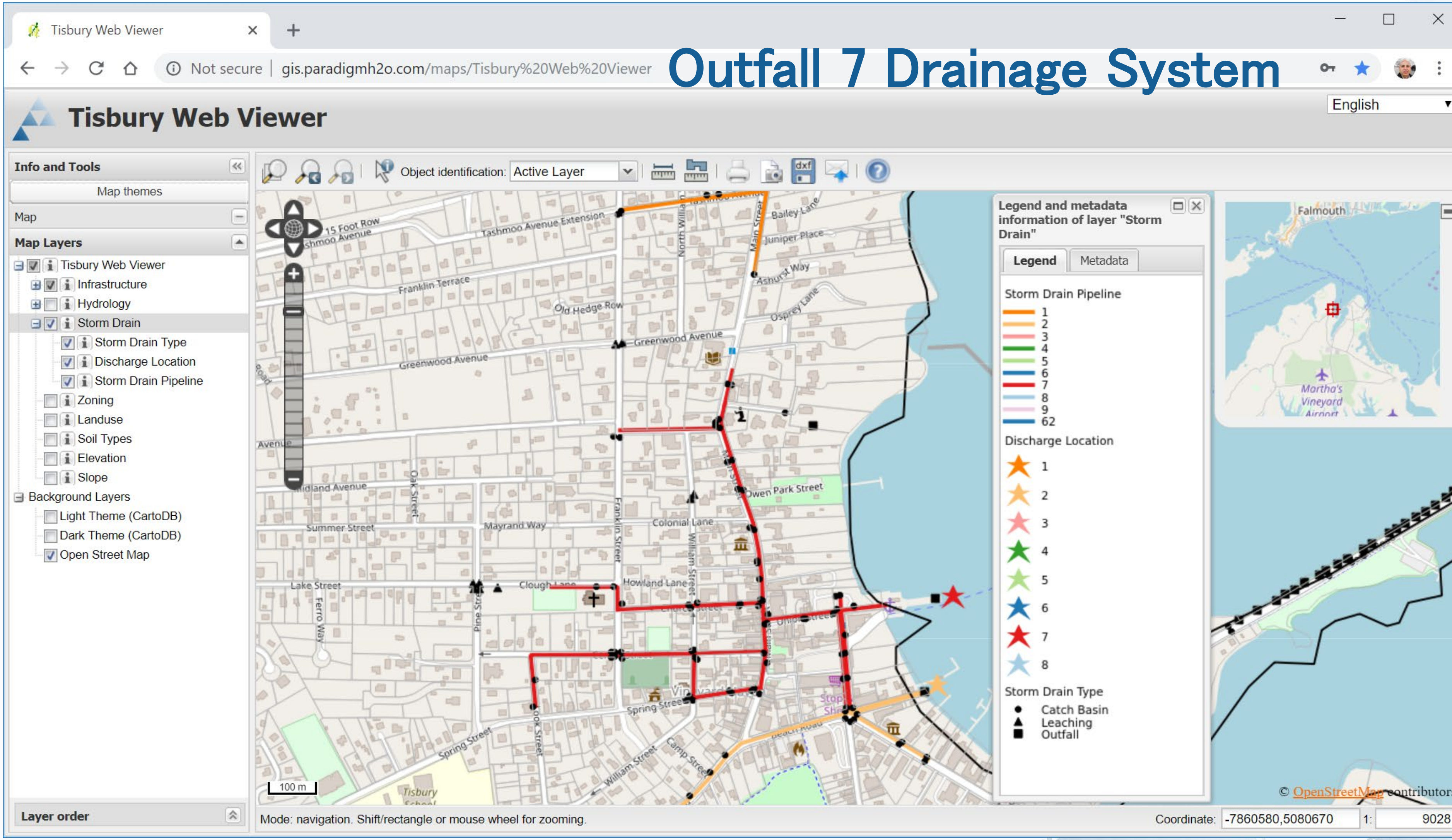
Management Category Based on Site Condition Suitability



Storm Drainage Map



Outfall 7 Drainage System



Pilot Study Area

- Outfall 7 as Assessment Point
- Establish Baseline Condition
  - Pipe network
  - Drainage to each catch basin (parcel boundaries)
  - Routing network
- Run GI SCM Scenarios
- Evaluate the effectiveness of GI SCM (annual based)
  - Flow volume
  - TN load

Discussion of issues/Drainage Master Plan

Nov 29, 2018

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

Field Investigation Concept Designs

"Bioretention Design"

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381,000 results!

GOOGLE

bioretention design

All Images Shopping Videos News More Settings Tools

About 381,000 results (0.33 seconds)

Images for bioretention design

More images for bioretention design

Report images

[PDF] Bioretention Design Specifications and Criteria
www.leesburgva.gov/home/showdocument?id=5057
Bioretention is flexible in **design**, affording many opportunities for the designer to be creative. This **design** guide first goes into a step by step process of how to size and **design bioretention** to accommodate the **design** storm runoff amount. After that, how to integrate the **bioretention** facility(ies) into the overall site **design** is ...

[PDF] Bioretention Manual - CT.gov
www.ct.gov/deep/lib/deep/p2/raingardens/bioretention_manual_2009_version.pdf
Mar 6, 2013 - This manual has been prepared to replace and update the 1993 edition of the **Design**. Manual for Use of **Bioretention** in Stormwater Management. This manual builds on that work and further identifies methodologies, practices, and examples of **bioretention**. Changes that were made focus primarily on four ...

