Introduction

Name

Affiliation

What is YOUR biggest challenge in stormwater control measure accounting/planning?

Opti-Tool Outreach Workshop Part 1

Research Based Stormwater System Accounting

UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER

New England Environmental Finance Center

November, 2017

Agenda for the Day

Introduction

Unit Operations & Processes (UOPs)

Review of BMPs

Review of BMP Worksheets and Cross-walks

Costs

Effective SWM Case Study

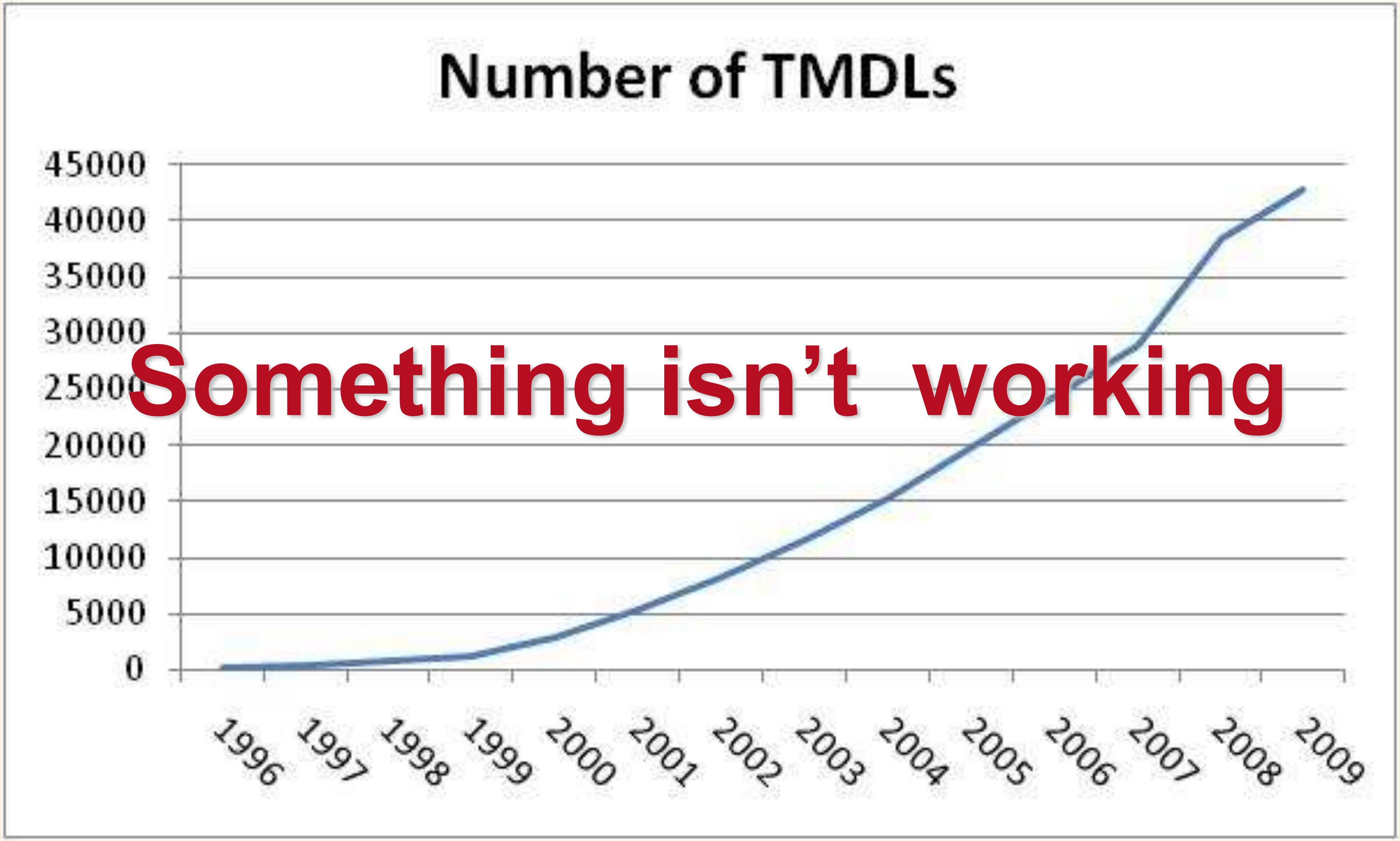
Site Design Assessment

Group Debrief & Discussion

Why We're Here

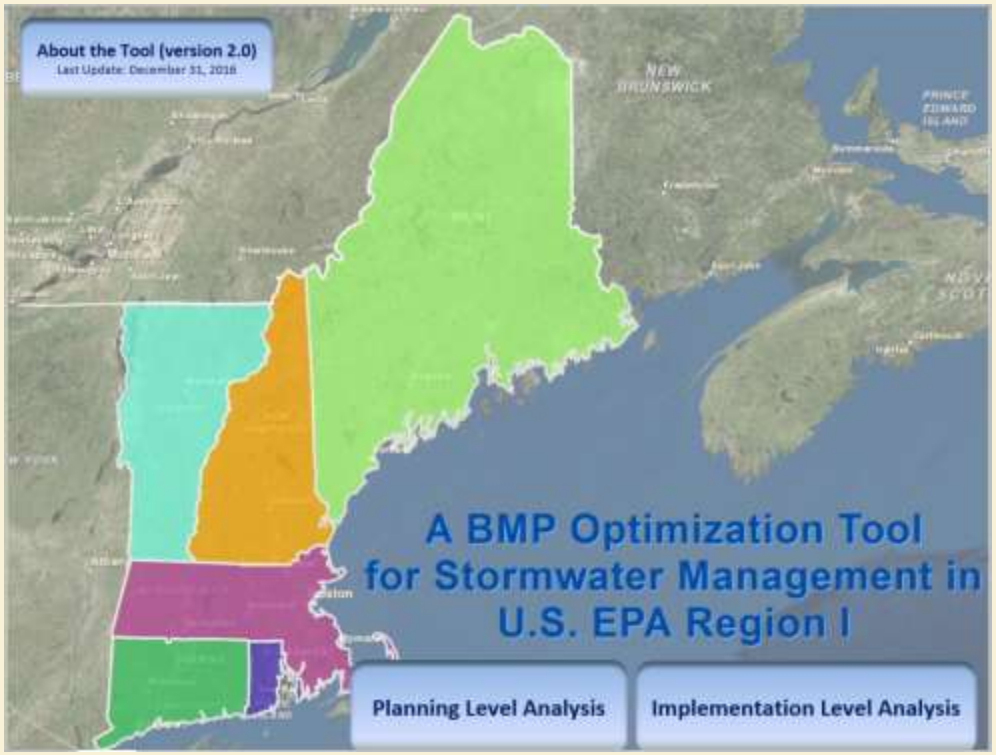
New England Environmental Finance Center

University of New Hampshire Stormwater Center



Something isn't working

What is the Opti-Tool



MA MS4 General Permit

United States Environmental Protection Agency (EPA)
National Pollutant Discharge Elimination System (NPDES)

GENERAL PERMITS FOR STORMWATER DISCHARGES FROM SMALL MUNICIPAL SEPARATE STORM SEWER SYSTEMS IN MASSACHUSETTS

AUTHORIZATION TO DISCHARGE UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of the Clean Water Act (CWA), as amended (33 U.S.C. §1251 *et seq.*), and the Massachusetts Clean Waters Act, as amended (M.G.L. Chap.21 §§ 26-53), any operator of a small municipal separate storm sewer system whose system:

- Is located in the areas described in part 1.1;
- Is eligible for coverage under part 1.2 and part 1.9; and
- Submits a complete and accurate Notice of Intent in accordance with part 1.7 of this permit and EPA issues a written authorization

is authorized to discharge in accordance with the conditions and the requirements set forth herein.

