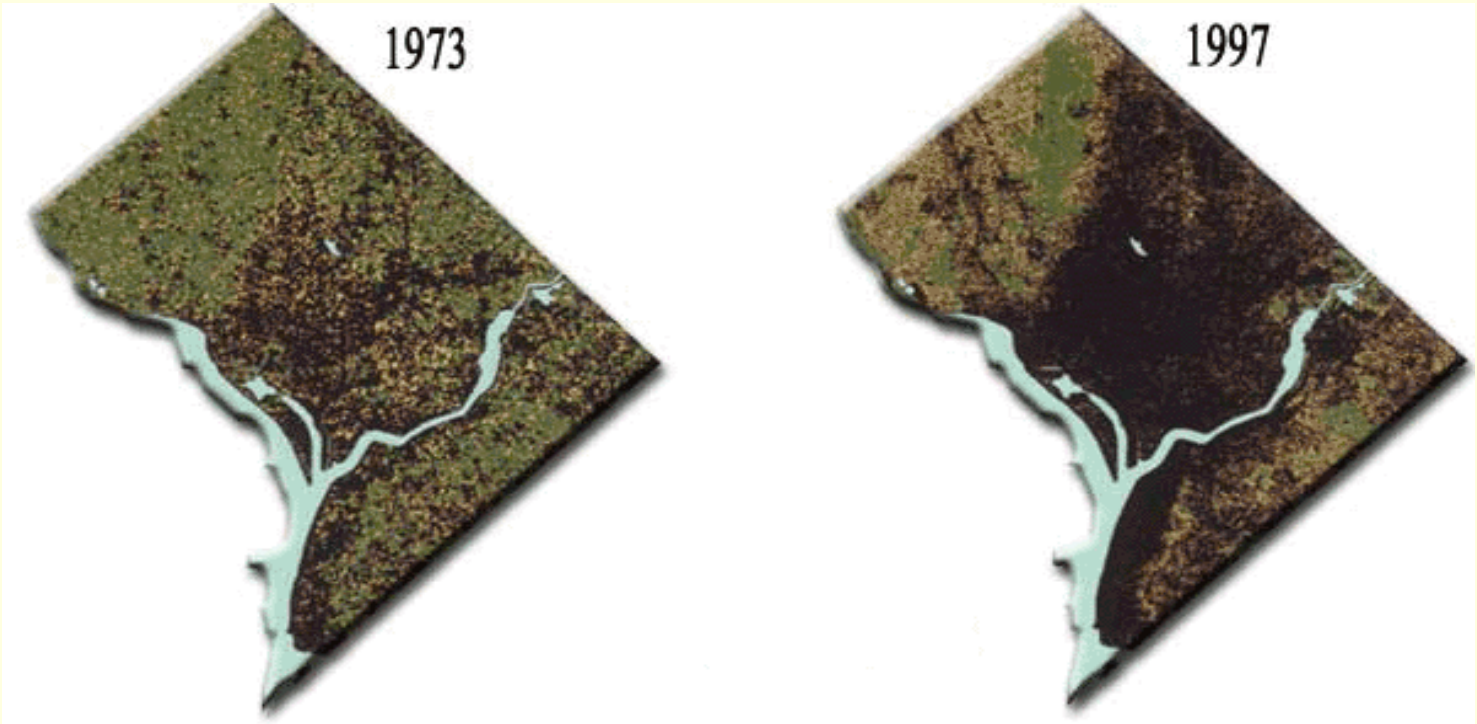
Green Build-Out Model:

Quantifying Stormwater Management Benefits of Trees & Green Roofs in the District of Columbia

Casey Trees Endowment Fund



(Courtesy American Forests)

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Piney Branch Outfall


LTI Anacostia Sampling


Hamilton Building, Portland

- Environmental engineering firm
  - Ann Arbor, MI and Washington, DC
- Specialists
  - Water quality assessment
  - Watershed management
  - TMDLs
  - NPDES permitting
- Provide high end technical support to EPA HQ, EPA Region 3, MD, VA, and DC, local governments
- Assisted with WASA LTCP

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Advisory Team

- EPA
  - Jenny Molloy (Water Permits Division, & Grant Project Officer)
  - Robert Goo (Non-point Source Control Branch)
  - Jonathan Essoka (Region 3, Anacostia Watershed Program)
  - Reginald Parrish (Urban Stormwater Coordinator, Chesapeake Bay Program Office)
- WASA
  - David Bardin (Board of Directors)
  - Dr. Siddique (DC WASA)
- DC Government
  - Dr. Karimi, Alexi Boado (Dep't. of Environment)
  - Chris Shaheen (Office of Planning)
  - John Thomas (Urban Forestry Administration)
- Federal Government
  - Jim Sherald, National Park Service, Center for Urban Ecology
  - Lance Davis, GSA Public Buildings Service Office of Applied Science, Sustainable Design Program
- Others
  - Nancy Stoner (NRDC)
  - Neil Weinstein (Low Impact Development Center)
  - Pete Johnson (CBF, Anacostia Program)

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Green Infrastructure Opportunity in DC

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Hypothesis

Washington, DC: 2002

Washington, DC: 2025

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Grant Background

- DC WASA
- EPA Water Quality Cooperative Grant
- Grant Partners
  - Casey Trees
  - LimnoTech
  - Advisory Team
- 12 month contract ending May 1, 2007
- Budget $202,600

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Grant Objectives

- Quantify the contribution that trees and green roofs could make towards reducing stormwater runoff and volumes and frequencies of discharge to the District's rivers
- Identify policy recommendations to facilitate implementation of trees and green roofs as stormwater controls

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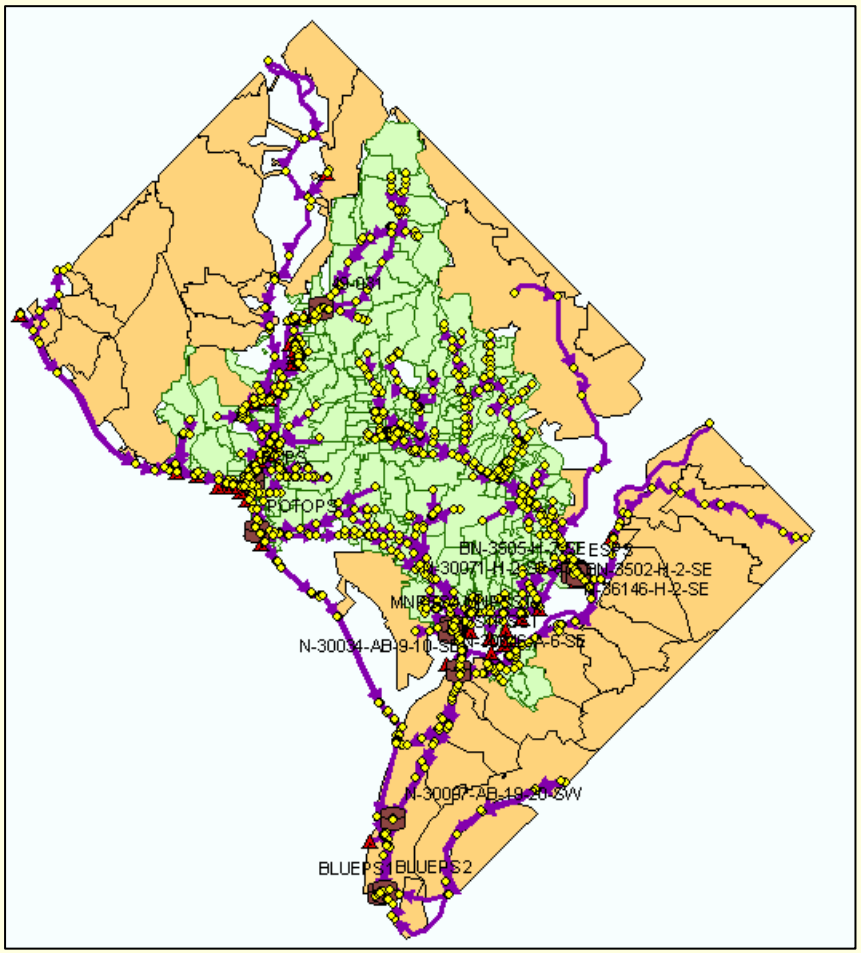
Background



- Two distinct systems
  - CSS
  - MS4
- Outfalls to Anacostia River, Potomac River, Rock Creek
- All waters impaired from stormwater runoff and CSOs
- LTCP