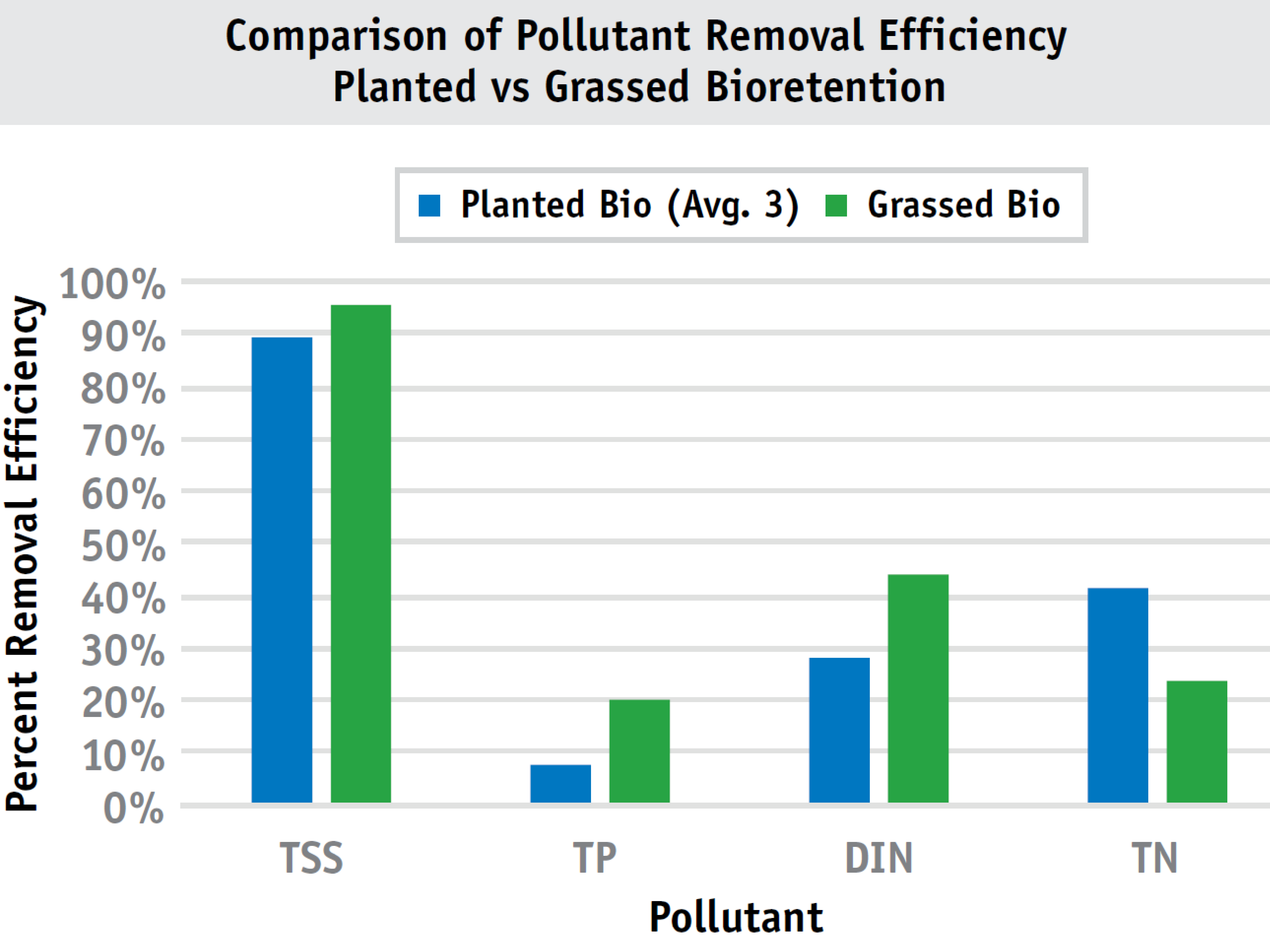
[PDF] Designing Bioretention Areas
https://www.unce.unr.edu/programs/sites/nemo/files/.../DesigningBioretentionAreas.pd...
"Bi. i i h i hi h. "**Bioretention** is the process in which contaminants and sedimentation are removed f ff S i from stormwater runoff. Stormwater is collected into the treatment area which. i t f b ff t i. d b d consists

Maintenance Must be Included in the Design Process

UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER

- Not by the designers, but by the people who are expected to do it and pay for it

The tale of two raingardens …


Comparison of Pollutant Removal Efficiency
Planted vs Grassed Bioretention
Planted Bio (Avg. 3)
Grassed Bio
Percent Removal Efficiency
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
TSS
TP
DIN
TN
Pollutant

Traditional Approach

KEY	QUANTITY	NAME
	50	TUSSOCK SEDGE *(Carex stricta)*
	75	COMMON RUSH *(Juncus effusus)*
	350	SWITCHGRASS *(Panicum virqatum)*
	15	BLUE FLAB *(Iris versicolor)*
	50	JOE PYE WEED *(Eupatorium maculatum)*
	20	BLUE CARDINAL FLOWER *(Lobelia siphilitica)*
	100	FOX SEDGE *(Carex Vulpinoidea)*
	15	NEW YORK ASTER *(Aster novi-belgii)*
	20	NEW YORK ASTER *(Aster novi-belgii)*
	40	BLUE CARDINAL FLOWER *(Lobelia siphilitica)*
	50	NEW YORK IRONWEED *(Vernonia noveboracensis)*
	50	NEW ENGLAND ASTER *(Aster novae-angliae)*
	150	BITTER PANICGRASS *(Panicum amarum)*
	40	BLUE CARDINAL FLOWER *(Lobelia siphilitica)*
	35	BLUE FLAB *(Iris versicolor)*
	75	COMMON RUSH *(Juncus effusus)*
	50	NEW YORK IRONWEED *(Vernonia noveboracensis)*
	15	NEW YORK ASTER *(Aster novi-belgii)*
	15	SWITCHGRASS *(Panicum virqatum)*
	20	BLUE CARDINAL FLOWER *(Lobelia siphilitica)*
	50	TUSSOCK SEDGE *(Carex stricta)*
	20	BLUE CARDINAL FLOWER *(Lobelia siphilitica)*