The following appendices are also included as part of these permits:
Appendix A – Definitions, Abbreviations, and Acronyms;
Appendix B – Standard permit conditions applicable to all authorized discharges;
Appendix C – Endangered Species Act Eligibility Guidance;
Appendix D – National Historic Preservation Act Eligibility Guidance;
Appendix E – Information required for the Notice of Intent (NOI);
Appendix F – Requirements for MA Small MS4s Subject to Approved TMDLs;
Appendix G – Impaired Waters Monitoring Parameter Requirements;
Appendix H – Requirements related to discharges to certain water quality limited waterbodies;

These permits become effective on **July 1, 2017**.

These permits and the authorization to discharge expire at midnight, **June 30, 2022**.

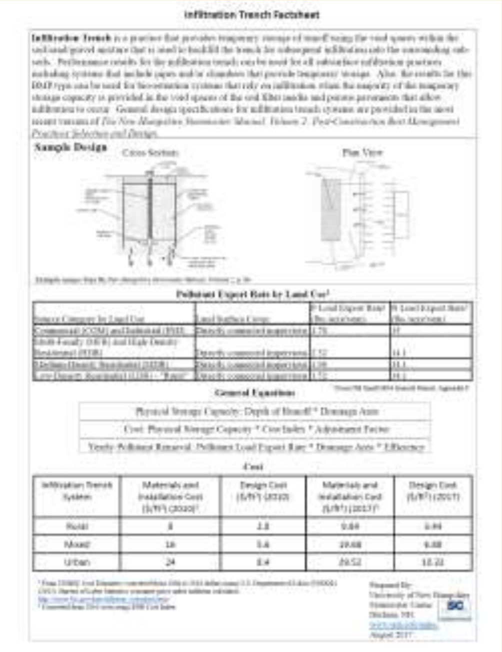
Signed this 1st day of April, 2016

Ken Moraff, Director
Office of Ecosystem Protection
United States Environmental Protection Agency
5 Post Office Square – Suite 100
Boston, Massachusetts 02109-3912

Signed this 4th day of April 2016

Douglas E. Fine
Assistant Commissioner for Water Resources
Department of Environmental Protection
One Winter Street
Boston, Massachusetts 02108

Materials We Will Use Today



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Stormwater System Classification Can Be Challenging

Because we don't always speak the same language

Swale Permeable Interlocking Concrete Pavers Retention Pond Detention Pond

Permeable Interlocking Concrete Pavers

Subsurface Detention Permeable Interlocking Concrete Pavers Water Quality Inlet

Permeable Interlocking Concrete Pavers

Downstream Defender Bio-Swale Naturalized Basin

Permeable Interlocking Concrete Pavers

Permeable Interlocking Concrete Pavers

Storm Trooper Vort-Sentry V2B1 Bay Saver

Permeable Interlocking Concrete Pavers

Permeable Interlocking Concrete Pavers

Bioretention Rain Garden Tree Filter Filtera

Permeable Interlocking Concrete Pavers

Permeable Interlocking Concrete Pavers

Sand Filter Delaware Austin ADS StormTech

Permeable Interlocking Concrete Pavers

Gravel Wetland Stormwater Wetland Surface Wetland

Permeable Interlocking Concrete Pavers

Permeable Interlocking Concrete Pavers

Pervious Concrete Porous Asphalt Constructed Wetland

Imagine the Ultimate System…

Now Consider Bioretention

No Need to Reinvent this Wheel

Use Unit Operations & Processes (UOPs)

- Physical Operations
- Biological Processes
- Chemical Processes
- Hydrologic Operations

Physical UOPs

Sedimentation

Enhanced Sedimentation

Filtration

Screening

Biological UOPs

Vegetative Process

Microbial Process

Chemical UOPs

Sorption

Antibacterial

Flocculation

Coagulation

Hydrologic UOPs

Flow Alteration

Volume Reduction

Agenda for the Day

New England Environmental Finance Center

University of New Hampshire Stormwater Center

- Introduction
- Unit Operations & Processes (UOPs)
- **Review of BMPs**
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Opti-Tool

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BMP Type	Design Storage Capacity (ft^3)	BMP Cost ($)	Treated Impervious Area (ac)	O&M (hr/yr)	Load Reduction (lbs)	Treated Runoff Depth (in)
Biofiltration with ISR	-	$ -	-	-	-	-
Bioretention	-	$ -	-	-	-	-
Dry Pond	-	$ -	-	-	-	-
Grass Swale*	-	$ -	-	-	-	-
Gravel Wetland	-	$ -	-	-	-	-
Infiltration Basin	-	$ -	-	-	-	-
Infiltration Chambers*	-	$ -	-	-	-	-
Infiltration Trench	-	$ -	-	-	-	-
Porous Pavement*	-	$ -	-	-	-	-
Sand Filter	-	$ -	-	-	-	-
Wet Pond	-	$ -	-	-	-	-

Note:Only fill in the yellow highlighted cells.

* Place holder for future option (not implemented)

https://www.epa.gov/tmdl/opti-tool-epa-region-1s-stormwater-management-optimization-tool

SCMs Currently Covered in Opti

Covered in Opti (8)

- Biofiltration with ISR
- Biofiltration
- Dry Pond
- Gravel Wetland
- Infiltration Basin
- Infiltration Trench
- Sand Filter
- Wet Pond

Covered in MS4 (2)

- Pemeable (Porous) Pavement
- Grass Swale

Some Definitions

Design Storage Volume (DSV), aka Design Storage Capacity

L = length

W = width

D = depth at design capacity before bypass

n = porosity/void space of fill material

- soil media (bio-retention soil mix, engineered soil mix, etc.) = 0.2
- peastone (⅜” washed) = 0.3
- reservoir stone (¾” washed) = 0.4

A = average surface area for calculating volume

DSV Example

Infiltration Basin/Surface Infiltration for raingarden or bio-retention with no underdrains

- DSV = Ponding water storage volume and void space volumes of soil filter media and stone layers, if applicable.
- $DSV = (A_{pond} \times D_{pond}) + (A_{soil} \times D_{soil} \times n_{soil}) + (A_{stone} \times D_{stone} \times n_{stone})$

DSV Example

Infiltration Basin/Surface Infiltration for raingarden or bio-retention with no underdrains

