2019 Mystic River Watershed Science Forum

Use of Opti-Tool in the Mystic River Watershed Nutrient Management Analysis

Presented on Behalf of Mystic Watershed Eutrophication Project Team
by Mark Voorhees, US EPA Region 1
April 30, 2019

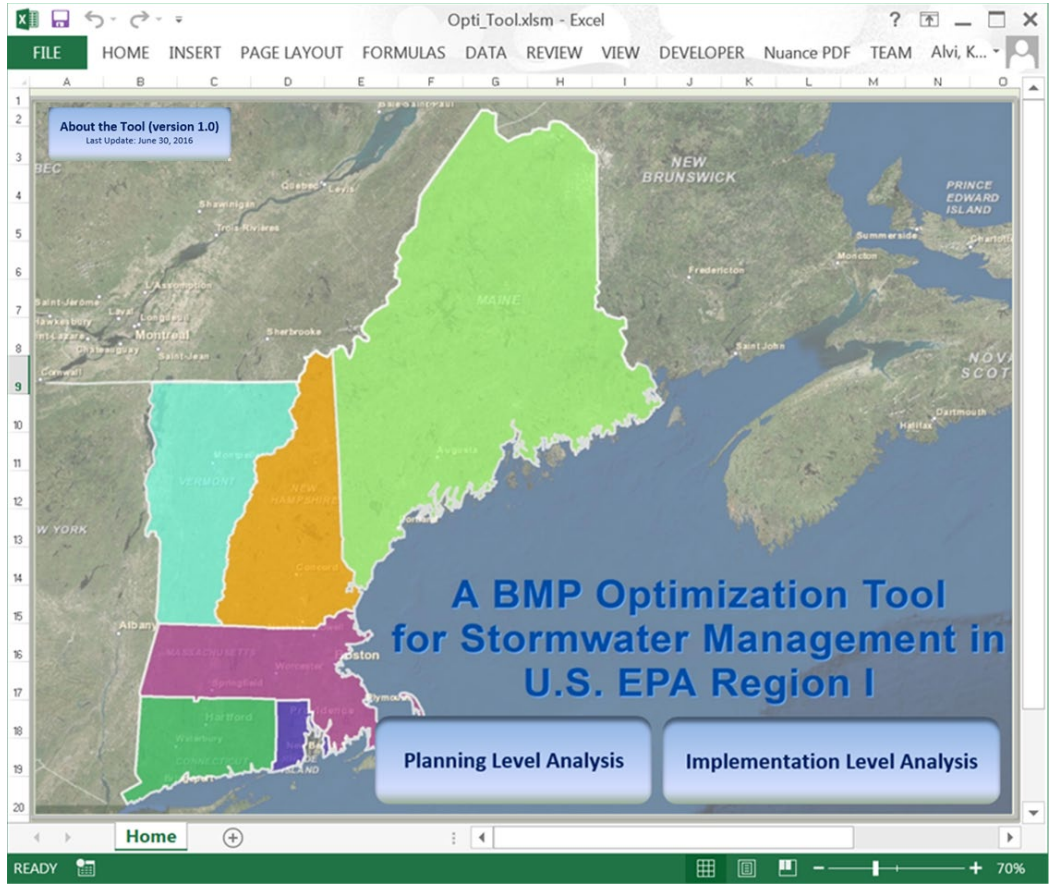
The Opti-Tool Analysis described in this presentation was funded by EPA and conducted by Environmental Research Group (ERG) Project Team including Paradigm Environmental, Horsley Witten Group, and PG Environmental

Topics & Questions to be discussed today

- What is Opti-Tool?
- Why use the Opti-Tool in the Mystic River Watershed?
- Stormwater Runoff Source loadings
- Demonstration of Opti-Tool SW Management Optimization Analysis
- Take-Away Messages

What is Opti-Tool?

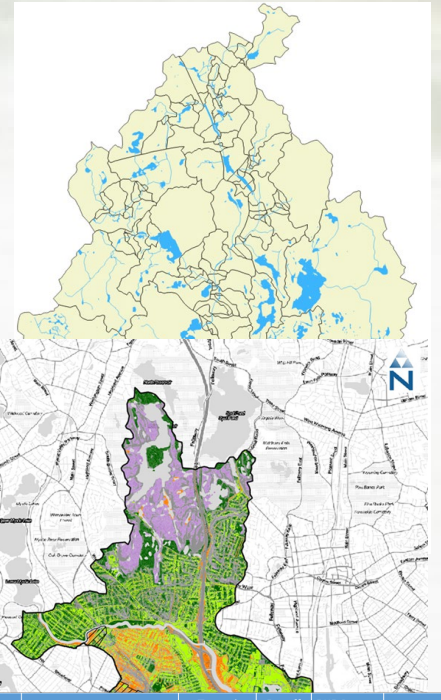
- A spreadsheet-based stormwater (SW) management optimization tool
  - Planning Level Analysis (EPA Region 1 SW Control Performance Curves)
  - Implementation Level Analysis (EPA SUSTAIN SW Control Simulation and Optimization Engine)
- Customized with calibrated hydrologic/WQ and SCM models suitable for New England Region
- Suitable for Region 1 MS4 (MA & NH) permit compliance for nutrients



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

Mystic River Watershed Eutrophication Management Analysis – Why Opti-Tool?

- Excessive nutrient loading is causing cultural eutrophication in numerous locations within the freshwater portion of the Mystic Watershed.
- SW is major source of Phos.(P) & restoration of water-quality/attainment of MA SWQS is estimated to require large reductions in SW runoff P loads (likely >50%)
- Extensive SCM retrofits are needed to control SW from watershed's existing IC; and
- What do these high levels of SCM retrofit management control look like, potentially cost ($) & what types of SCMs would be most cost effective?