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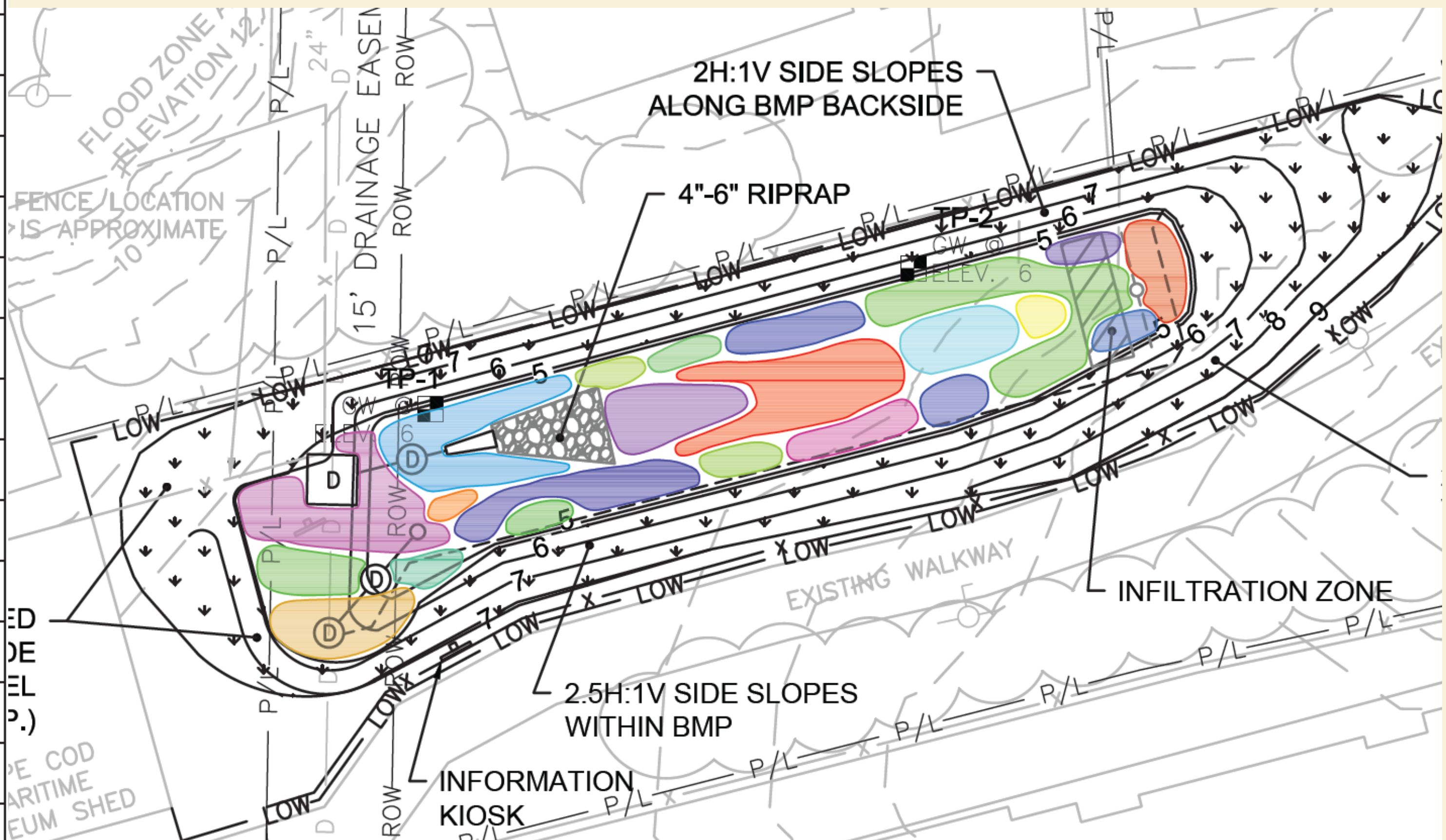

The Site Today

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Add it to the toolbox!