- $DSV = (A_{pond} \times D_{pond}) + (A_{soil} \times D_{soil} \times n_{soil}) + (A_{stone} \times D_{stone} \times n_{stone})$

A = 100 sf
Ponded Depth = 1’
Soil Depth = 2’
Stone Depth = 1.5’

DSV = (100 x 1 x 1) + (100 x 2 x 0.2) + (150 x 1 x 0.4)

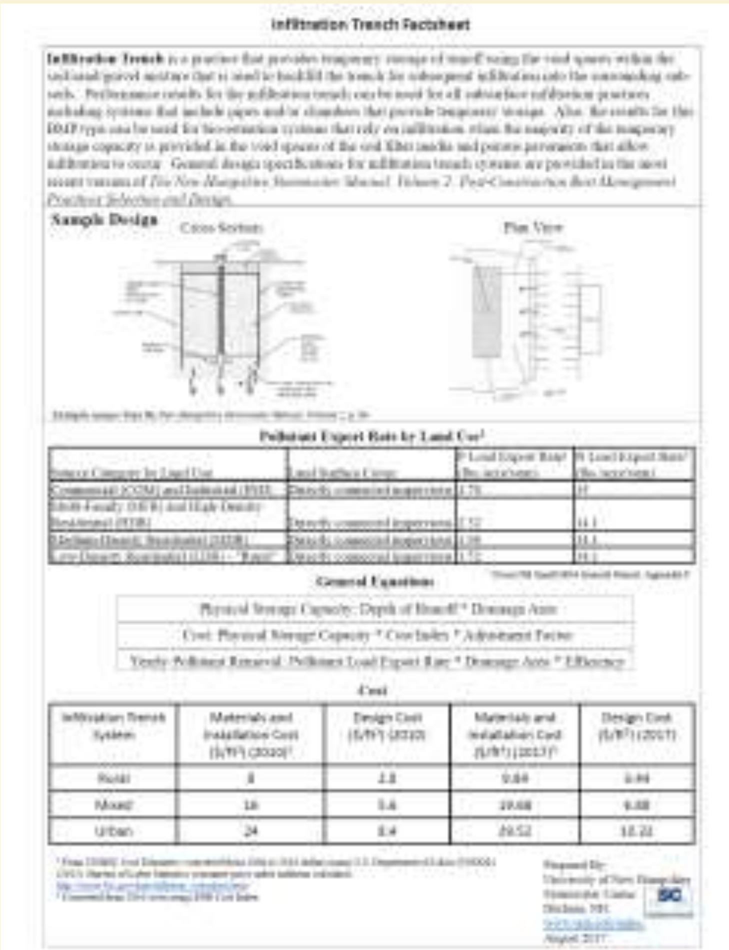
DSV = 200 cf

Treated Runoff Depth

= DSV/WQV x 12

Drainage Area	1 acre (43,560 sf)
Impervious Area	0.6 acres (26,136 sf)
WQV = Area sf x 1/12	2,000 cf
DSV	200 cf
Treated Runoff Depth	0.1 inches

Review of Worksheets


Infiltration Trench Factsheet

Sample Design

Cross Section

Plan View

Pollutant Export Rate by Land Use

General Equations

Cost


Massachusetts Stormwater Manual	New Hampshire Stormwater Manual	EPA Pollutant Curves	EPA Cost Estimates

Fill in the Blanks

BMP Type	DSV (cf)	Treated IC acres (sf)	Treated Runoff Depth	% Load Reduction TSS	TP	TN
Bioretention/ Infiltration Basin	200	1 (26,136)	1.2			

HSG A = 8.24 in/hr

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Life Cycle Costs Including Maintenance

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BMP	Area of IC treated	WQv (cf)	BMP Area ft3	Annual Ave Maintenance $	Annual Maintenance hours	Capital Cost per acre of IC treated	2010 Adj Capital Cost of system *	Added design contingency of 35%	Capital Costs per ft^3	Capital Costs per cf treated (WQv)	Capital Costs per BMP storage volume (cf)	Capital Costs/sf of IC	Amoritized Life Cylce Costs ***
Vegetated Swale	1.00	3,630	5,400	$822.50	9.5	$11,200.00	$12,928.68	$17,453.72	$3.23	$4.81	NA	$0.26	$33,903.72
Retention Pond	1.00	3,630	12,880	$3,060.00	28.0	$13,700.00	$15,814.54	$21,349.63	$1.66	$5.88	$5.88	$0.31	$82,549.63
Detention Pond	1.00	3,630	12,880	$2,380.00	24.0	$13,700.00	$15,814.54	$21,349.63	$1.66	$5.88	$5.88	$0.31	$68,949.63
Chamber System	1.00	3,630	434	Not assessed	Not assessed	$34,000.00	$34,434.75	$46,486.91	$107.13	$12.81	$107.13	$0.78	Not assessed
Sand Filter	1.00	3,630	640	$2,807.50	28.5	$12,417.00	$14,333.52	$19,350.25	$30.23	$5.33	$15.51	$0.29	$75,500.25
Gravel Wetland	1.00	3,630	1,920	$2,138.33	21.7	$22,300.00	$25,741.92	$34,751.59	$18.10	$9.57	$7.59	$0.51	$77,518.26
Bioretention	1.00	3,630	4,326	$1,890.00	20.7	$20,000.00	$23,086.92	$31,167.34	$7.21	$8.59	$13.37	$0.46	$68,967.34
Enhanced Bio	0.39	935	373	$1,890.00	21.0	$29,000.00	$29,000.00	$39,150.00	$105.09	$41.86	$105.09	$0.67	$68,967.34
Porous Asphalt	1.00	3,630	32,670	$1,080.00	6.0	$21,780.00	$22,058.49	$29,778.96	$0.91	$8.20	$4.60	$0.50	$51,378.96
Pervious Concrete**	1.00	3,630	32,670	$1,080.00	6.0	$74,052.00	$74,998.88	$101,248.49	$3.10	$27.89	$15.63	$1.70	$122,848.49
Permiable Interlocking Concrete Pavement **	1.00	3,630	32,670	$1,080.00	6.0	$74,052.00	$74,998.88	$101,248.49	$3.10	$27.89	$15.63	$1.70	$122,848.49

note all costs were converted from 2004 dollars to 2010 dollars with the exception of the permeable pavements which were converted from 2008 dollars to 2010 dollars

* See reference information from USDOL

** PA cost estimates were calculated as the difference between PA installations and a typcical dense mix pavement equivalent. PC and PICP costs were developed using the same methodology and compared to typical DMA, not typical concrete or paver pavements.