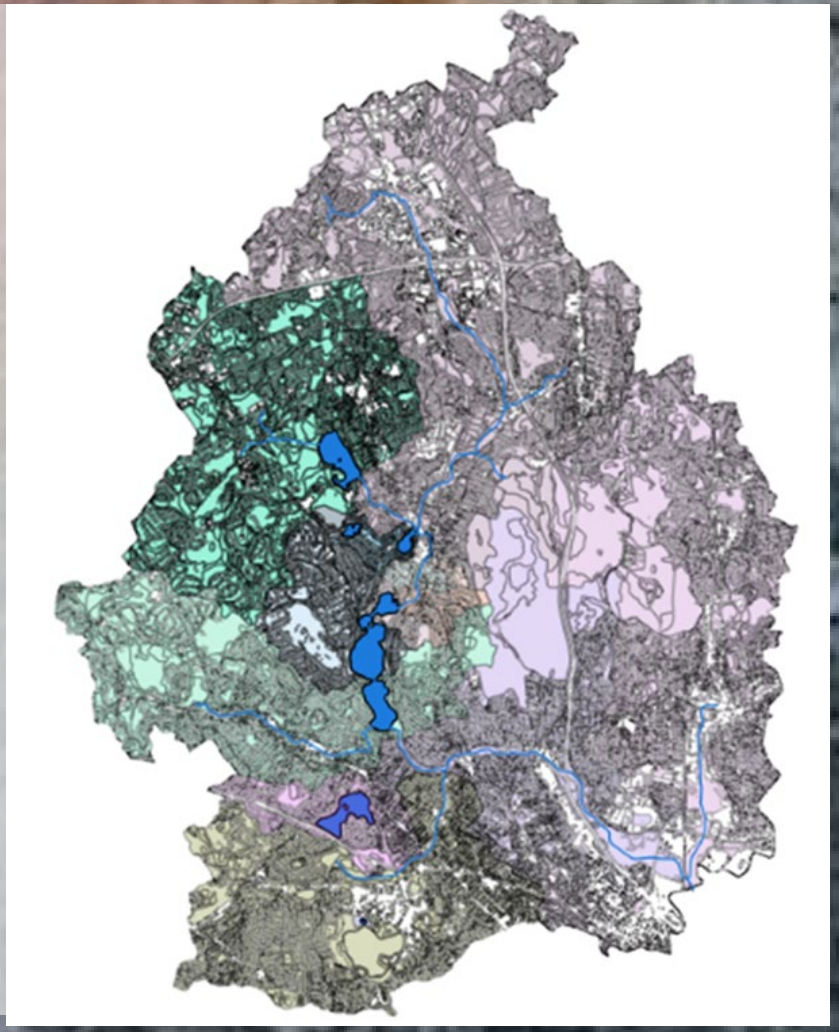
BMPID	BMP Type	Land Use	Treated Impervious Area (acres)	Runoff Depth (in.)	BMP Storage Capacity (gallon)	BMP Cost ($)
BMP1	Infiltration-B	High Density Residential	31.78	0.2	172,602	$287,952
BMP2	Infiltration-B	Commercial	20.95	0.4	227,576	$379,665
BMP3	Infiltration-B	Industrial	28.17	0.3	229,493	$382,863
BMP4	Infiltration-B	Open land	17.26	0.4	187,524	$312,847
BMP5	Infiltration-B	Highway	13.67	0.3	111,346	$185,758
BMP6	Infiltration-C	High Density Residential	714.35	0.4	7,760,632	$12,947,054
BMP7	Infiltration-C	Commercial	114.01	0.3	928,962	$1,549,786
BMP8	Infiltration-C	Industrial	61.24	0.1	166,323	$277,476
BMP9	Infiltration-C	Open land	16.09	0.5	218,522	$364,560
BMP10	Infiltration-C	Highway	46.76	0.2	254,005	$423,757
BMP11	Biofiltration	High Density Residential	9.74	0.2	52,914	$218,713
BMP12	Biofiltration	Commercial	-	-	-	-
BMP13	Biofiltration	Open land	-	-	-	-
BMP14	Biofiltration	Highway	-	-	-	-
BMP15	Porous Pavement	High Density Residential	-	-	-	-
BMP16	Porous Pavement	Commercial	-	-	-	-
BMP17	Porous Pavement	Industrial	-	-	-	-
BMP18	Porous Pavement	Open land	-	-	-	-
		Total	1,074.01	(0.1 - 0.5)	10,309,898	$17,330,429

Opti-Tool: Mystic River Watershed Nutrient Management Analysis

- Opti Tool used in 2 ways in the Mystic:
  1. Quantify SW runoff source volumes and pollutant loadings as part of the watershed and water quality modelling to address cultural eutrophication; and
  2. Perform demonstration SW management optimization analysis with same SW source loadings for a pilot watershed to help inform the development of cost effective and feasible management strategies

SW Source Hydrologic Response Unit (HRU) Modelling using Opti-Tool

- Characterize watershed HRUs by land use, IC, PC, and hydrologic soil group (HSG)
- Apply WQ calibrated SWMM HRU models for continuous simulations using local hourly precipitation data for 2007-2016 period
  - SWMM HRU models include calibrated build-up Washoff processes to regional data; and
  - Consistent with average annual pollutant export rates in EPA R1 MS4 permits



Hydrologic Response Unit (HRU) SW Source Area Modelling in Opti-Tool

Impervious Cover Types

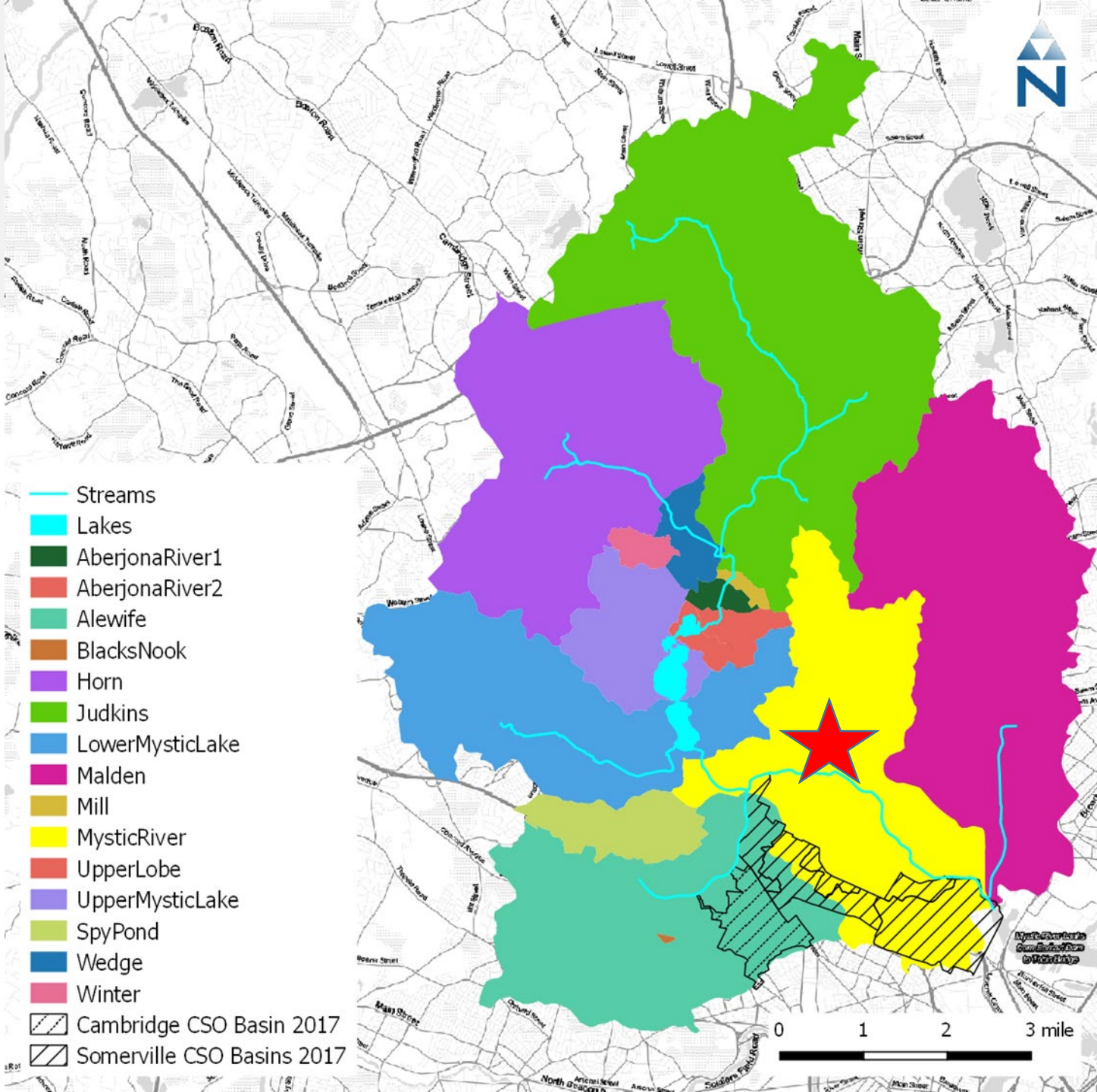
1. Commercial/Industrial
2. High-Density Residential
3. Medium-Density Residential
4. Low Density Residential
5. Highway
6. Open Land
7. Forest
8. Agriculture