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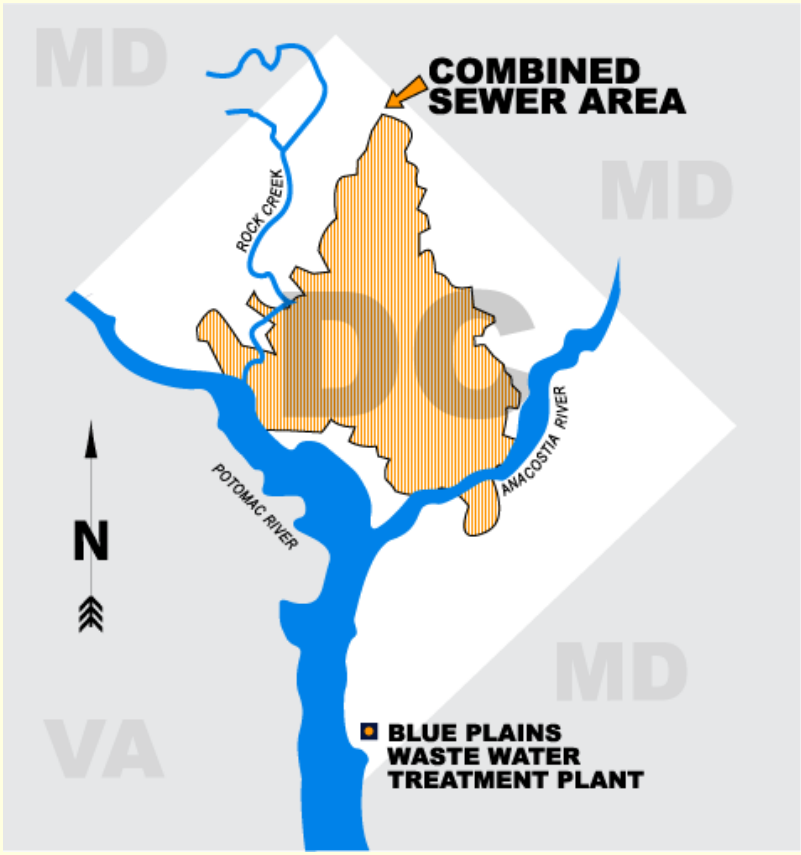
Grant Method



- Add to Mike Urban Model (MOUSE)
  - MS4 area
  - Green component
- Quantify interception storage at different coverage scenarios
  - Intensive Greening Scenario
    - Physically possible
  - Moderate Greening Scenario
    - More practical

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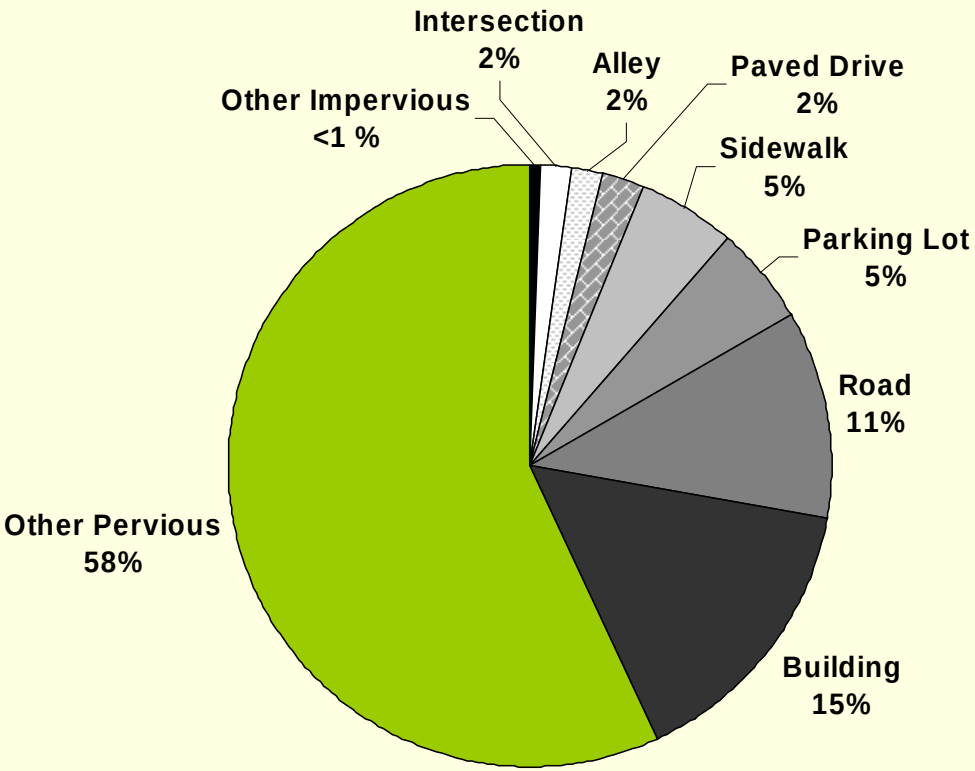
Mike Urban Model

- Hydrologic
  - Stormwater Volume
- Hydraulic
  - Untreated Discharge
  - Discharge Frequency
- Mass Balance Equation
  - Runoff = Precipitation – Storage – Infiltration – Evapotranspiration
  - Storage = interception storage * coverage area

Green Component



- Interception Storage
  - Trees = 0.03 inch
  - Green roofs = 1 inch

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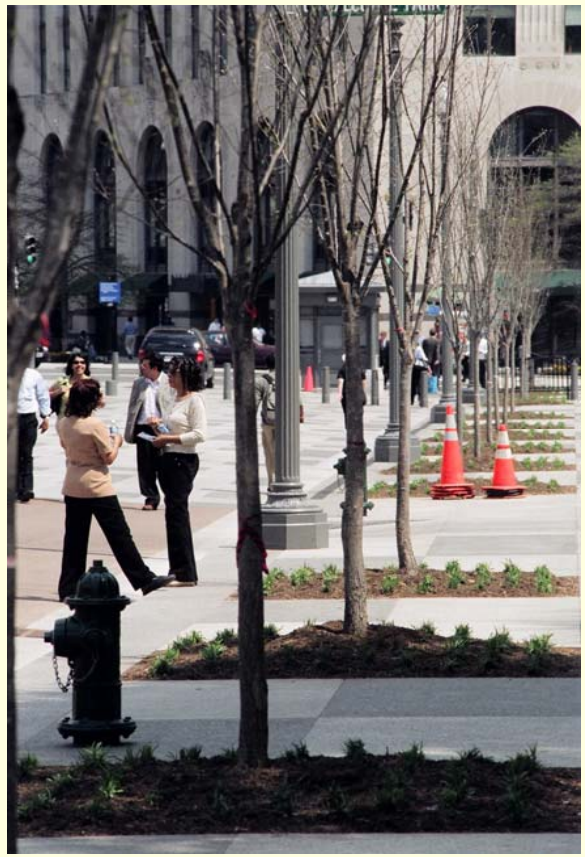
Land Use - Existing Streets



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Land Use - Existing Parking Lots