*** Life cycle costs were calculated based on 2010 capital costs and amoritized annual maintenance costs over an expected useful life of 20 years

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

Design, Capital, and Construction Costs

Infiltration Trench System	Materials and Installation Cost ($/ft³) (2010)[2]	Design Cost ($/ft³) (2010)	Materials and Installation Cost ($/ft³) (2017)[3]	Design Cost ($/ft³) (2017)
Rural	4	1.88	4.92	1.72
Mixed	8	3.76	9.84	3.44
Urban	12	5.64	14.76	5.16

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**

Fill in the Blanks

BMP Type	DSV (cf)	Treated IC acres (sf)	Treated Runoff Depth	% Load Reduction		
				TSS	TP	TN
Bioretention/ Infiltration Basin	200	1 (26,136)	1.2	99	99	99

BMP Type	BMP Cost ($/yr)	O&M Costs (hrs/yr)
Bioretention/ Infiltration Basin		12.42

Assume Urban Environment

14.76 + 5.16 = 19.92 x 200 = $3,984

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Hand out case description of Daisy Field project: case should be designed to prompt/spark thinking about alternatives using GI/BMP approaches; Hold Discussion. 25 minutes

Daisy Field

- 47.4 Acre Ultra-urban environment at 65% IC
- Not a lot of space to put Bmps
- 62% TP reduction requirement as the discharge is to the Charles River

Watershed Characteristics

	Daisy Field
P	1
A	70.47
I	0.65
Rv	0.635
WQV (acre-in)	1.88
WQV (ft^3)	81,936.36
S	1.11
Q (in)	0.320325
CN	90
Ia	0.22
Ia/P	0.22
TC (hr)	0.12

What would you do?

Agenda for the Day

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Other Considerations

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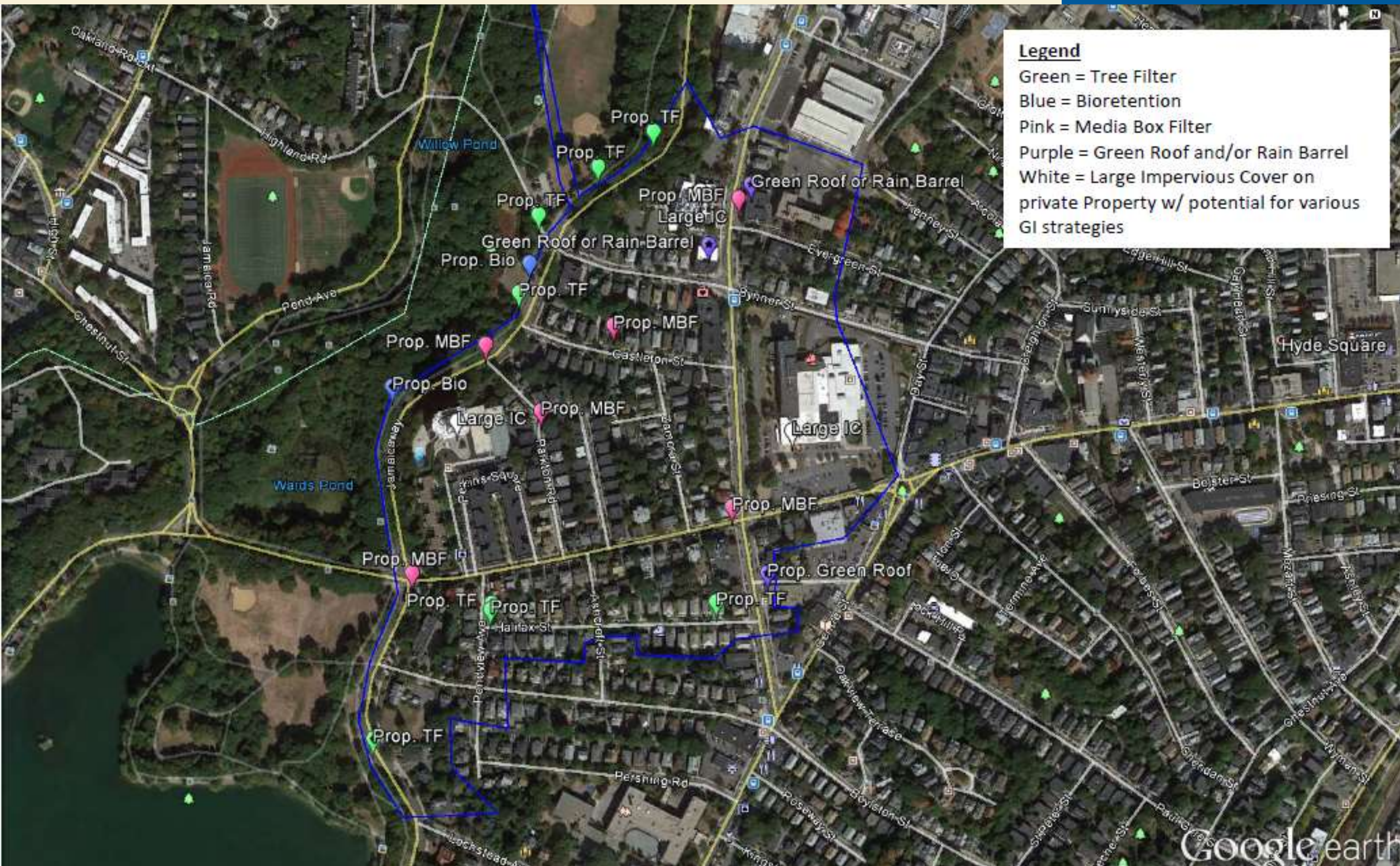