Pervious Cover Types

9. Forest Pervious
10. Agriculture Pervious
11. Developed Land Pervious – Hydrologic Soil Group A
12. Developed Land Pervious – Hydrologic Soil Group B
13. Developed Land Pervious – Hydrologic Soil Group C
14. Developed Land Pervious – Hydrologic Soil Group C/D
15. Developed Land Pervious – Hydrologic Soil Group D

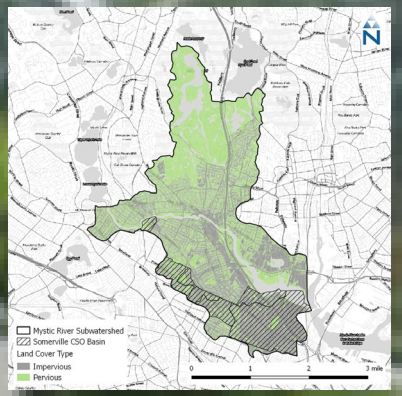
Demo SW Nutrient Management Analysis using Opti-Tool

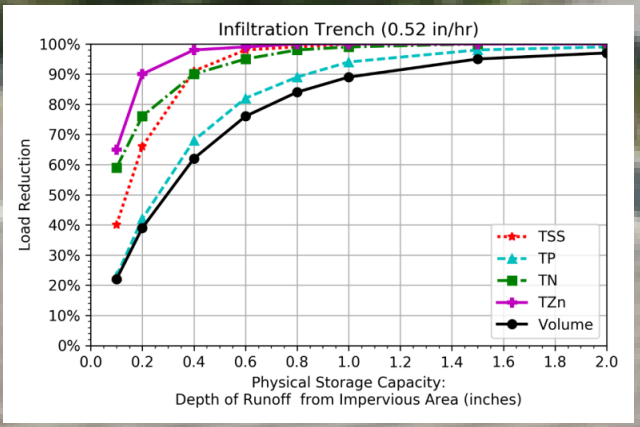
- Pilot sub-watershed
  - Mystic River (5,151 acres)
  - Exclude CSO drainage (1,010 acres)
- SW Management Categories
  - SCM suitability analysis/watershed characteristics
  - Porous Pavement (impervious)
  - SCM drainage area (impervious)
- Opti-Tool
  - SCM optimization simulation
  - Phosphorus Reduction Cost-effective (CE) curve



Some Key SW Management concepts to keep in mind today

- Focus is on resolving impacts from existing impervious cover and therefore, on retrofitting impervious cover with enhanced and/or new SW control measures (SCMs)
- Opti-Tool analysis results account for runoff volumes & pollutant loads from all rain events (cumulative) instead of single design storms (e.g., 24 hour type II design storm)
- Similarly, Stormwater Control measures (SCMs) reductions are cumulative for all rain events not a single storm event.