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Land Use - Existing Roofs

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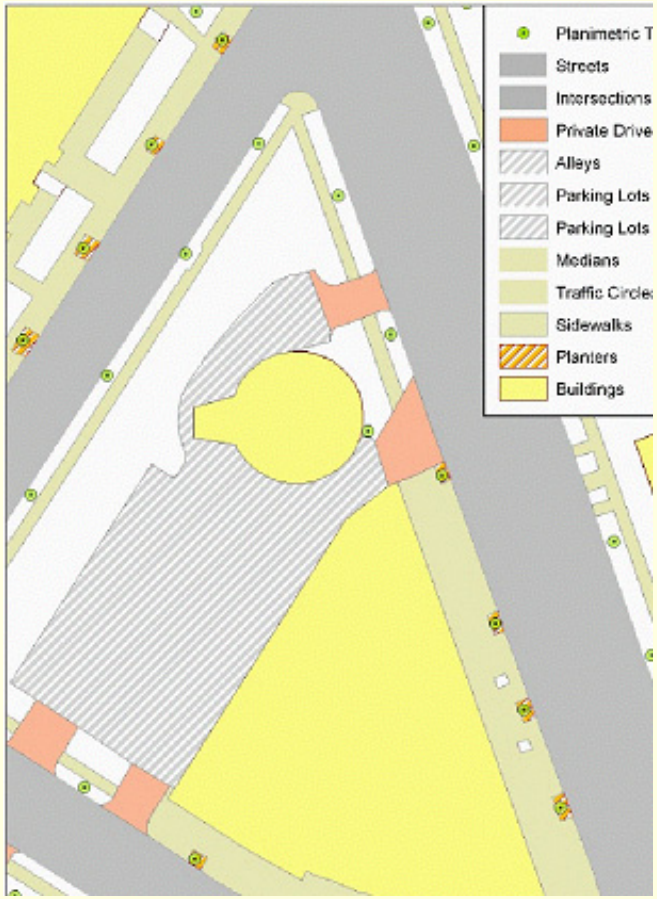
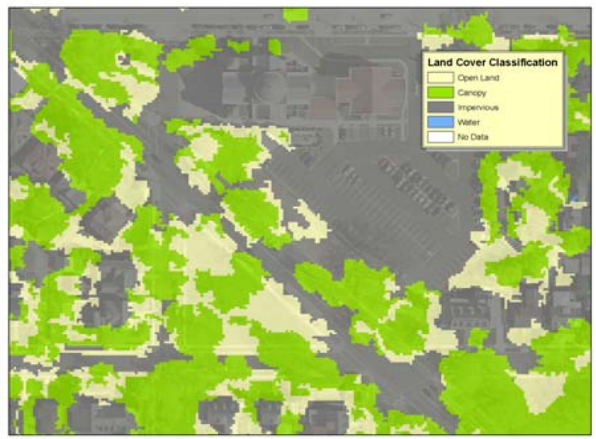
Land Cover Data





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Tree Cover Assumptions

Land Cover Type	Existing Tree Cover	Moderate Greening Scenario	Intensive Greening Scenario
Impervious			
Streetscapes (roads, sidewalks, intersections)	22%	25%	35%
Parking lots	7%	30%	50%
Paved drives	23%	50%	80%
Alleys	26%	35%	50%
Median islands, traffic islands, hidden medians, other	23%	30%	40%
Pervious			
Includes parks, open space, recreational areas, golf courses, soccer fields, cemeteries, front & back yards, school yards, etc	53%	57%	80%
TOTAL Tree Cover	**35%**	**40%**	**57%**

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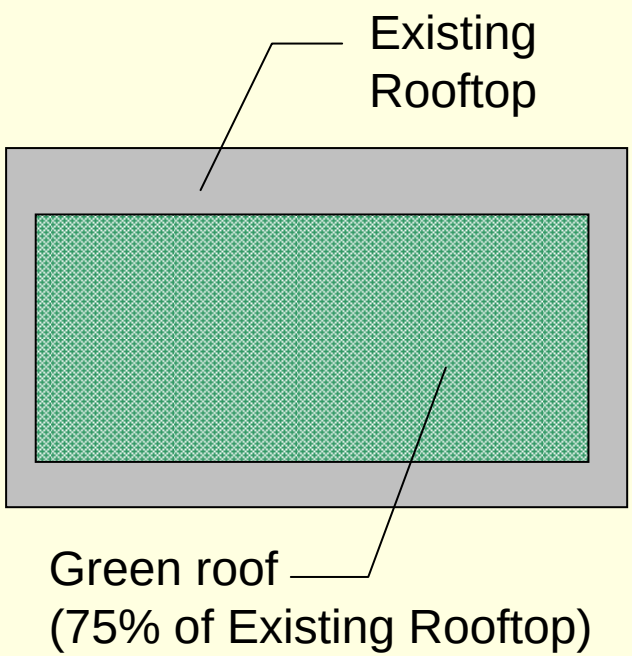
Building Coverage



- Green Roof Ready Area
  - Space needed for HVAC, access, and maintenance
- Total bldg footprint area = 260 million sf
- Green Roof Ready area = 194 million sf

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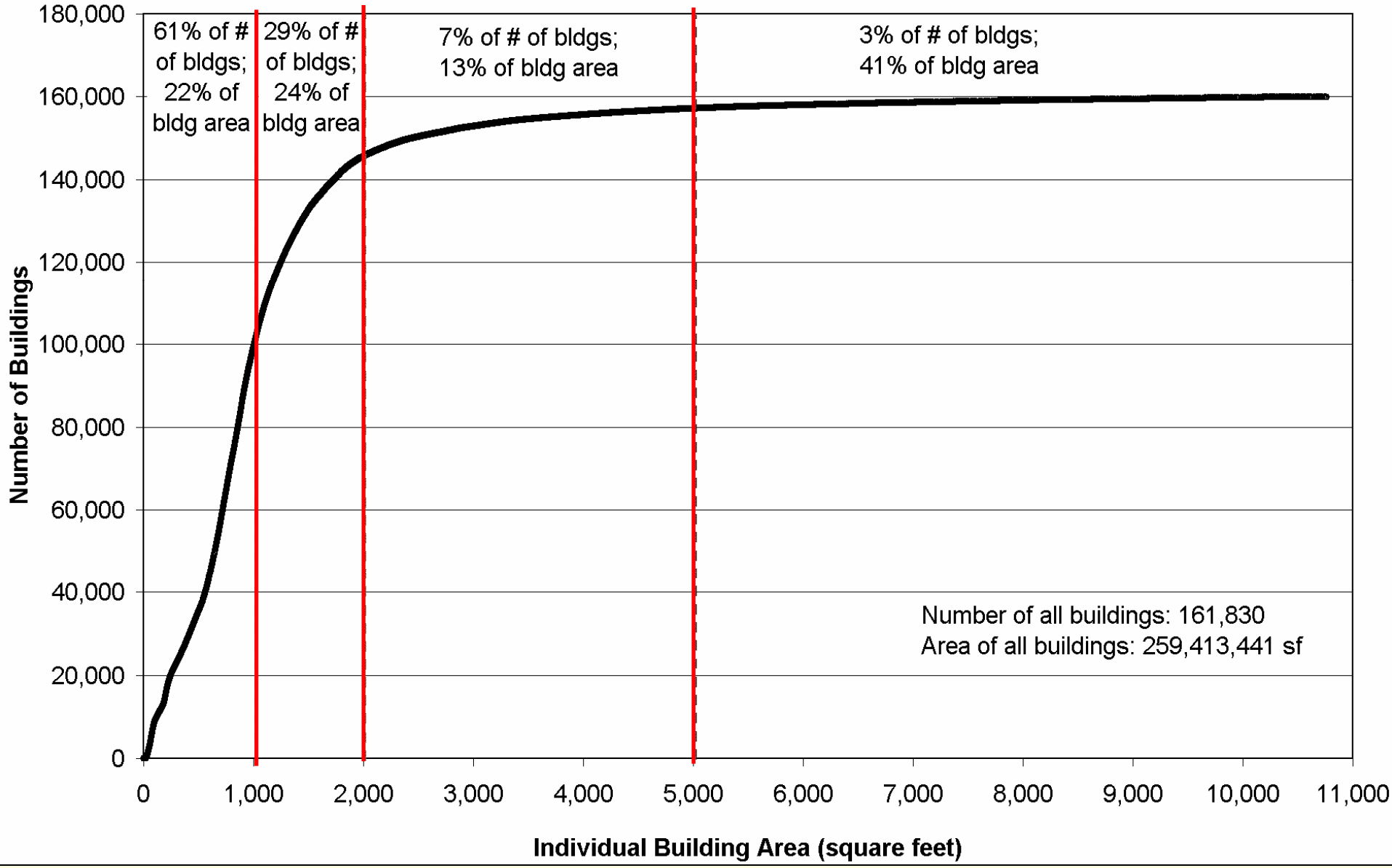
Distribution of Buildings in DC



Green Roof Coverage Assumptions[1]

Roof Type	Existing Coverage	Moderate Greening Scenario[2]	Intensive Greening Scenario[2]
< 1,000sf	0%	2%	10%
1,000sf – 2,000sf	0%	6%	30%
2,000sf – 5,000sf	0%	10%	50%
> 5,000sf	0%	18%	90%
TOTAL	**0%**	**10.5% 20 million sf**	**53% 103 million sf**

Notes
1. These percentages are based on the building area (not the number of buildings)
2. The scenarios represent the building area that is “green roof ready”.