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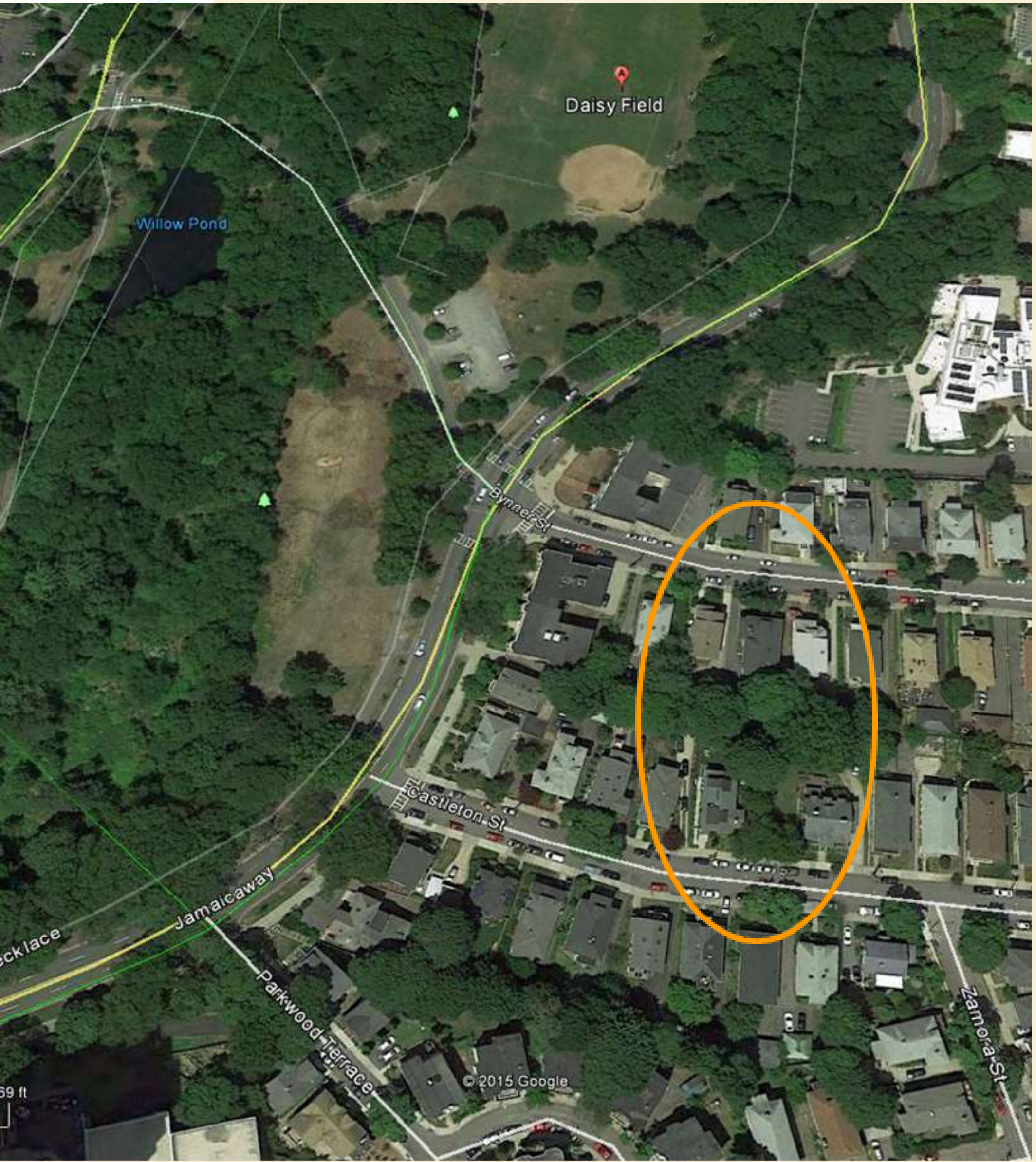
Location	Best Management Practice	Rationale
Along west side of Jamaica Way	Tree Filters (5)	Existing storm drain line and several catch basins. There are also some recently planted trees that could be transplanted into tree filter units. These would provide some treatment through filtration, infiltration, rhizosphere, and flow attenuation. Media amendments would be added to remove phosphorus.
Halifax St and Pondview Ave	Tree Filters (2)	There is an existing storm drain line and catch basins on each side of the Halifax St. The existing street scape includes trees.
Halifax St near S. Huntington St	Tree Filter	There is an existing storm drain line and a catch basin that could be converted to a tree filter.
• Parkwood Terrace and Jamaica Way • Perkins St and Jamaica Way	Media Box Filters	Existing storm drain line and catch basin. Large vegetated strip between road and sidewalk that is likely in City right-of-way. Large trees are in this proximity so an MBF would be a better fit.
• North end of Parkton Rd • Perkins St and S. Huntington • Castleton St • Evergreen St and S. Huntington	Media Box Filters	Existing storm drain line and catch basins on each side of Perkins St. No vegetated area but an MBF might fit under the road depending on other utilities.
Just south of Highland Rd and Jamaica Way intersection	Bioretention	Existing storm drain line and room for a bioretention cell that could treat surface runoff and then be piped into existing line.
West of Jamaica Way near Wards Pond	Bioretention	Plenty of area for a bioretention cell but some trees may need to be removed. Effluent could discharge cool treated water to Wards Pond.
• El Mundo Newspaper • Intersection of Bynner St and South Huntington • Intersection of Evergreen St and South Huntington	Green Roof and Rain Barrel installations	These are flat roof buildings with concrete block or brick exteriors, which may be strong enough for green roof systems. There are several other buildings in the drainage area that could be identified if this is a viable strategy.
• MSPCA, Animal Care & Adoption Center • Perkins Square – Sagamore Advisors • Mt. Pleasant Home	Tree Filters, Bioretention(s), media box filters	Three of the largest, privately owned impervious cover areas in the watershed. There are media strips, large parking areas, and large roof tops that could all be managed using various GI strategies.

Other Considerations



"Hi, Tim and I were just chatting about siting systems. Is there any reason why we could not put a system where the orange oval is in the pic below?"

"I'm going to say almost definitively no. It's private property and we have no way to get those property owners to work with us. Additionally, my understanding is that we want a visible area for public education (a park in this tributary area)."

Other Considerations

We need to avoid the ball fields for now. In the future, Parks may choose to redo the fields and we will propose an Underground Gravel Filter at that time.

What are we trying to treat?

We are trying to treat the first 1" of water across the whole catchment

If that cannot be done, then aim for the 62% reduction of phosphorus

Who owns what?

a. Parks owns the pipe that runs under Daisy Field, starting from 18GMH252 and continuing to the outfall

i. However, BWSC owns 18GMH252

b. Parks also owns the outfall into Leverett Pond

Other Considerations

In the “TOPOGRAPHY” layer there are several sub-layers that seem to be paired for identical points on the map. They consistently differ by 6.5’. Which surface elevation layer is correct or relative to the Pipe Invert Elevation layers? For example:

Sub-Layer Name	Elevation	Elevation	Elevation	General Location of Point
Topo DETBCB Elevation	29.0	34.8	28.3	East of Jamaica Way / Willow Pond Rd intersection.
Topo DET Elevation	22.5	28.3	21.8	Same as above
Difference	6.5	6.5	6.5	
Topo INDBCB Elevation	26.5			On contour line southeast of Jamaica Way / Willow Pond Rd. int.
Topo INDD Elevation	20			Same as above
Difference	6.5			
Topo BCB Elevation	33.0	31.8	34.2	In vicinity of Jamaica Way / Willow Pond Rd. intersection
TOP GEN Elevation	26.5	25.3	27.7	Same as above
Difference	6.5	6.5	6.5	

Other Considerations

Here are the updated 90% Concept Designs for Daisy Field Stormwater Infrastructure

Bio-2 is probably too close to the heritage oaks for comfort, but we can leave it there for now.

Bio-4 is located in the primary walking path from the parking lot to the softball diamonds and is unlikely to be acceptable to Parks.

The current location of the Subsurface Gravel Wetland is **not an option** and will need to be moved.