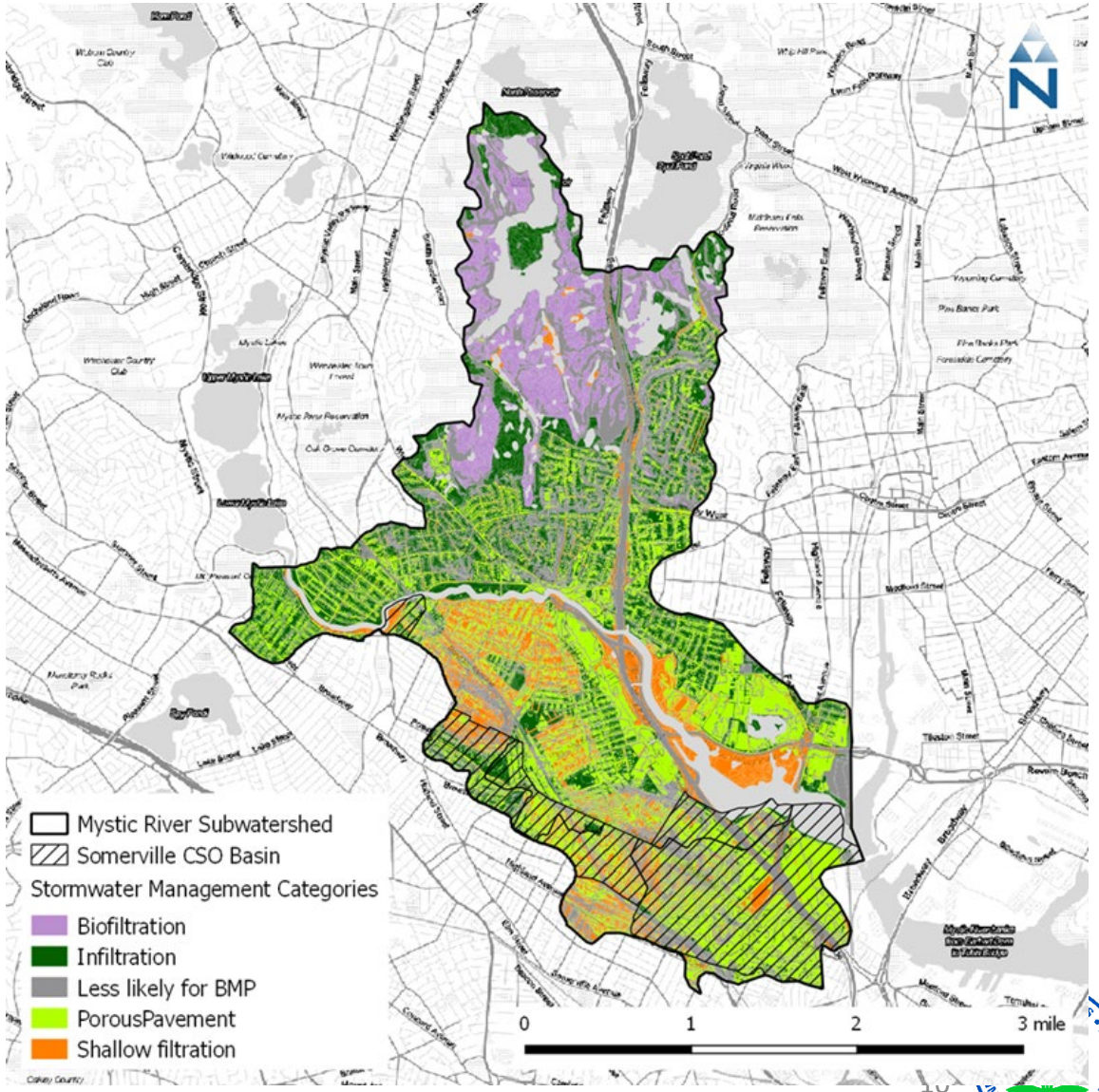




Mystic River: SCM Siting Criteria

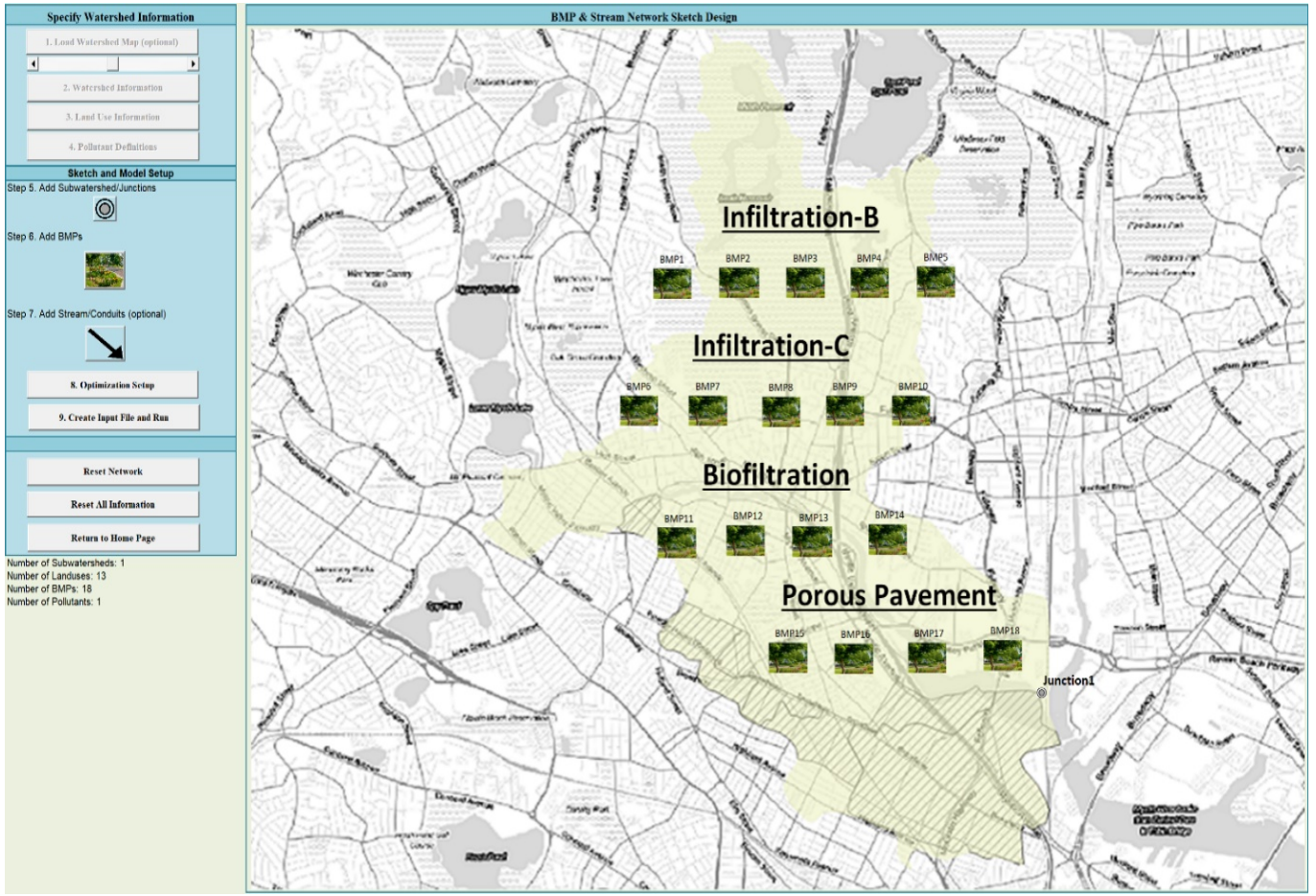
Cover Type	Ground Slope (%)	AUL / 21E	HSG	Management Category	BMP Type(s) in Opti-Tool
Pervious Area	<= 15	Is a AUL / 21E Site	A/B/C/D or No Data (HSG C assumed)	Shallow filtration	Biofiltration
		Not a AUL / 21E Site	A/B/C or No Data (HSG C assumed)	Infiltration	Infiltration Basin, Infiltration Trench
			D	Biofiltration	Biofiltration, Gravel Wetland
	> 15	--	--	Less likely for onsite BMP	--
Impervious Area	<= 5	--	A/B/C/D or No Data (HSG C assumed)	Shallow filtration	Porous Pavement
	> 5	--	--	Less likely for onsite BMP	--