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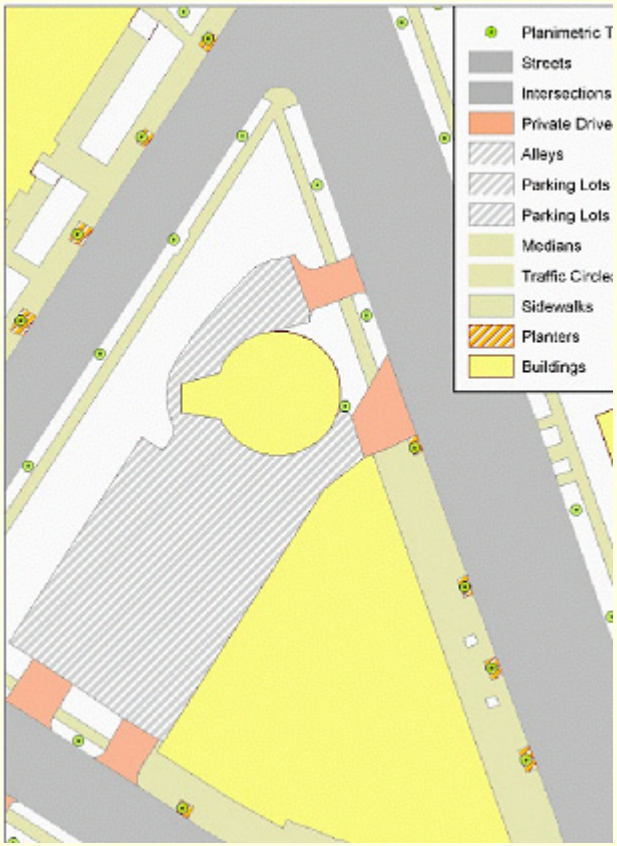
Tree Box Scenario



- Increase tree box size in downtown area from 3x5 to 6x20
- Changes 105 sf of impervious to pervious per tree space

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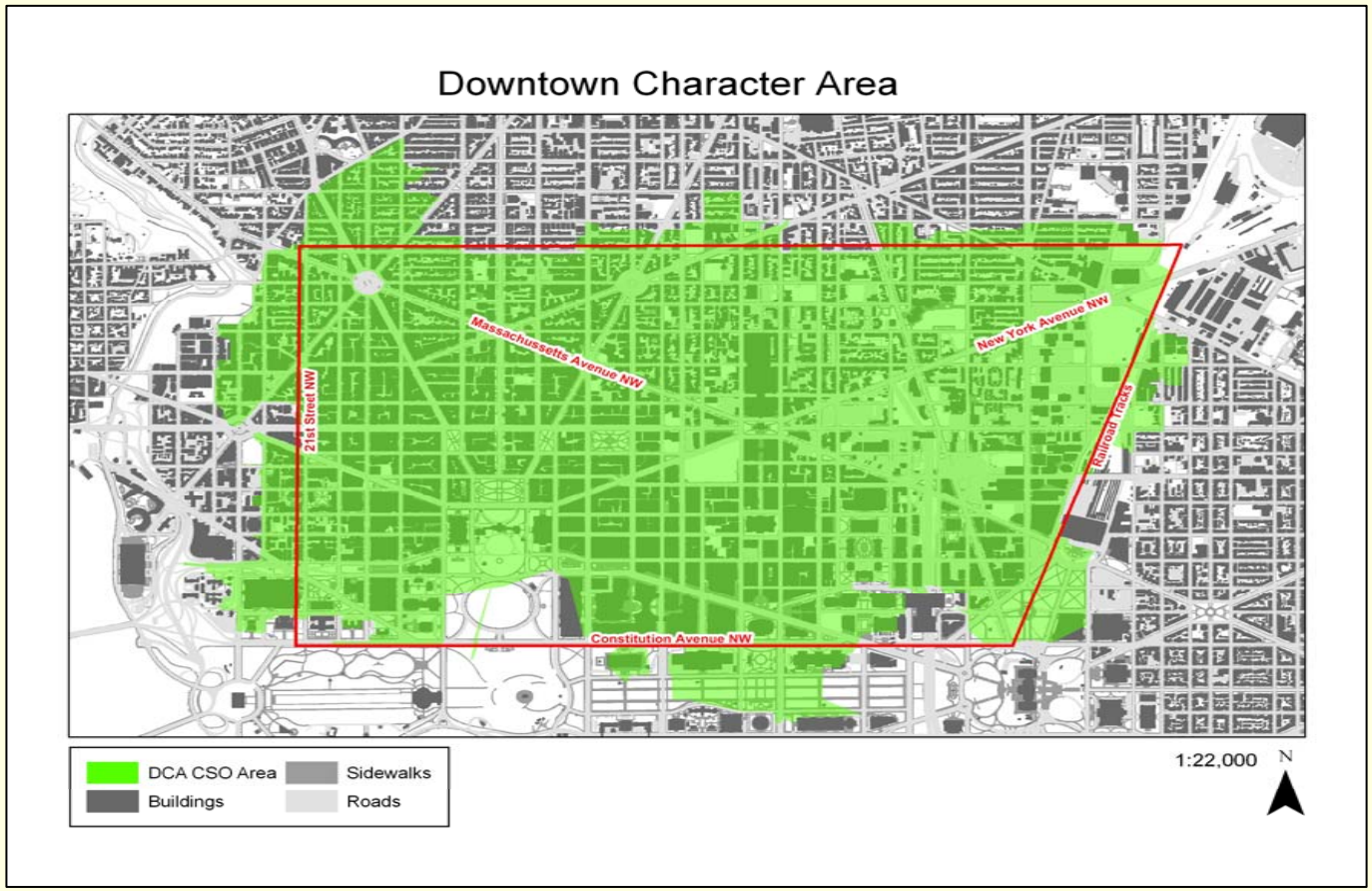
Tree Boxes (from average 4x6 ft to 6x20 ft)



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Key Findings to Date

- Trees, Green Roofs, & Tree Boxes Combined
- Findings by Sewer System and Watershed
- Operational Savings
- Pollutant Load Reductions from Green Roofs
- General Hydrologic Relationships
  - Unit area reduction factors
  - Peak shaving

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Summary of Stormwater Runoff and Sewer System Discharge Reductions

	Moderate Greening Scenario		Intensive Greening Scenario	
	MG	%	MG	%
Stormwater Runoff Reductions				
CSS	170	2.2	634	8.3
MS4	141	1.6	581	6.6
Entire Sewer System	311	1.9	1216	7.4
Sewer System Discharge Reductions				
CSS	141	6.1	514	22.0
MS4	141	1.6	581	6.6
Entire Sewer System	282	2.6	1095	10.0

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Trees, Green Roofs, & Tree Boxes

For an average year:

- Intensive Greening Scenario
  - Prevented over 1.2 billion gallons of stormwater from entering the sewer system
  - Resulting in a reduction of
    - 10% or >1 billion gallons in discharge volumes to DC's rivers
    - 6.7% in cumulative CSO frequency (74 events)
- Moderate Greening Scenario
  - Prevented over 310 million gallons of stormwater from entering the sewer system
  - Resulting in a reduction of
    - 2.6% or 282 million gallons in discharge volumes to DC's rivers
    - 1.5% in cumulative CSO frequency (16 events)