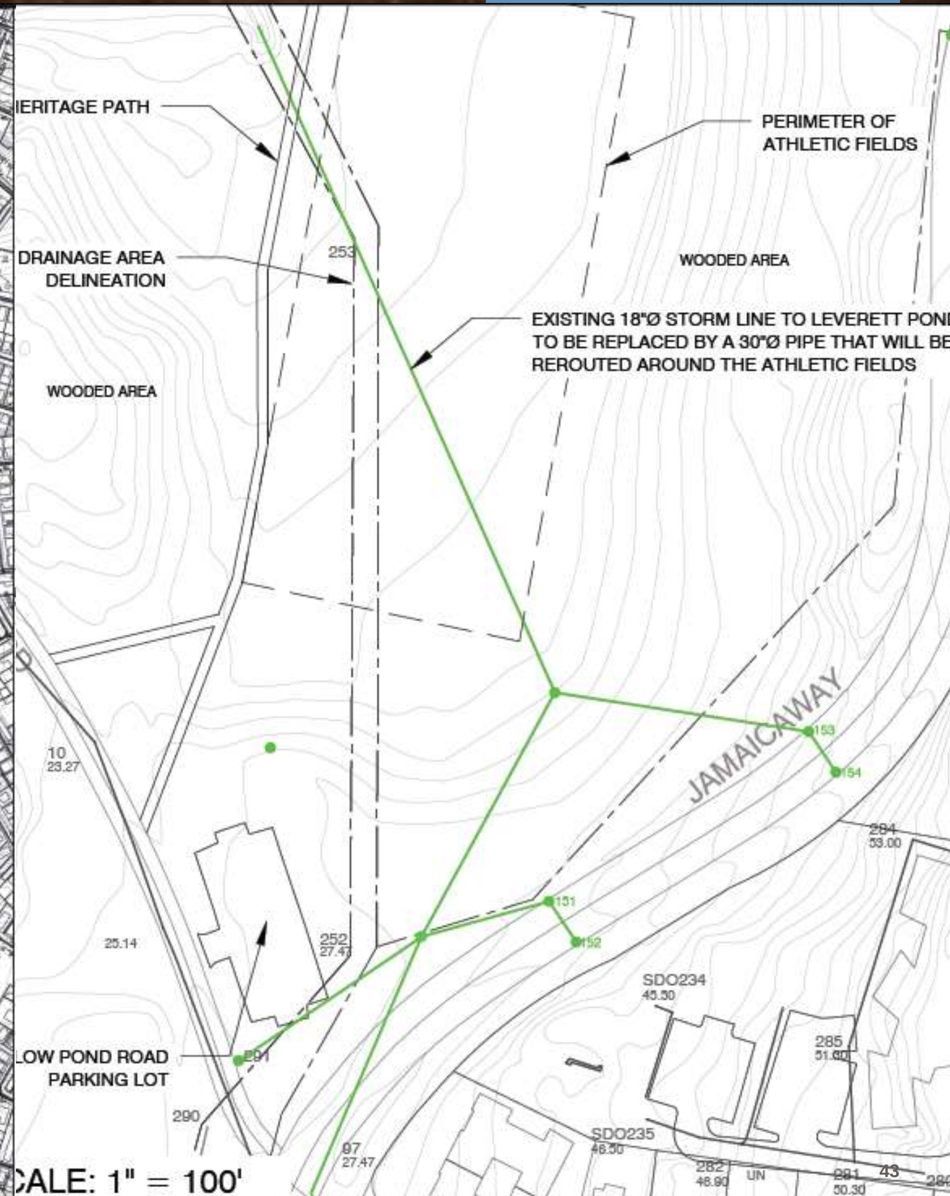
Other Considerations

Well, lo and behold, after our initial meeting and site walk with Parks, if some scheduling and budgeting concerns can be addressed with Parks' long planned Daisy Field renovation, we might be able to do something under the athletic fields (assuming that grass and not artificial turf can be used).

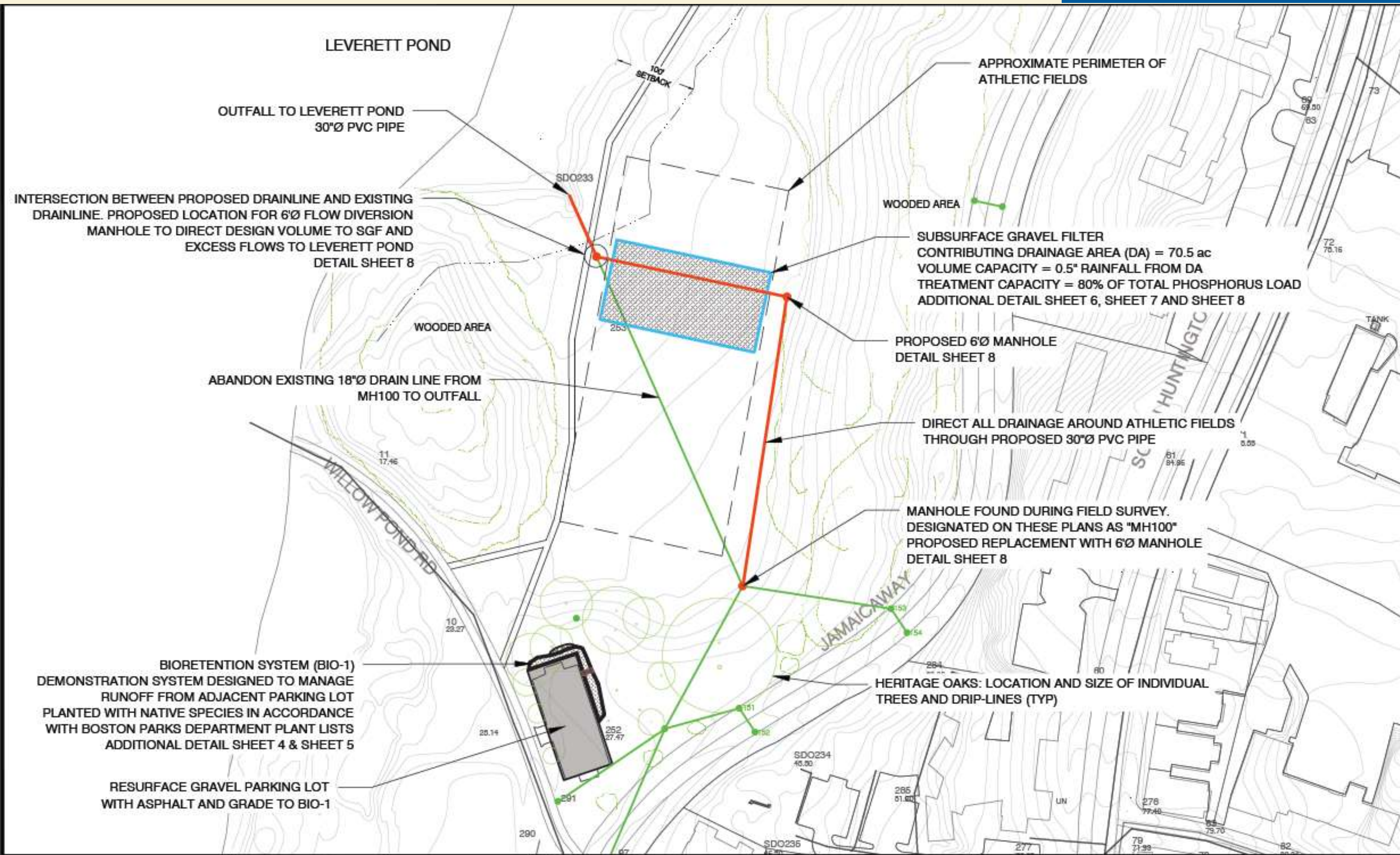
We are still waiting for a letter from Parks with the official feedback, but based on what I heard during the meeting and the walk, we need to start putting together final pollutant removal and cost estimates for a feature under the fields