Mystic River: SW Management Categories



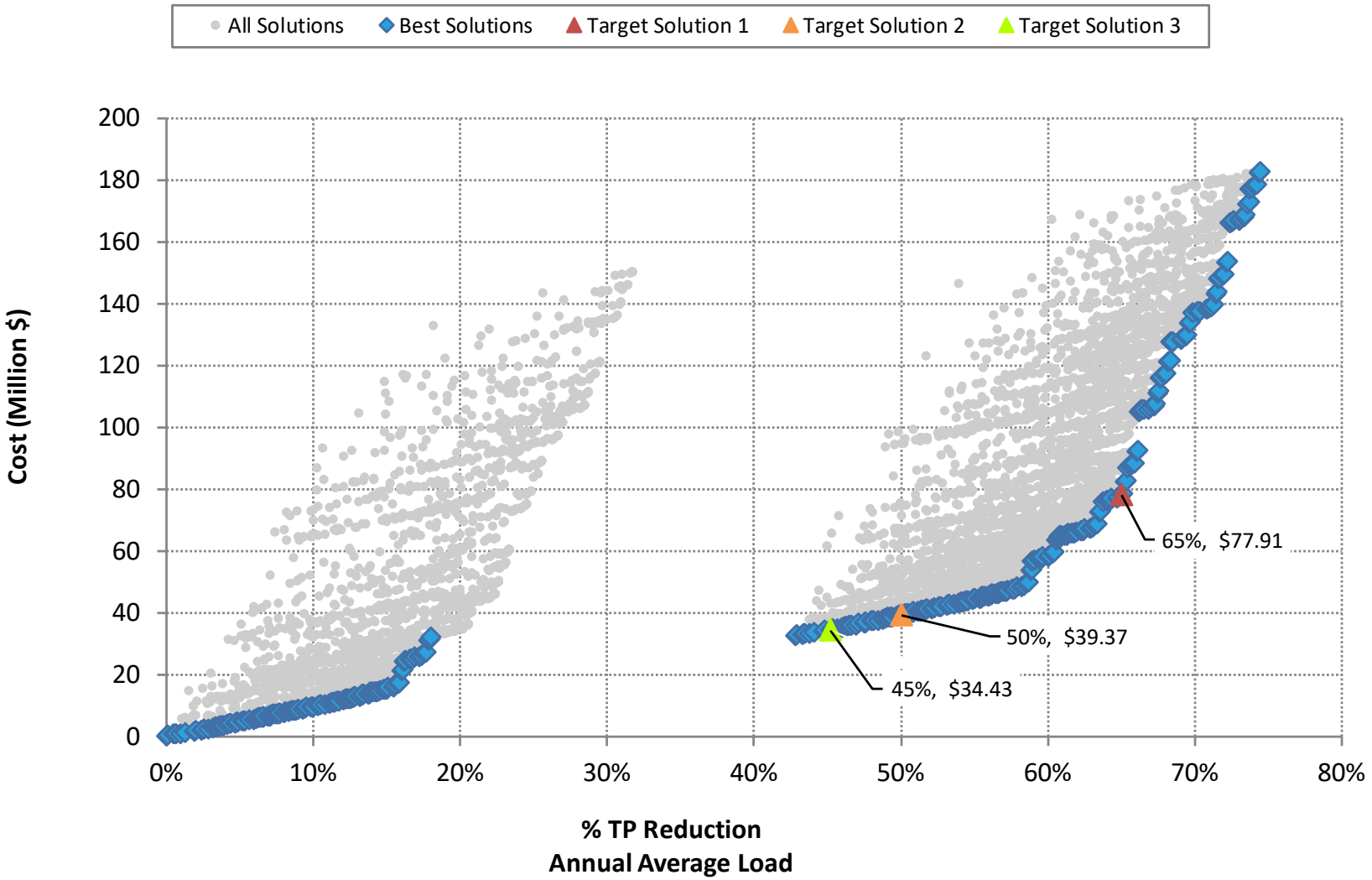
Opti-Tool: Model Setup

- Set-up two optimization scenarios
  - Optimize SCMs with fixed design capacity = 1 inch IC runoff depth
  - Optimize SCM types and sizes ranging from 0.1 to 1.0 inch IC runoff depth
- Identify stormwater TP load reduction solutions
  - 65% numeric target
  - 50% numeric target
  - 45% numeric target



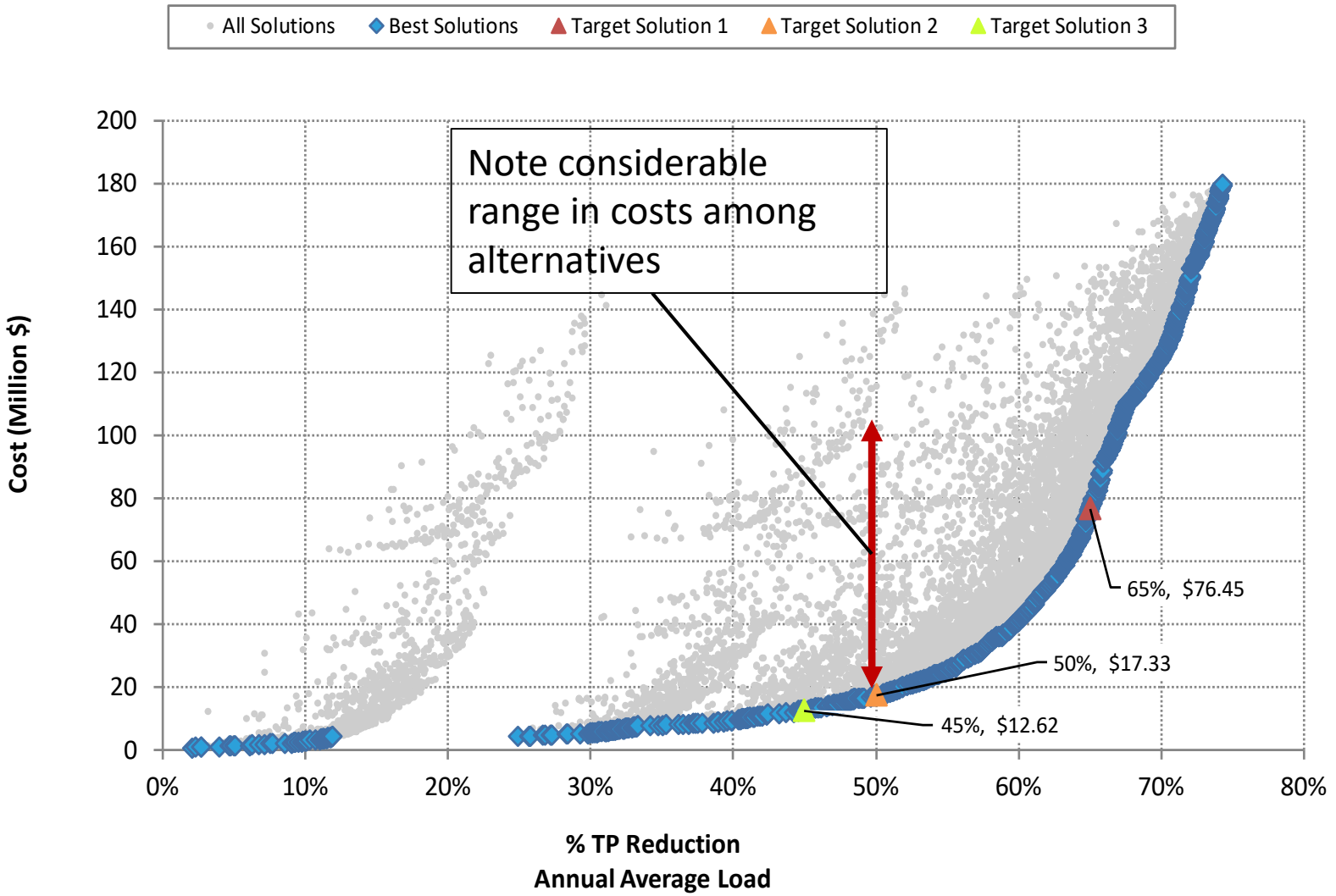
Opti-Tool: Model Results Scenario 1 – SCMs with fixed design capacity = 1 inch IC runoff depth)