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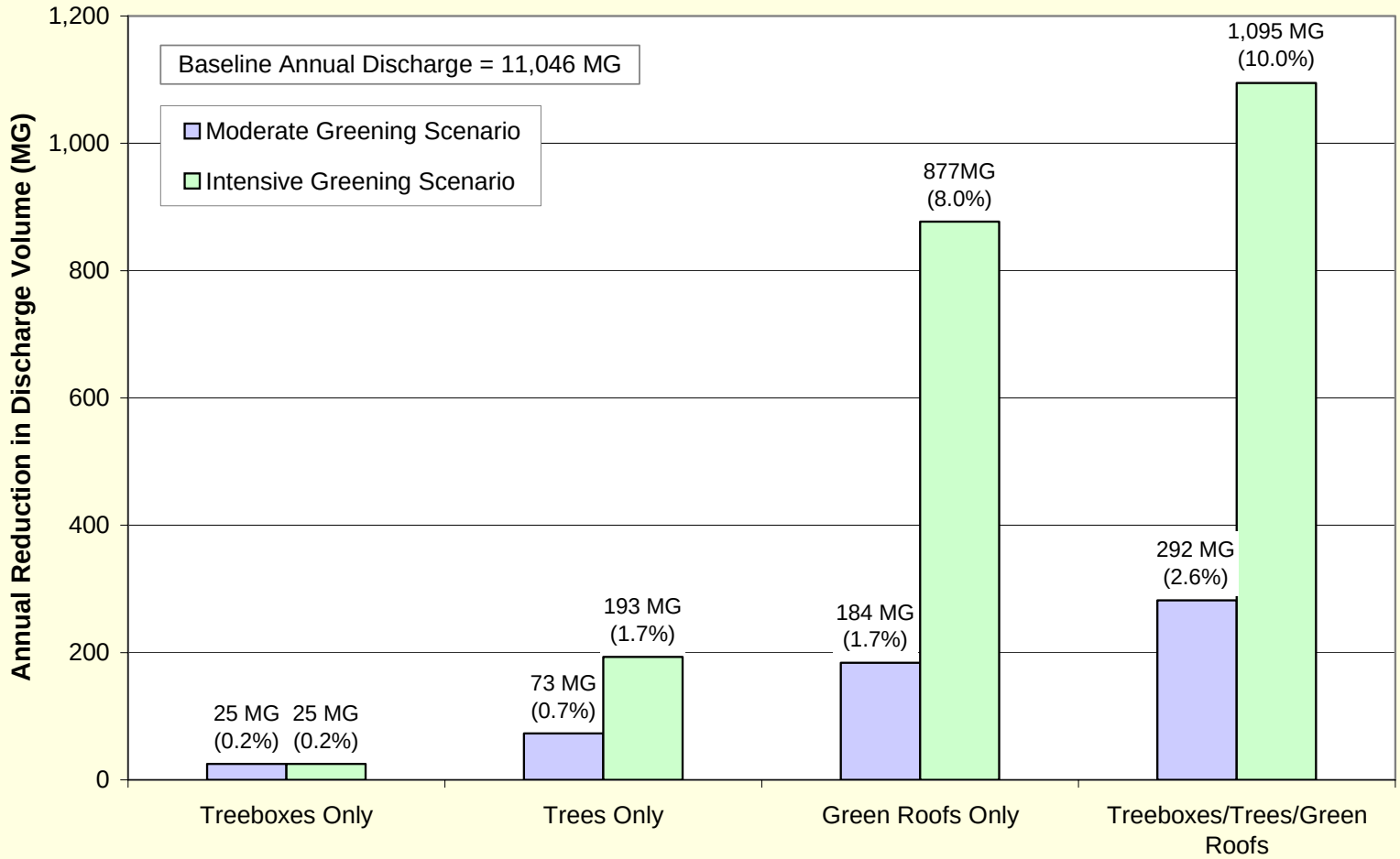
Reduction in CSO and Stormwater Discharge to All Waterbodies



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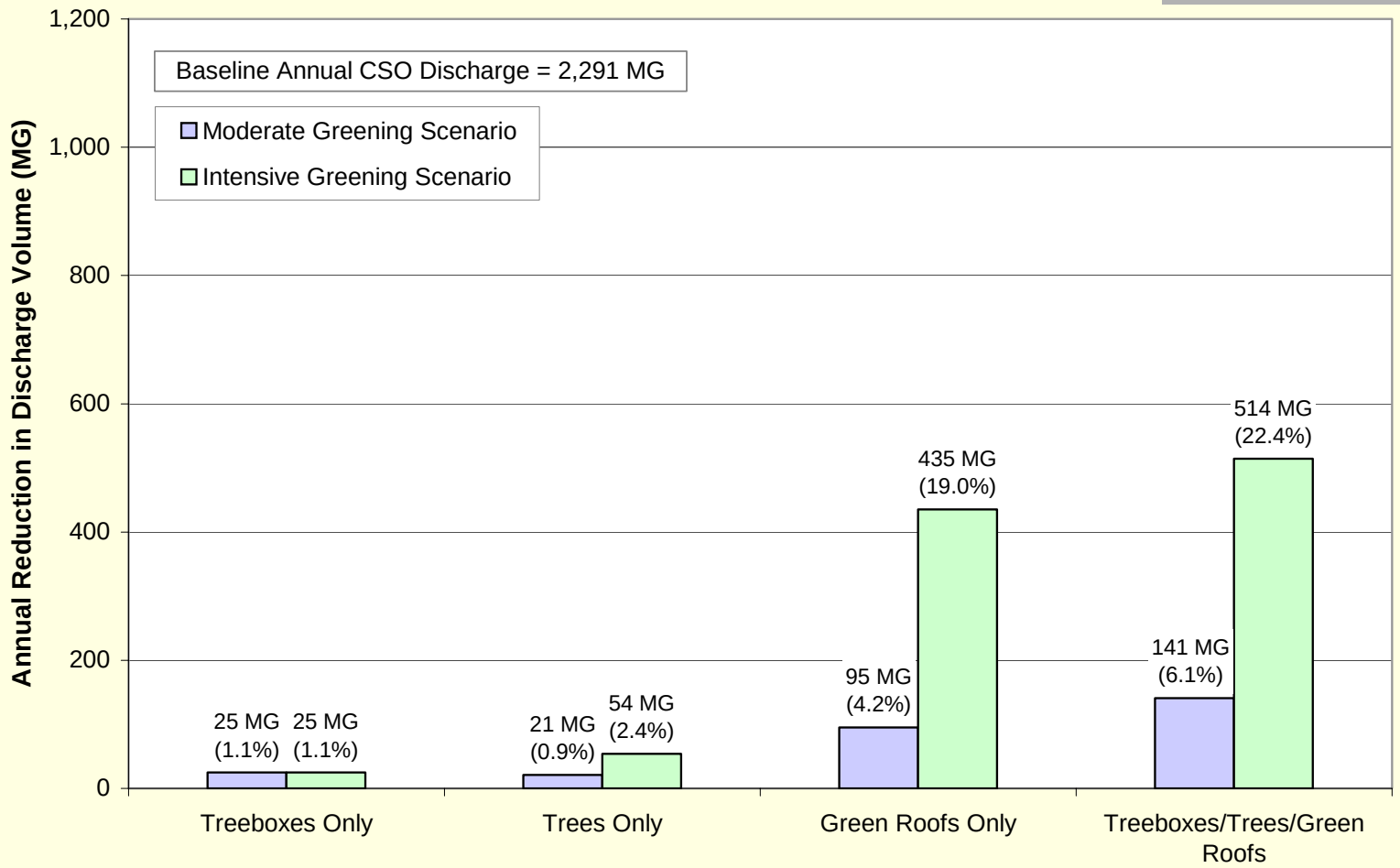
Reduction in CSO Discharge



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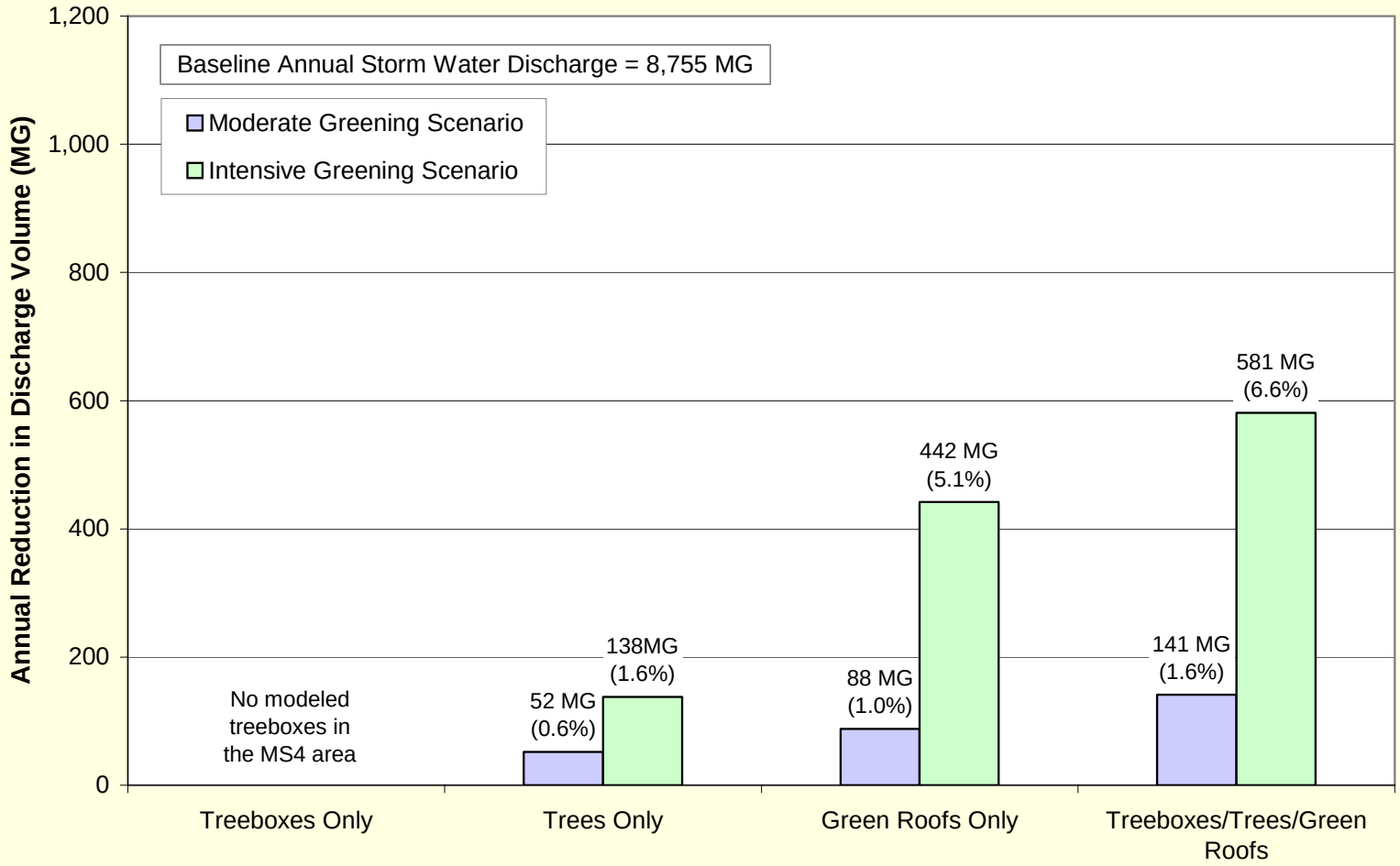
Reduction in Storm Water Discharge from the MS4 Area