Inevitably we need to expand our toolbox

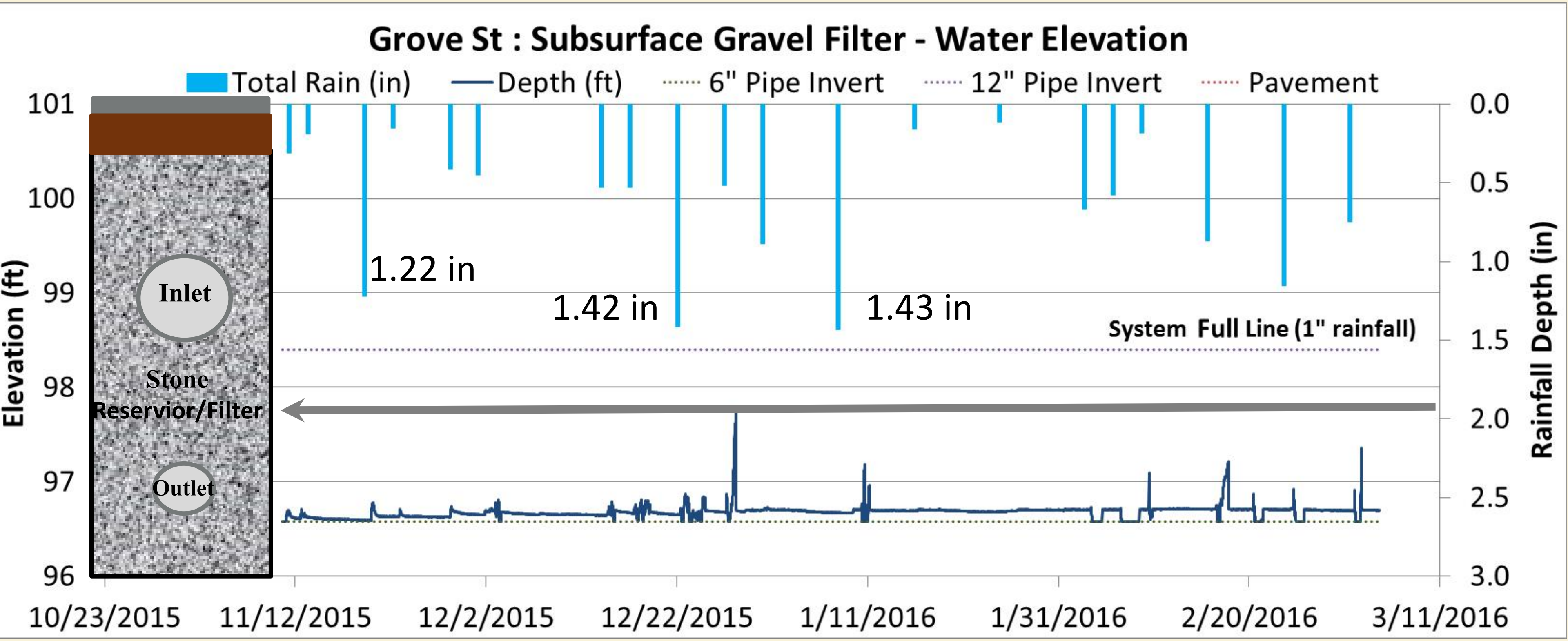
The more SCMs/Modifications /Innovations the better

There is not a lot of room for “turf” battles!

Need for Innovation

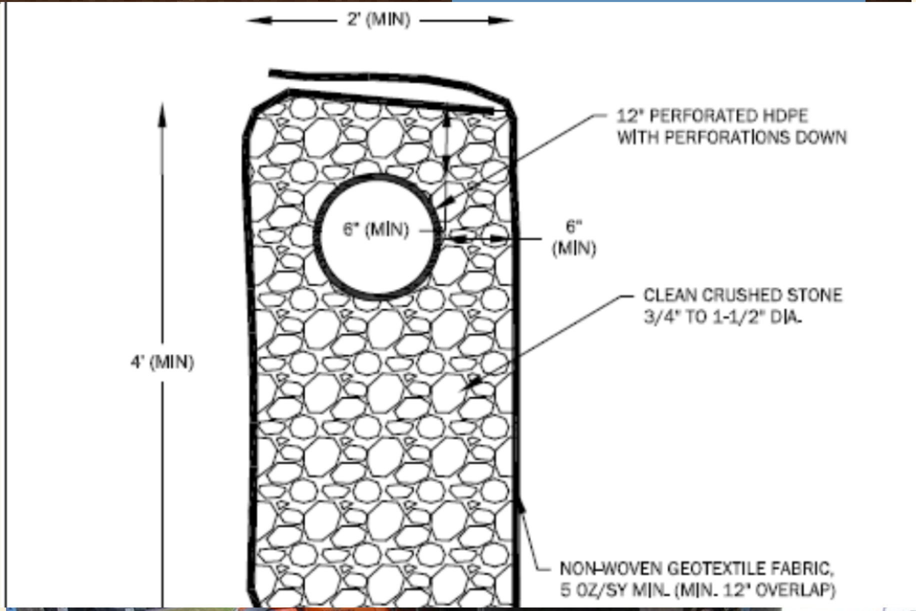
- "Boulanginator" (subsurface gravel filter) mimics performance of PA with regular pavement.
- The hydraulic inlet and outlets are controlled through perforated pipes and underdrains.
- treat runoff from 1.96 acres and 0.61 acres DCIA