What we did…

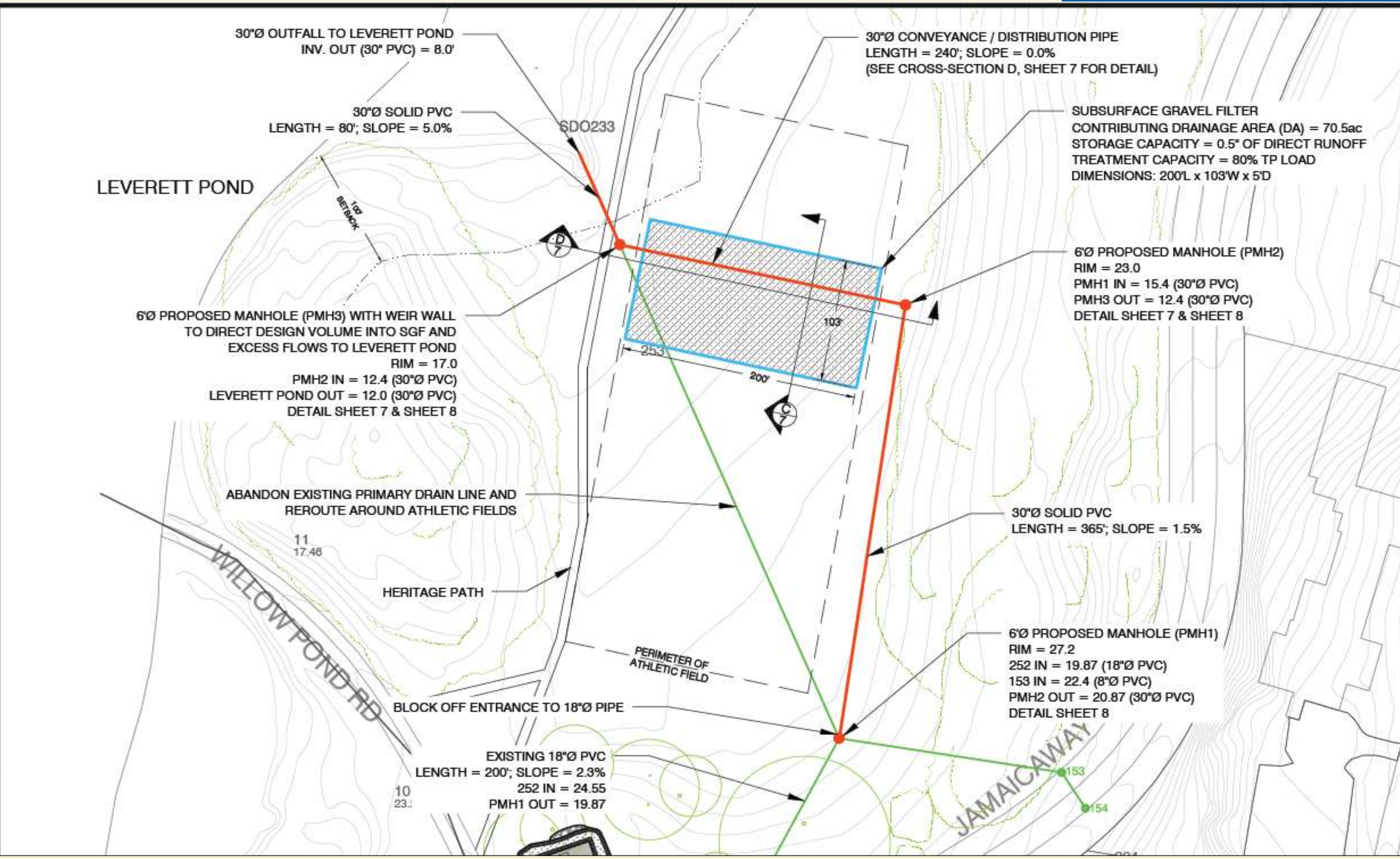

PROJECT LOCATION
PERIMETER OF ATHLETIC FIELDS
SUBCATCHMENT DRAINAGE AREA DELINEATION AREA = 23.1ac
DRAINAGE AREA DELINEATION AREA = 70.5ac
SUBCATCHMENT DRAINAGE AREA DELINEATION AREA = 47.4ac
SCALE: 1" = 500'


IERITAGE PATH
PERIMETER OF ATHLETIC FIELDS
WOODED AREA
DRAINAGE AREA DELINEATION
EXISTING 18"Ø STORM LINE TO LEVERETT PONI
TO BE REPLACED BY A 30"Ø PIPE THAT WILL BE
REROUTED AROUND THE ATHLETIC FIELDS
WOODED AREA
JAMAICAWAY
LOW POND ROAD PARKING LOT
SDO234
SDO235
CALE: 1" = 100'