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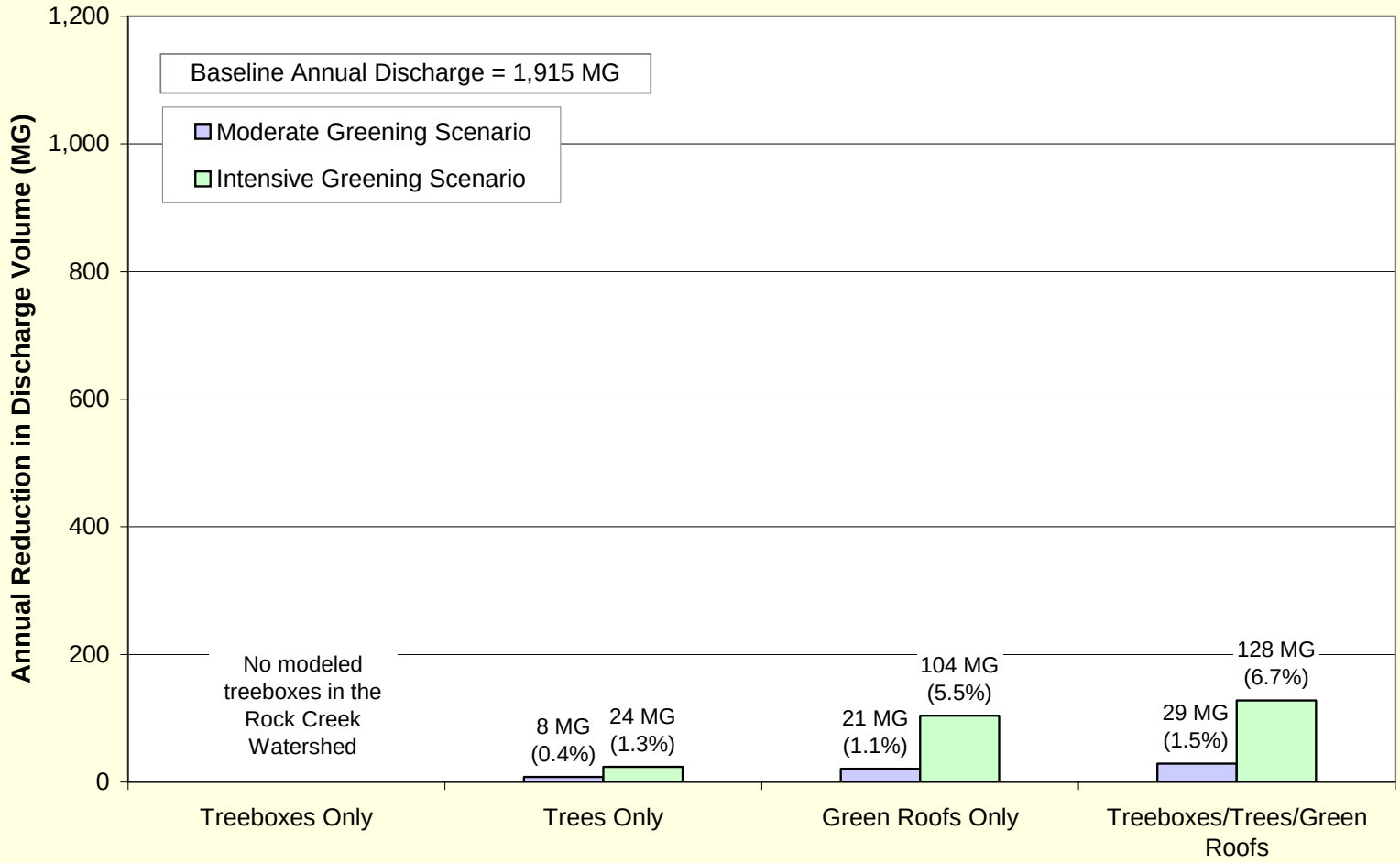
Reduction in CSO and Stormwater Discharge to Rock Creek



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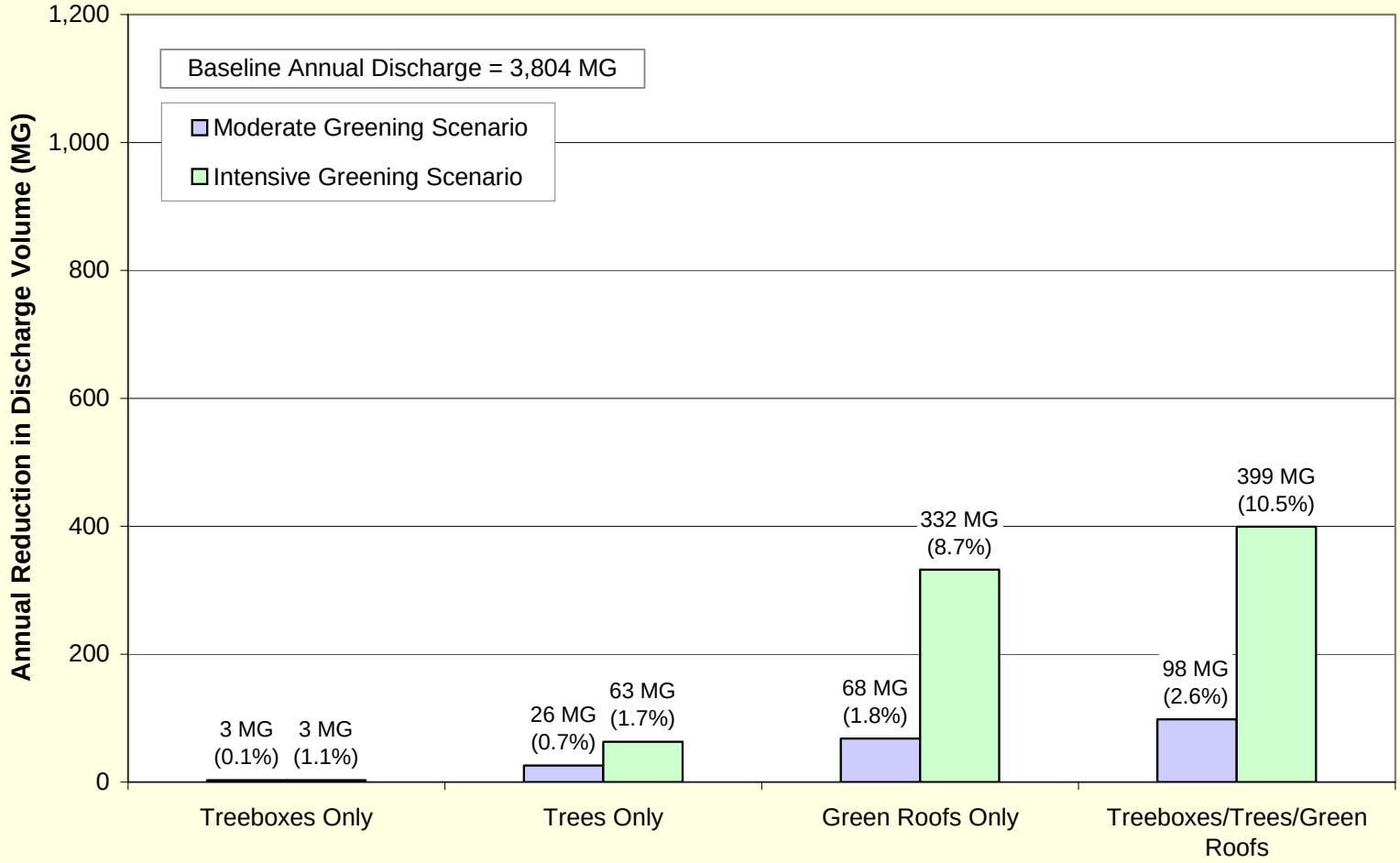
Reduction in CSO and Stormwater Discharge to the Potomac River