Boulangenator Performance

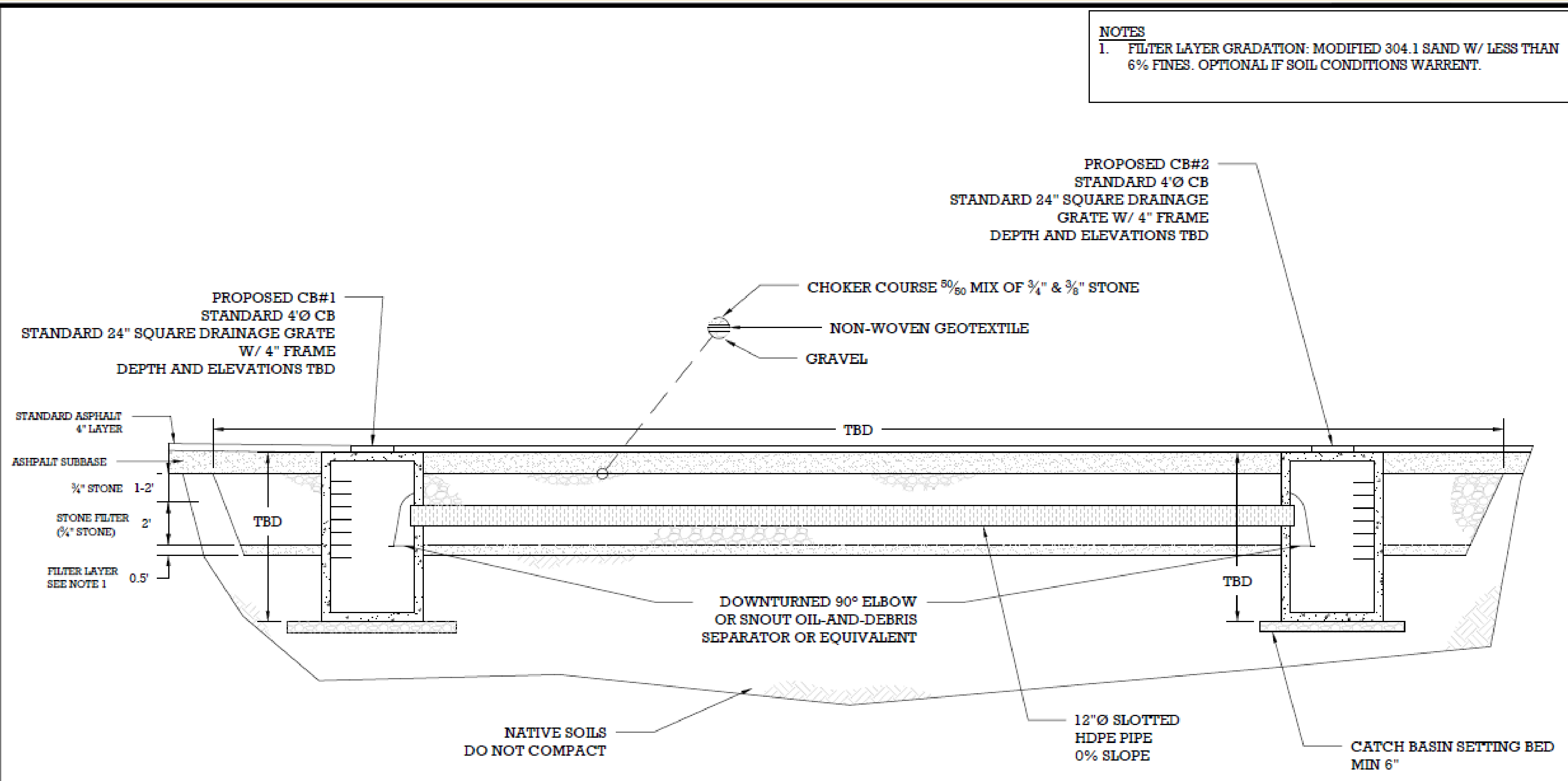


Need for Innovation

- In HSG A installed an infiltration trench between two conv CBs
- A simple but effective adaptation instead of solid pipe.
- Treats runoff from 3.36 acres and 1.04 acres DCIA