- Identify a solution on the CE-Curve for stormwater load reduction target
- Target solution 1
  - Annual average TP load reduction: 65%
  - Million $77.91
- Target solution 2
  - Annual average TP load reduction: 50%
  - Million $39.37 (49% less cost)
- Target solution 3
  - Annual average TP load reduction: 45%
  - Million $34.43 (56% less cost)



Opti-Tool: Model Results Scenario 2 – SCM design capacities allowed to vary 0.1 to 1 inch IC runoff depth

- Identify a solution on the CE-Curve for stormwater load reduction target
- Target solution 1
  - Annual average TP load reduction 65%
  - Million $76.45
- Target solution 2
  - Annual average TP load reduction 50%
  - Million $17.33 (77% less cost)
- Target solution 3
  - Annual average TP load reduction 45%
  - Million $12.62 (83% less cost)



Opti-Tool: Scenario Comparison

Scenario ID	Scenario Description	TP Load Reduction Target (%)	Impervious Area Treated (acre)	Runoff Depth (in.)	BMP Storage Capacity (Million gallon)	BMP Cost (Million $)
Scenario 1	BMP size (1 in.) and optimize the spatial locations	65%	1,329	1	36.09	$77.91
		50%	869	1	23.60	$39.37
		45%	760	1	20.64	$34.43
Scenario 2	Optimize BMP size (0.1 in. increment and max size 1 in.) and the spatial locations	65%	1,353	(0.4 - 1.0)	34.52	$76.45
		50%	1,074	(0.1 - 0.5)	10.31	$17.33
		45%	1,041	(0.1 - 0.3)	7.48	$12.62

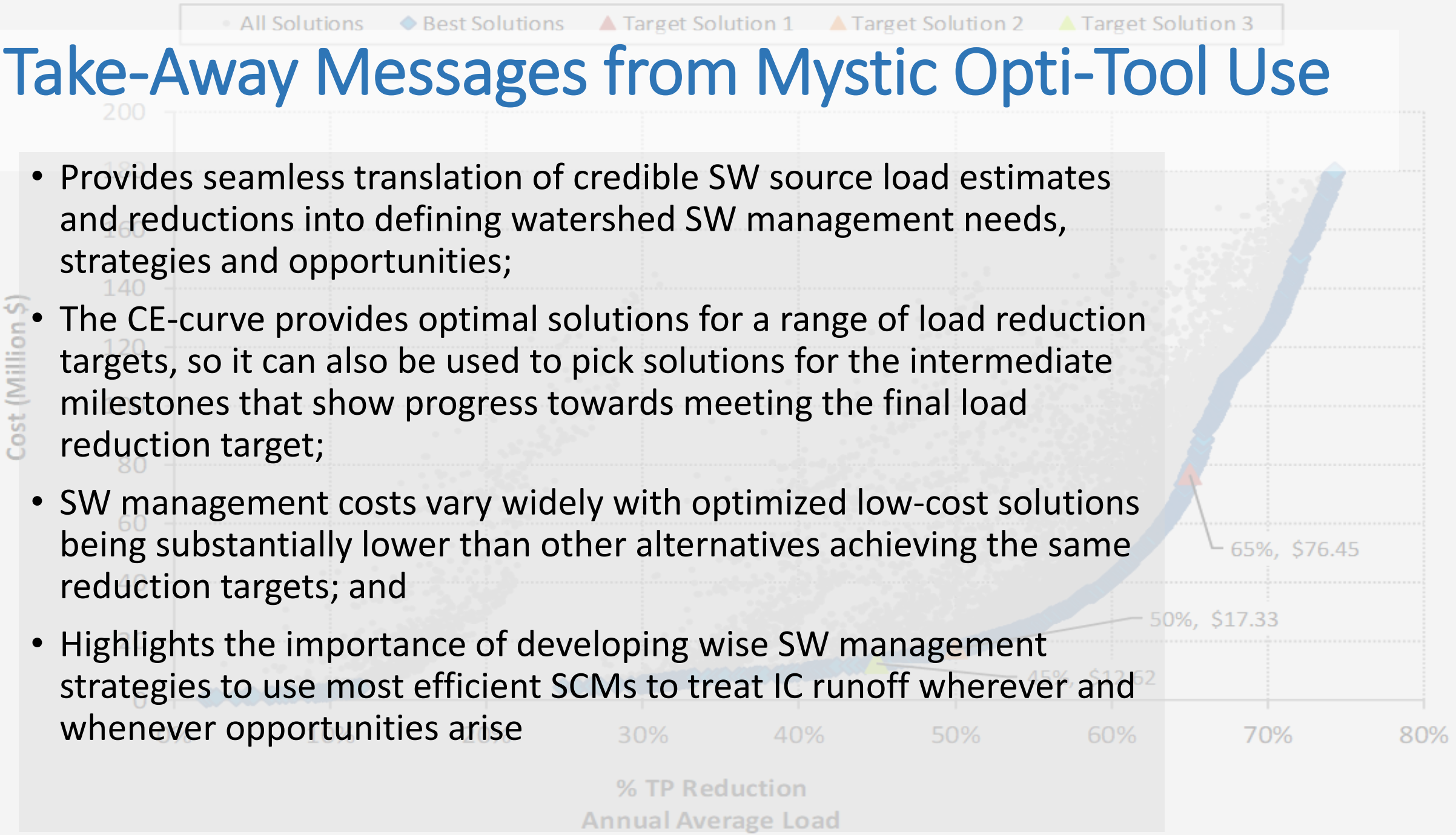
Difference: Million $1.5 (2%)

Difference: Million $22 (56%)

Difference: Million $22 (63%)

Take-Away Messages from Mystic Opti-Tool Use

- Provides seamless translation of credible SW source load estimates and reductions into defining watershed SW management needs, strategies and opportunities;
- The CE-curve provides optimal solutions for a range of load reduction targets, so it can also be used to pick solutions for the intermediate milestones that show progress towards meeting the final load reduction target;
- SW management costs vary widely with optimized low-cost solutions being substantially lower than other alternatives achieving the same reduction targets; and
- Highlights the importance of developing wise SW management strategies to use most efficient SCMs to treat IC runoff wherever and whenever opportunities arise



Questions ?