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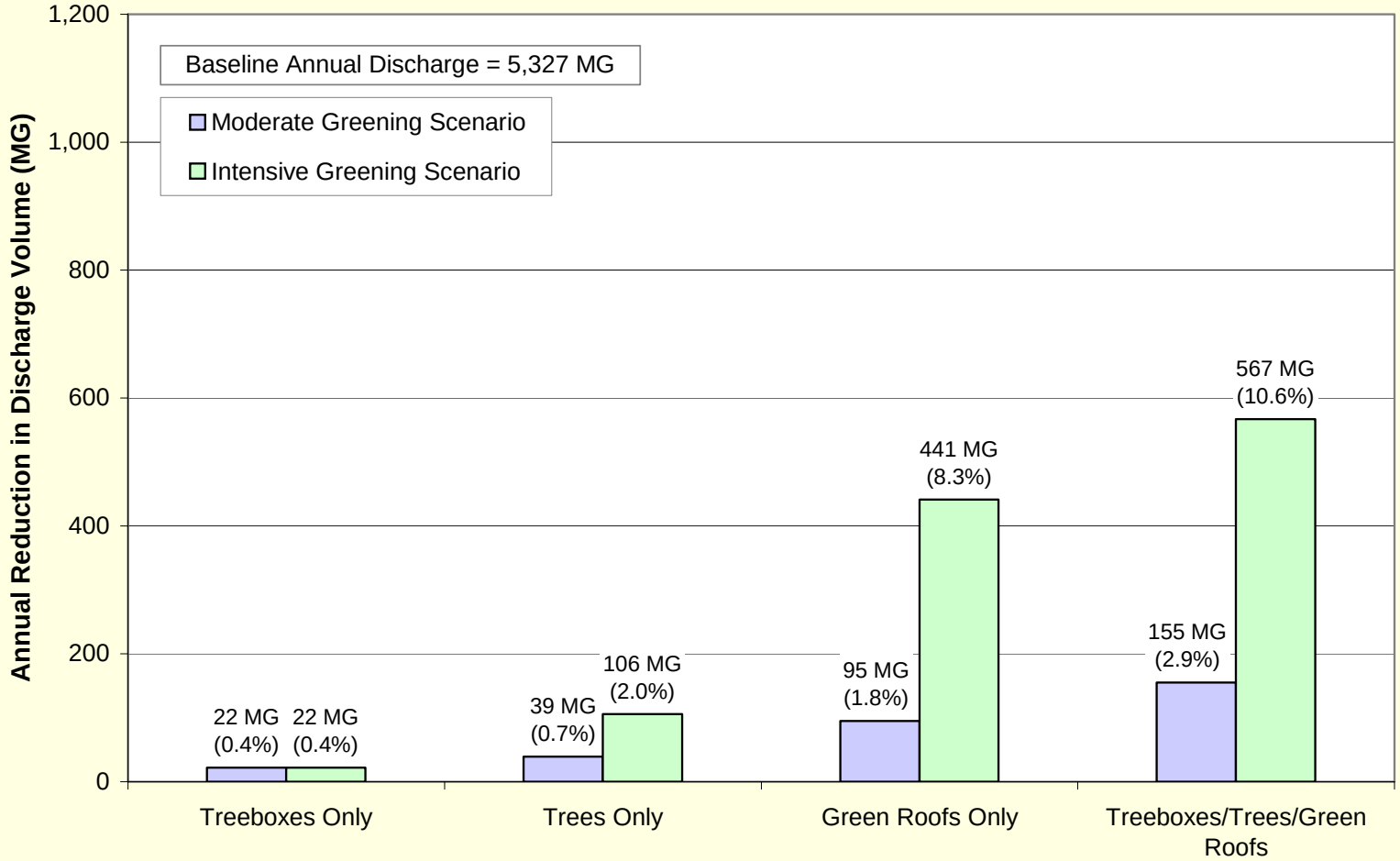
Reduction in CSO and Stormwater Discharge to the Anacostia River



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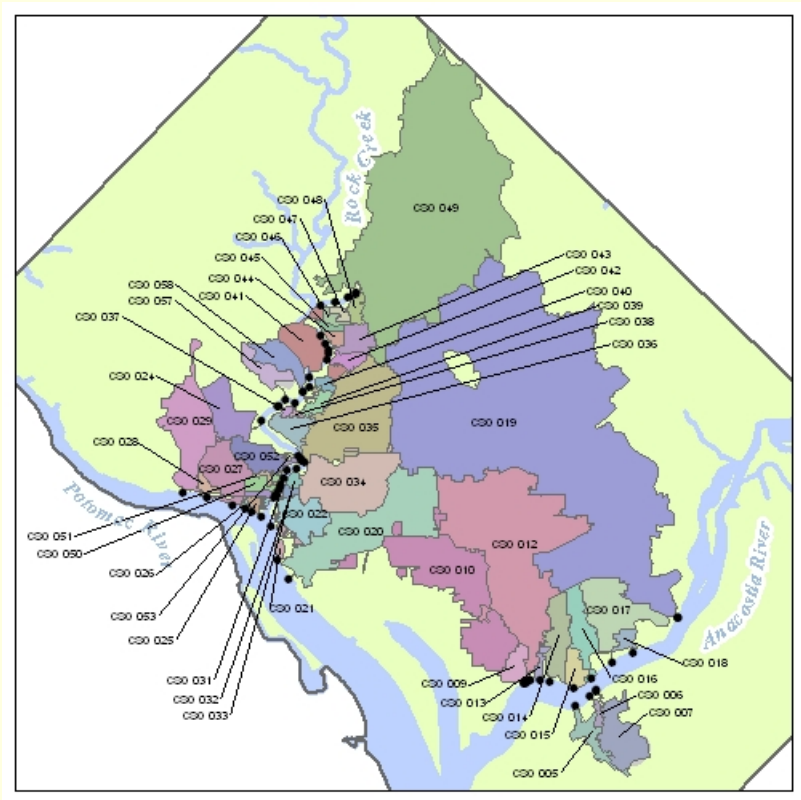
Discharge Reductions by Sewershed



		Baseline (MG)	Tree Boxes (MG)	Trees (MG)	Green Roofs (MG)	ALL (MG)
012	Tiber Creek	43.39	40.90 (5.7%	39.53 8.9%	21.22 51.1%	14.88 65.7%
013	Canal Street Sewer	20.06	19.98 (0.4%	19.56 2.5%	16.07 19.9%	15.49 22.8%
014	Navy Yard	79.00	78.99 (0.0%	77.62 1.7%	67.25 14.9%	65.86 16.6%