Infiltration Trench



PROFILE VIEW - INLET

Red Fox Apartments, Newfound Lake, NH

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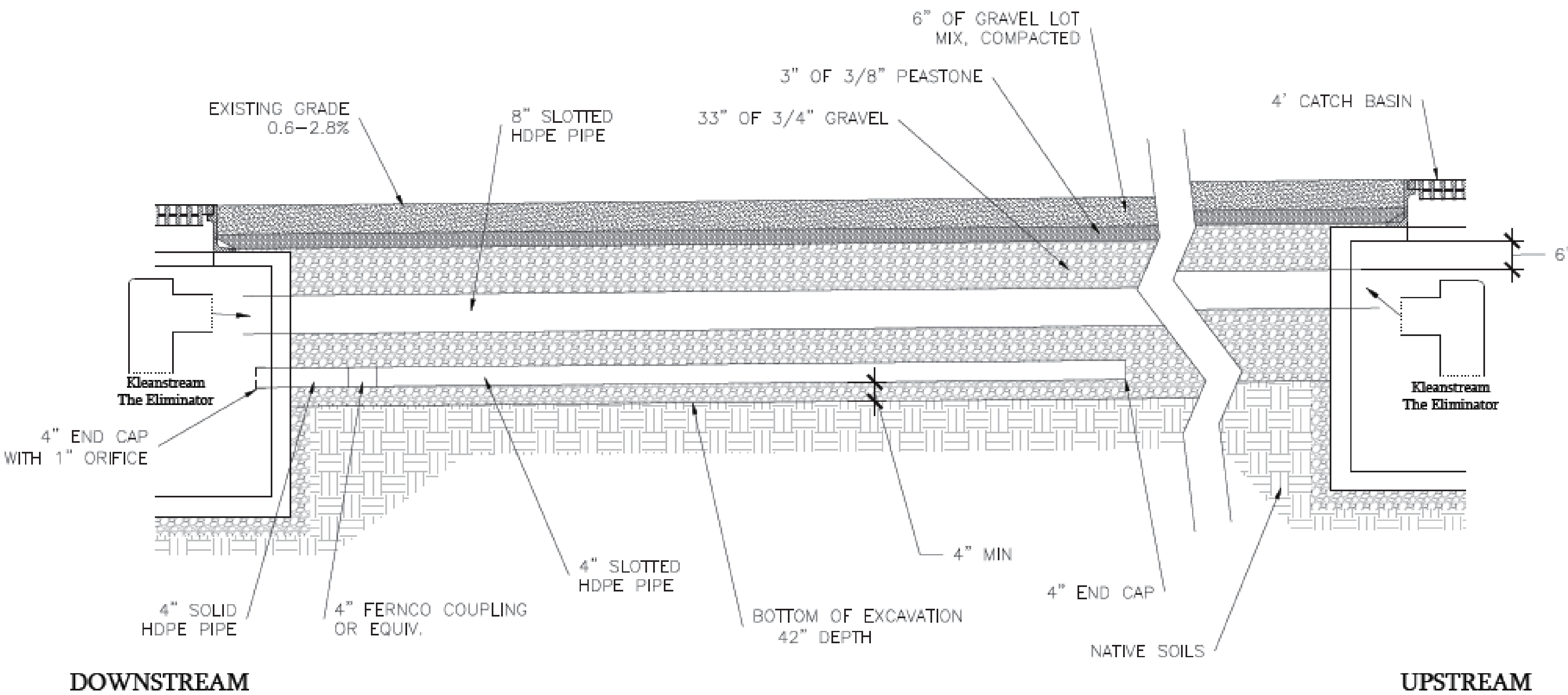
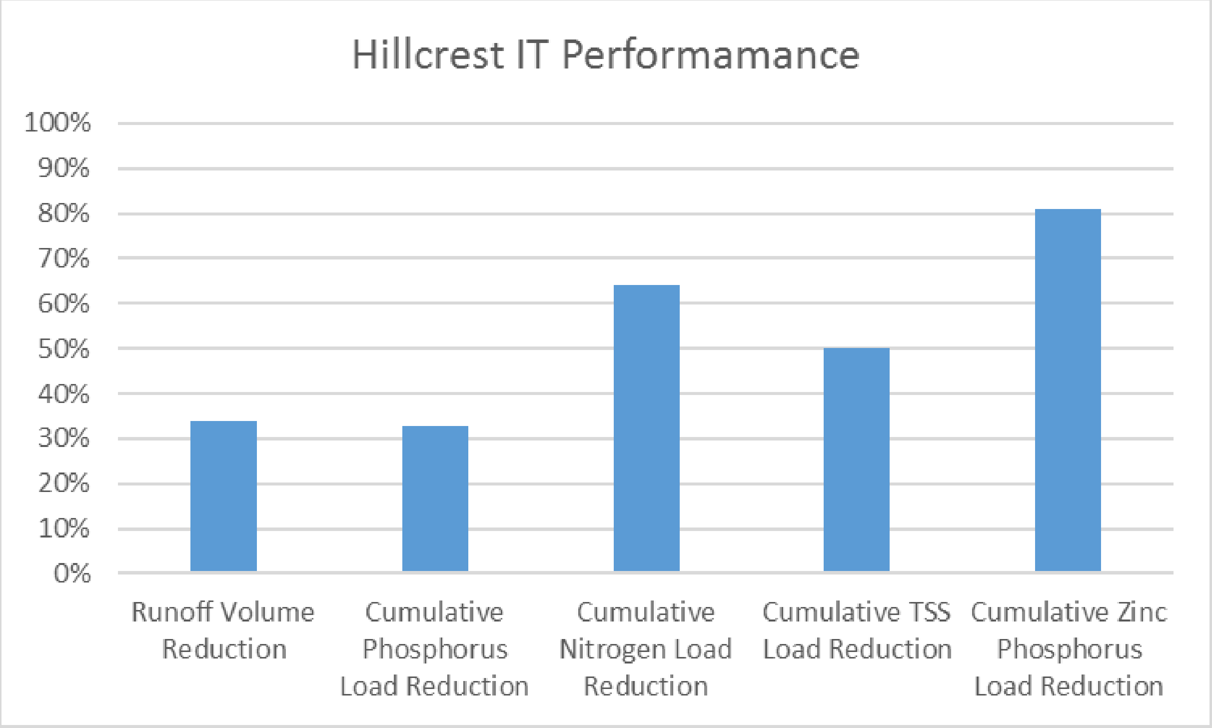
Red Fox Apartments, Newfound Lake, NH



Modeled Performance

Infiltration Trench (2.41 in/hr) BMP Performance Table	
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1
Runoff Volume Reduction	34%
Cumulative Phosphorus Load Reduction	33%
Cumulative Nitrogen Load Reduction	64%
Cumulative TSS Load Reduction	50%
Cumulative Zinc Phosphorus Load Reduction	81%