Thank you

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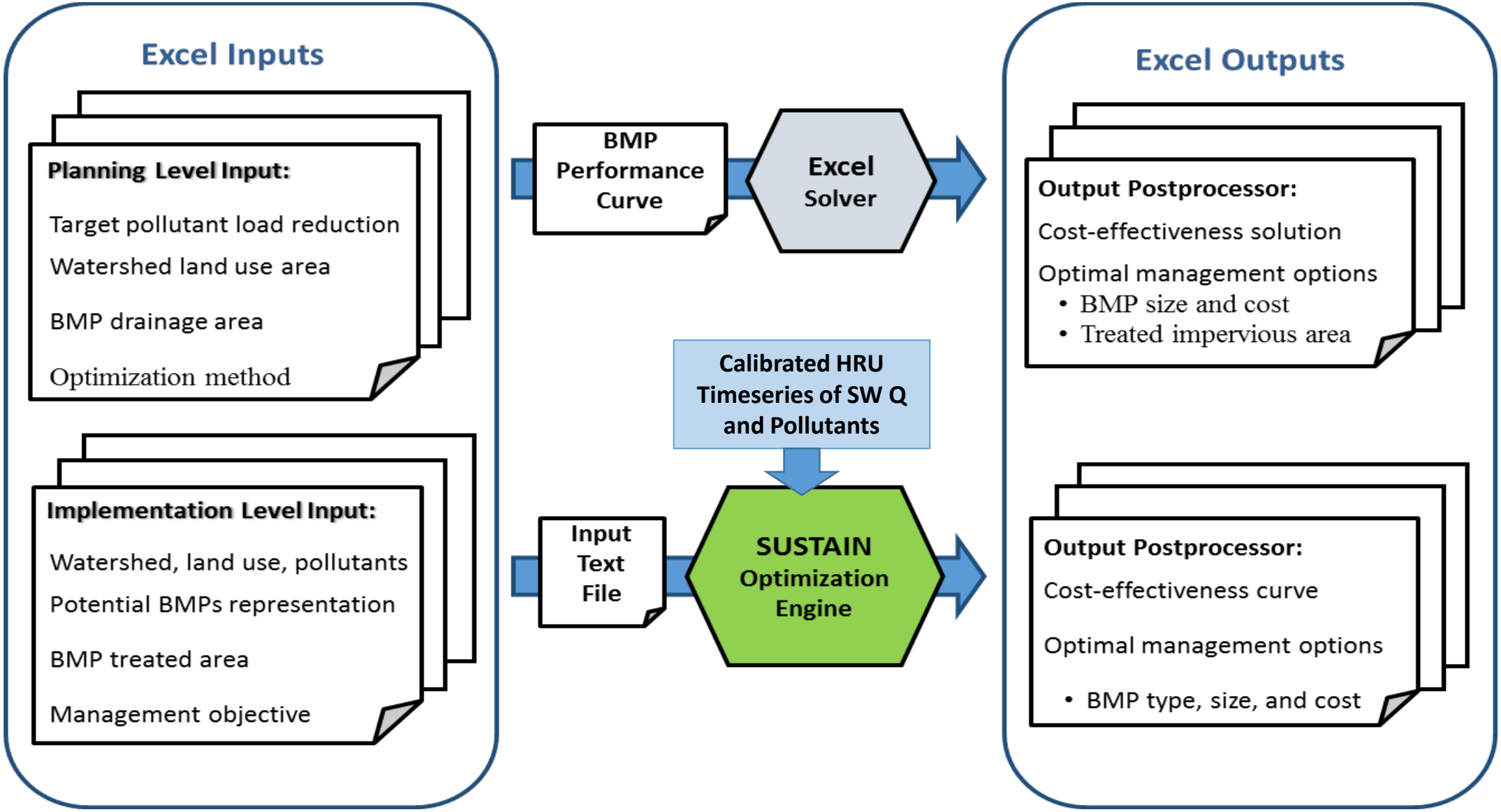
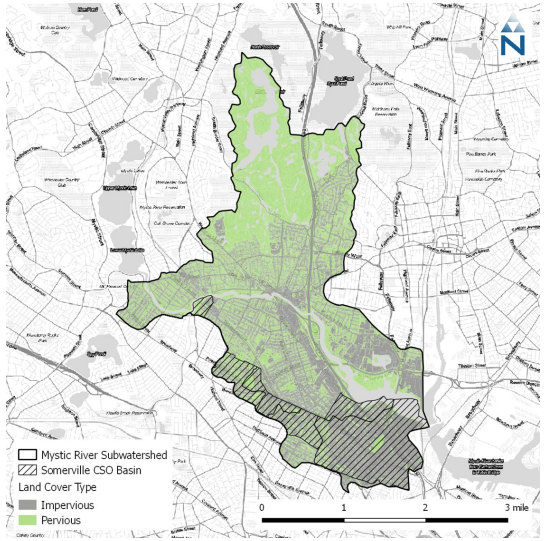
Extra slides follow

Opti-Tool Planning and Implementation Options

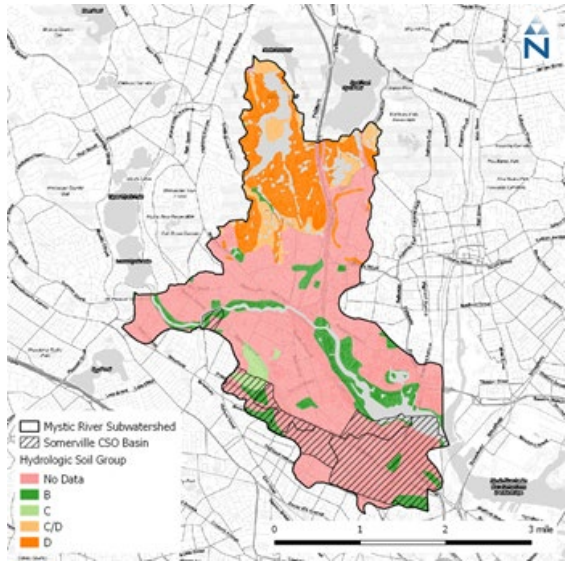


Develop SW Management Categories

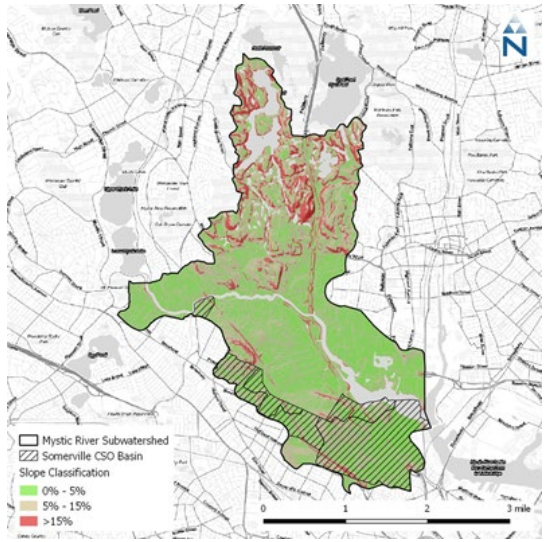
- GIS SCM suitability analysis:
  - Impervious cover;
  - Soils data: HSG & Depth to bedrock or groundwater;
  - Surface slope; and
  - Hazardous waste sites
- Select best SCM for each SW management category
  - Surface infiltration;
  - infiltration trench;
  - Porous pavement;
  - Biofiltration; and
  - Gravel wetland