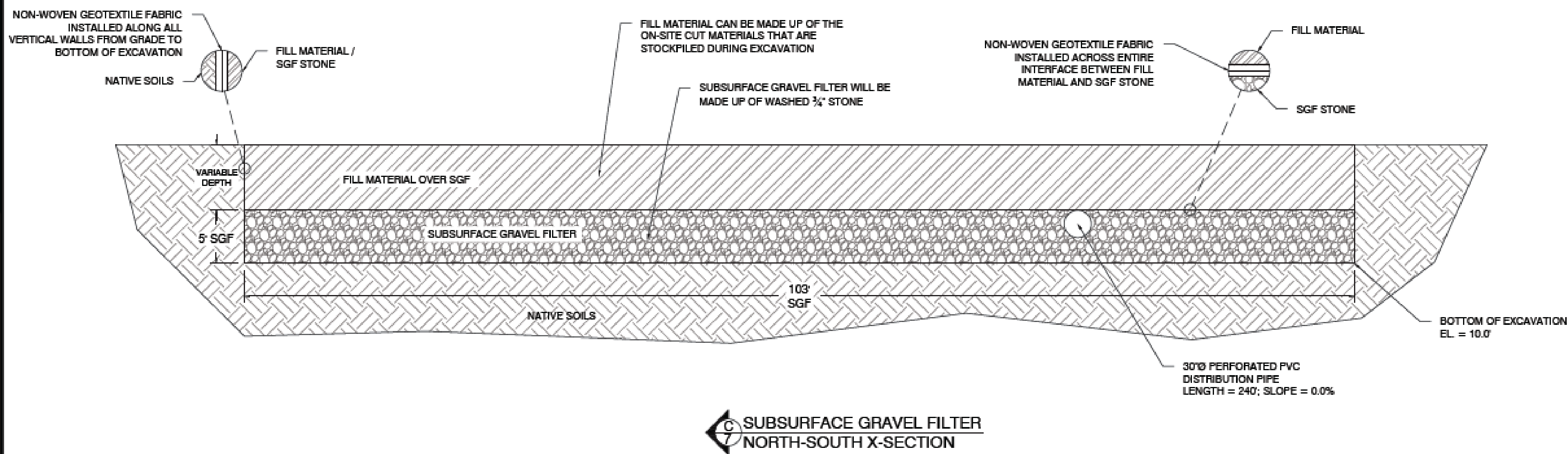
Final Design

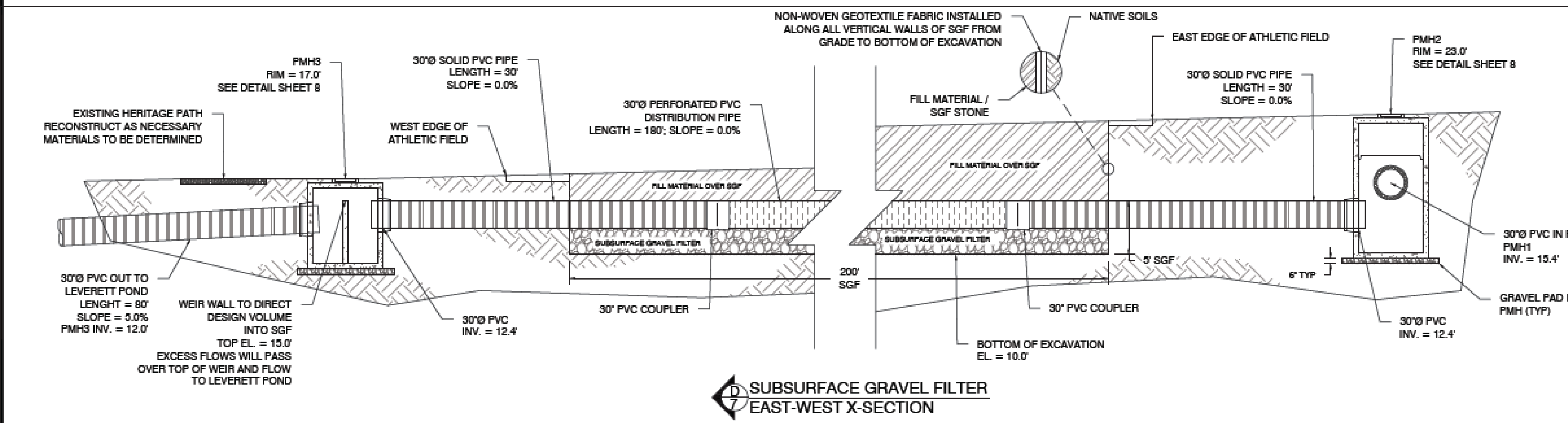


Final Design cont…



Final Design cont…





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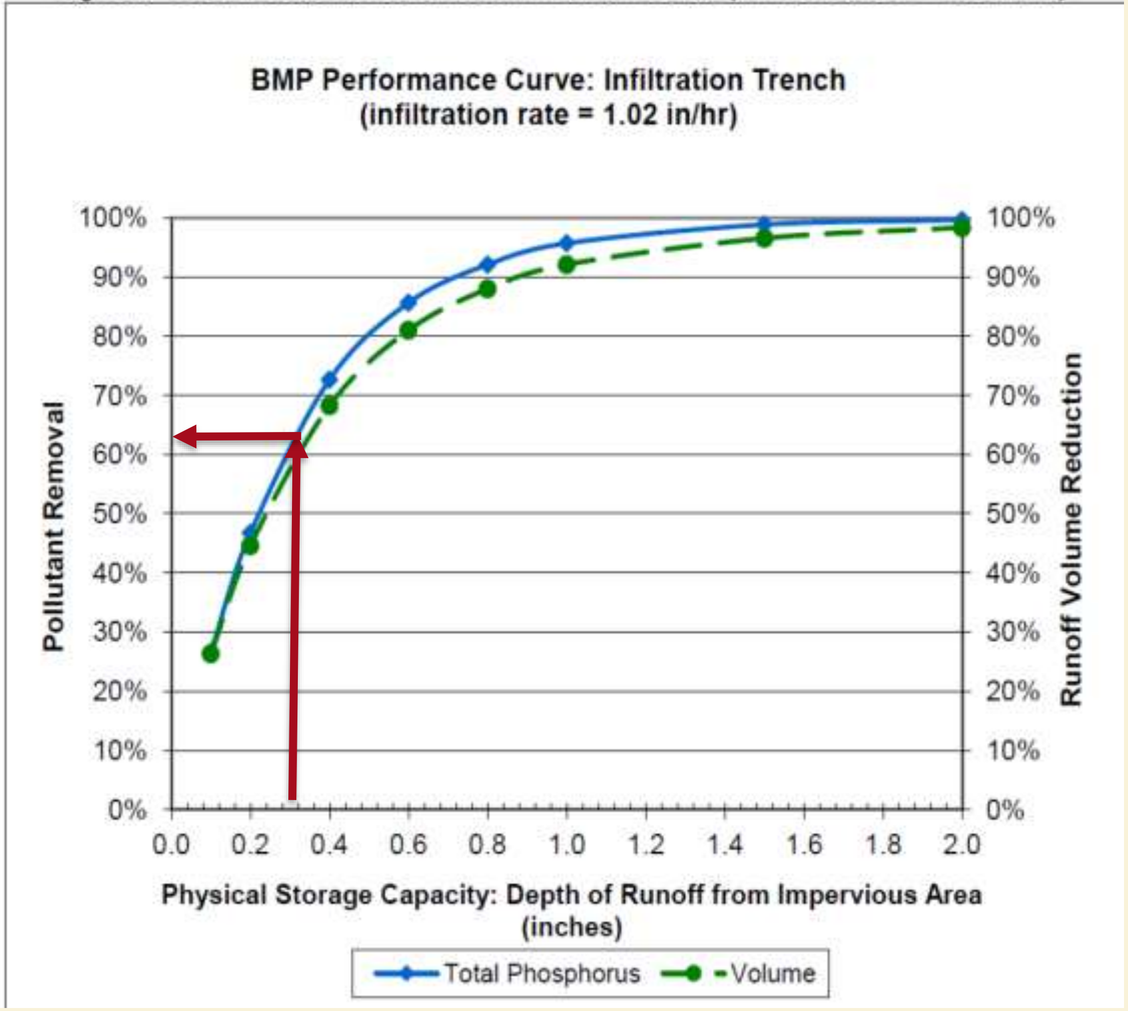
Infiltration Trench (IR = 1.02 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction

BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2
Runoff Volume Reduction	26.3%	44.6%	68.2%	81.0%	88.0%	92.1%	96.5%	98.
Cumulative Phosphorus Load Reduction	27%	47%	73%	86%	92%	96%	99%	10

Figure 3- 4: BMP Performance Curve: Infiltration Trench (infiltration rate = 1.02 in/hr)



Results

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			

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Next Steps

Group discussion of best use of UNHSC data sheets, who could benefit from workshop 2 on Opti-Tool and automation/optimization approach.

Input to further design of Workshop 1 as well as prospectively for Workshop 2.

Questions?