SGWS Costs

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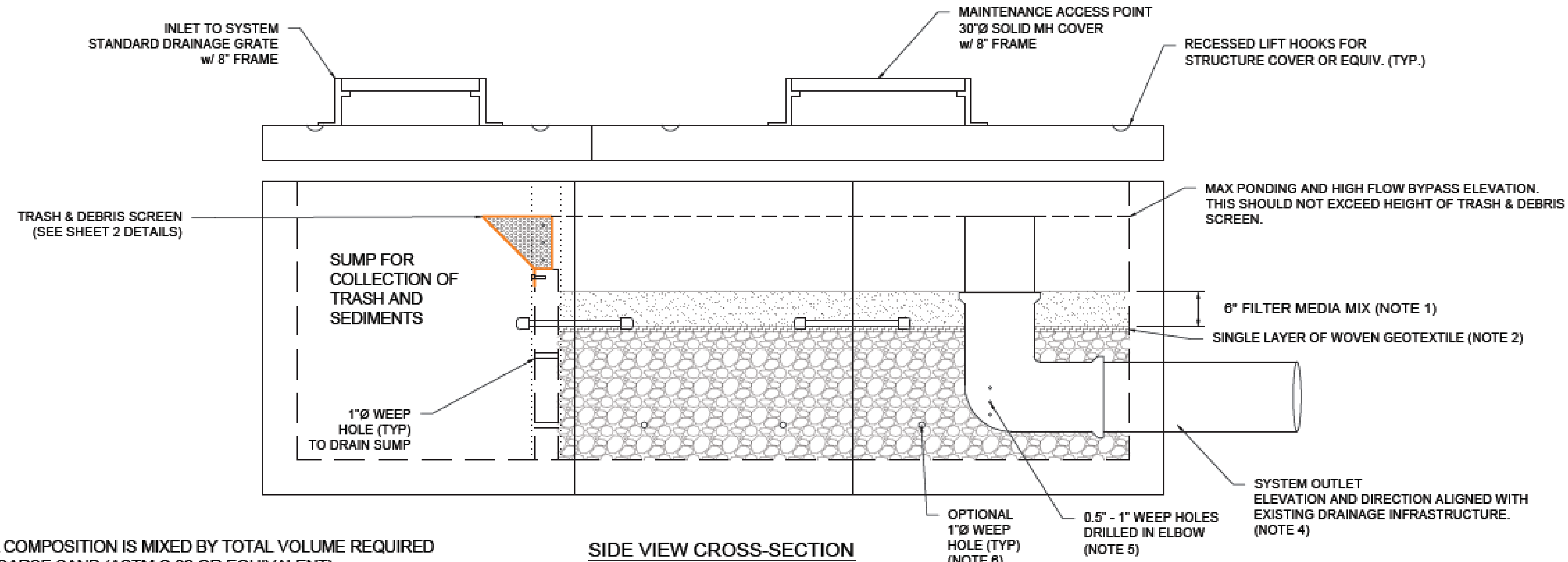
Site Characteristics and System Treatment Capacity						Annual Removals (lbs/yr)		
Project	Impervious Area (sf)	Impervious Area (acres)	Best Management Practice	Hydrologic Soil Group	Depth of Runoff Treated from Impervious Area (in)	Total Suspended Sediment	Total Phosphorus	Total Nitrogen
Hillcrest IT	39,640	0.91	Infiltration Trench	B	0.10	97	0.35	8.8

Water Quality Volume	Hillcrest IT
Drainage Area (ft^2)	39,640
% Impervious Cover	100%
Impervious Area (ft^2)	39,640
Conv WQV (ft^3) (@ P = 1.0in)	3,303
System Treatment	
System Area (ft^2)	10
Reservior Storage (ft^3)	400
System Storage (ft^3)	320
Rainfall Depth Treated (in)	0.10

Marginal Extra Materials	Marginal Cost Difference
700 cf stone	$10,000

Sectional Media Box Filter Design – version 3



SIDE VIEW CROSS-SECTION

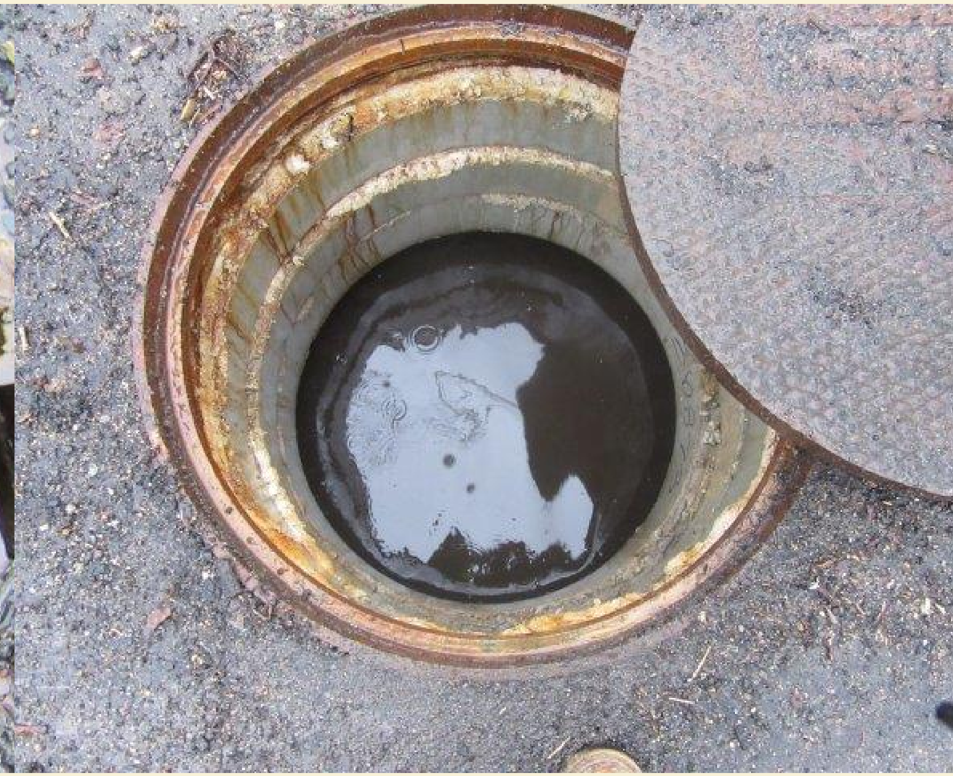
NOTES:

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

August 2017

- Filtering Catch Basin Designed to replace conv DSCB where applicable
- This system was the third iteration
- The City has purchased four additional filtering catch basins and will install them in other areas throughout the city.
- The system is designed to treat 0.5 acres (0.25 acres/section) of IC per section and costs 2,400 per

In Operation



Update May 2018

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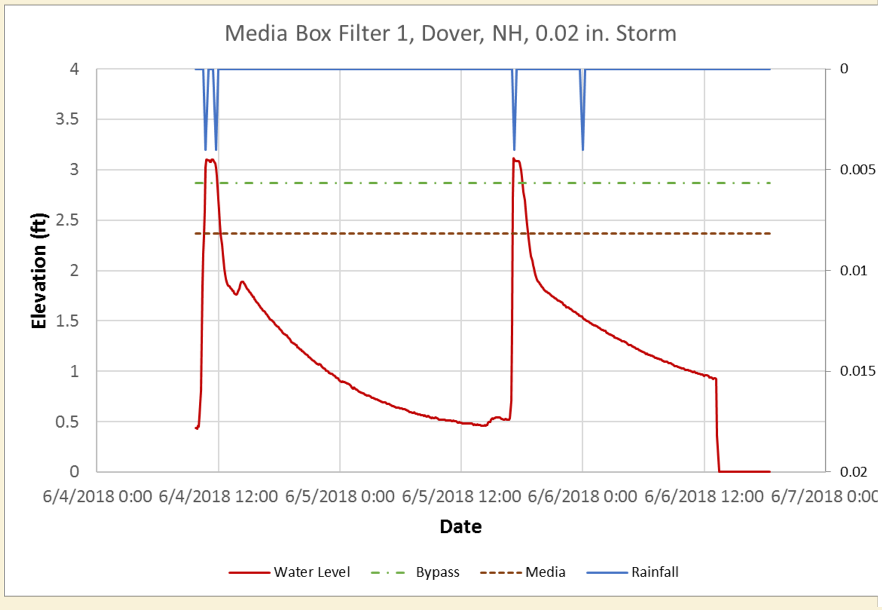
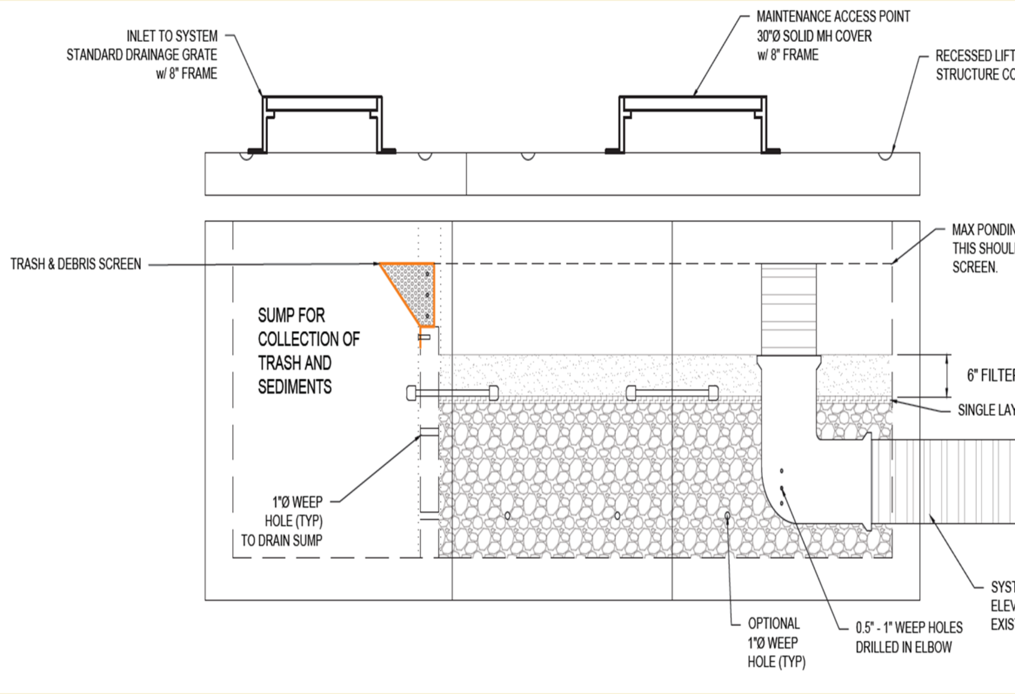
STORMWATER CENTER

Update May 2018

Update May 2018



Media Box Filter 1, Dover, NH, 0.02 in. Storm
Elevation (ft)
Date
Water Level
Bypass
Media
Rainfall



INLET TO SYSTEM
STANDARD DRAINAGE GRATE
w/ 8" FRAME
MAINTENANCE ACCESS POINT
30"Ø SOLID MH COVER
w/ 8" FRAME
TRASH & DEBRIS SCREEN
SUMP FOR COLLECTION OF TRASH AND SEDIMENTS
1"Ø WEEP HOLE (TYP) TO DRAIN SUMP
OPTIONAL 1"Ø WEEP HOLE (TYP)
0.5" - 1" WEEP HOLES DRILLED IN ELBOW

Lunch Break

Watershed Tour

Nov 29, 2018