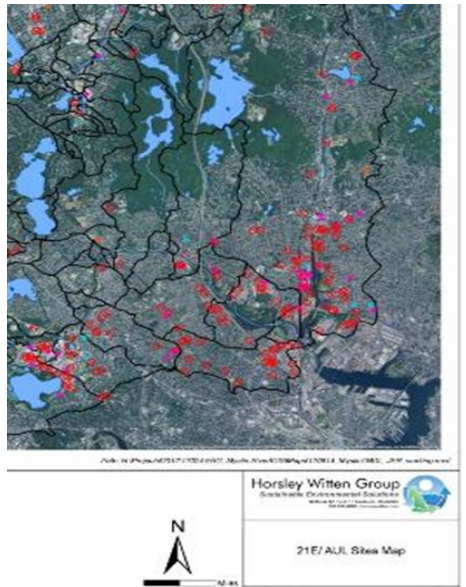
Impervious Cover



HSGs



Surface slope



Opti-Tool: Model Inputs

- Boundary Conditions
  - Sub-watershed land use area distribution (existing condition)
  - SCM drainage land use area distribution (treated impervious areas)
  - Unit-area HRU hourly runoff timeseries (2007 – 2016)
- SCM Specifications
  - SCM footprints (range for optimization)
  - SCM parameters (default in Opti-Tool)
- Optimization Criteria
  - Objective Function - Minimize cost
  - Evaluation Factor – Average annual TP load reduction

Mystic River: Opti-Tool Stormwater Management Categories

- **Total SCMs – 18**
- By Land Use Type
  - Commercial (4)
  - Industrial (3)
  - High Density Residential (4)
  - Highway (3)
  - Open Land (4)
- By SCM Type
  - Infiltration – B (5)
  - Infiltration – C (5)
  - Biofiltration (4)
  - Porous Pavement (4)

Opti-Tool: Scenario 2 (Target Solution 1 = 65% P Load Reduction)

BMPID	BMP Type	Land Use	Treated Impervious Area (acres)	Runoff Depth (in.)	BMP Storage Capacity (gallon)	BMP Cost ($)
BMP1	Infiltration-B	High Density Residential	31.78	0.6	517,806	$863,855
BMP2	Infiltration-B	Commercial	20.95	0.6	341,364	$569,497
BMP3	Infiltration-B	Industrial	28.17	0.7	535,483	$893,346
BMP4	Infiltration-B	Open land	17.26	0.7	328,168	$547,482
BMP5	Infiltration-B	Highway	13.67	0.4	148,461	$247,677
BMP6	Infiltration-C	High Density Residential	714.35	0.8	15,521,265	$25,894,108
BMP7	Infiltration-C	Commercial	114.01	1.0	3,096,513	$5,165,908
BMP8	Infiltration-C	Industrial	61.24	0.8	1,330,580	$2,219,806
BMP9	Infiltration-C	Open land	16.09	0.9	393,340	$656,208
BMP10	Infiltration-C	Highway	46.76	0.7	889,019	$1,483,150
BMP11	Biofiltration	High Density Residential	9.74	0.7	185,198	$765,496
BMP12	Biofiltration	Commercial	167.92	1.0	4,559,847	$18,847,683
BMP13	Biofiltration	Open land	5.25	1.0	142,555	$589,236
BMP14	Biofiltration	Highway	86.81	0.8	1,885,773	$7,794,661
BMP15	Porous Pavement	High Density Residential	-	-	-	-
BMP16	Porous Pavement	Commercial	-	-	-	-
BMP17	Porous Pavement	Industrial	18.84	-	4,647,530	$9,916,595
BMP18	Porous Pavement	Open land	-	-	-	-
		Total	1,352.83	(0.4 - 1.0)	34,522,900	$76,454,707

Opti-Tool: Scenario 2 (Target Solution 2 = 50% P Load Reduction)

BMPID	BMP Type	Land Use	Treated Impervious Area (acres)	Runoff Depth (in.)	BMP Storage Capacity (gallon)	BMP Cost ($)
BMP1	Infiltration-B	High Density Residential	31.78	0.2	172,602	$287,952
BMP2	Infiltration-B	Commercial	20.95	0.4	227,576	$379,665
BMP3	Infiltration-B	Industrial	28.17	0.3	229,493	$382,863
BMP4	Infiltration-B	Open land	17.26	0.4	187,524	$312,847
BMP5	Infiltration-B	Highway	13.67	0.3	111,346	$185,758
BMP6	Infiltration-C	High Density Residential	714.35	0.4	7,760,632	$12,947,054
BMP7	Infiltration-C	Commercial	114.01	0.3	928,962	$1,549,786
BMP8	Infiltration-C	Industrial	61.24	0.1	166,323	$277,476
BMP9	Infiltration-C	Open land	16.09	0.5	218,522	$364,560
BMP10	Infiltration-C	Highway	46.76	0.2	254,005	$423,757
BMP11	Biofiltration	High Density Residential	9.74	0.2	52,914	$218,713
BMP12	Biofiltration	Commercial	-	-	-	-
BMP13	Biofiltration	Open land	-	-	-	-
BMP14	Biofiltration	Highway	-	-	-	-
BMP15	Porous Pavement	High Density Residential	-	-	-	-
BMP16	Porous Pavement	Commercial	-	-	-	-
BMP17	Porous Pavement	Industrial	-	-	-	-
BMP18	Porous Pavement	Open land	-	-	-	-
		Total	1,074.01	(0.1 - 0.5)	10,309,898	$17,330,429

Opti-Tool: Scenario 2 (Target Solution 3 = 45% P Load Reduction)

BMPID	SCM Type	Land Use	Treated Impervious Area (acres)	Runoff Depth (in.)	SCM Storage Capacity (gallon)	SCM Cost ($)
BMP1	Infiltration-B	High Density Residential	31.78	0.2	172,602	$287,952
BMP2	Infiltration-B	Commercial	20.95	0.3	170,682	$284,749
BMP3	Infiltration-B	Industrial	28.17	0.2	152,995	$255,242
BMP4	Infiltration-B	Open land	-	-	-	-
BMP5	Infiltration-B	Highway	13.67	0.2	74,230	$123,838
BMP6	Infiltration-C	High Density Residential	714.35	0.3	5,820,474	$9,710,290
BMP7	Infiltration-C	Commercial	114.01	0.2	619,308	$1,033,191
BMP8	Infiltration-C	Industrial	61.24	0.1	166,323	$277,476
BMP9	Infiltration-C	Open land	-	-	-	-
BMP10	Infiltration-C	Highway	46.76	0.2	254,005	$423,757
BMP11	Biofiltration	High Density Residential	9.74	0.2	52,914	$218,713
BMP12	Biofiltration	Commercial	-	-	-	-
BMP13	Biofiltration	Open land	-	-	-	-
BMP14	Biofiltration	Highway	-	-	-	-
BMP15	Porous Pavement	High Density Residential	-	-	-	-
BMP16	Porous Pavement	Commercial	-	-	-	-
BMP17	Porous Pavement	Industrial	-	-	-	-
BMP18	Porous Pavement	Open land	-	-	-	-
		Total	1,040.66	(0.1 - 0.3)	7,483,533	$12,615,207