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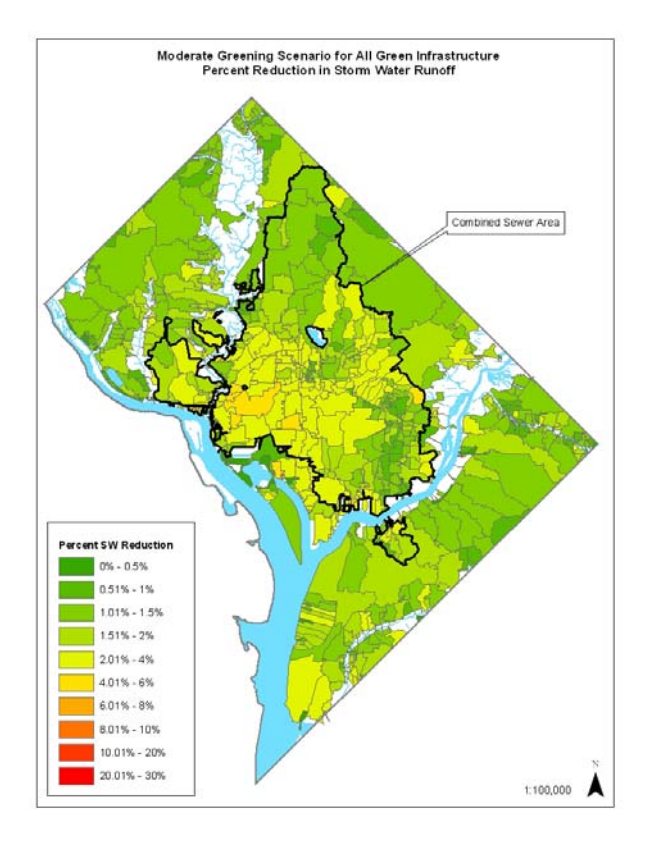
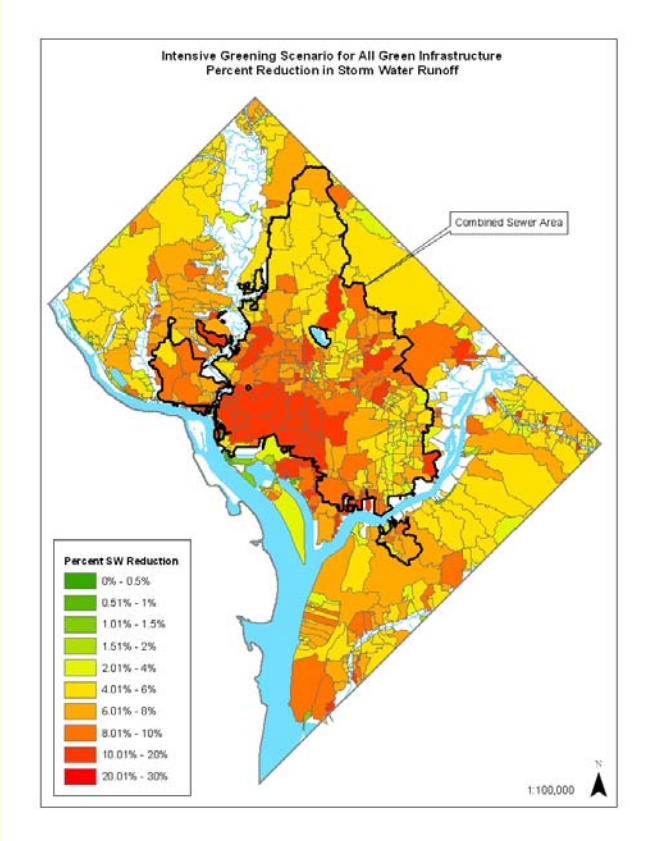
Runoff Reduction: All Green Infrastructure





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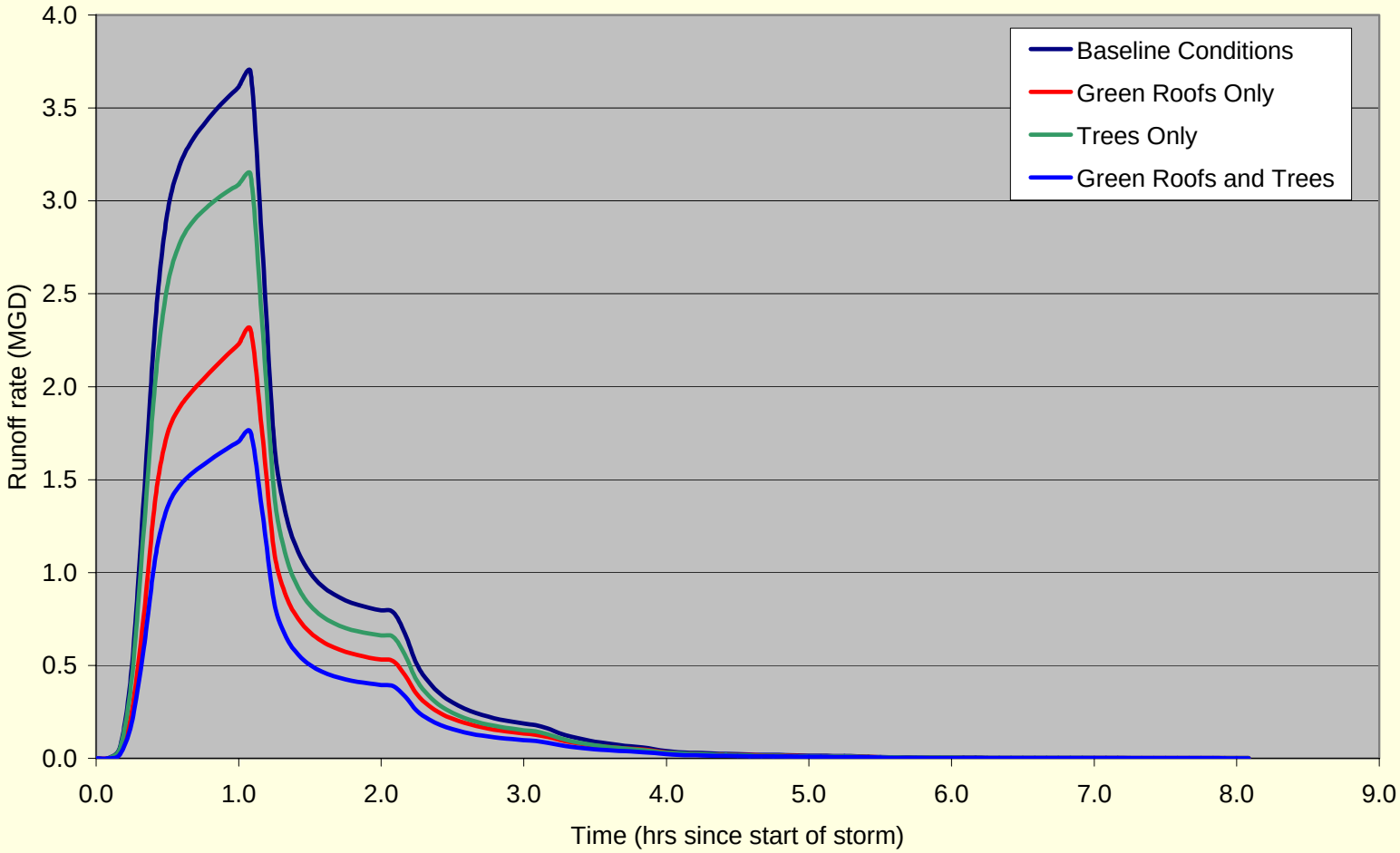
Unit Area Reduction Factors

Type of Greening	Stormwater runoff volume reduction per unit area (MG/acre/year)	Acres required to achieve a one MG reduction in stormwater over an average year (acres/MG)
Green roofs	0.38960	2.5667
Trees over impervious areas	0.11117	8.9952
Trees over pervious areas (NRCS Soil Type D)	0.02210	45.249
Trees over pervious areas (NRCS Soil Type C)	0.00276	362.32
Trees over pervious areas (NRCS Soil Type A & B)	0.00008	12,500

- Can be used for quick planning calculations in the Washington, DC area or for other urban areas with similar climate conditions and rainfall distribution patterns

Peak Shaving



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Operational Savings

- Operational savings for WASA
- Operational costs assumed to decrease proportionally for every gallon avoided
  - Utility costs for pumping (electricity)
  - Treatment costs including those associated with biosolids disposal, treatment chemicals, and supplies
- Exploratory review of literature = $0.01/gallon
- Savings approximately $1.4 - $5.1 million/year

Pollutant Loading Reductions

Pollutant	Intensive Greening Scenario	
	lbs reduced/year	% reduction
Total Suspended Solids	77,000	0.8%
Biochemical oxygen demand (BOD)	34,000	1.5%
Total phosphorous	340	0.6%
Total Kjeldahl nitrogen (TKN)	11,000	4.6%
Ammonia	3,400	4.1%
Copper	120	2.3%
Lead	180	1.8%
Zinc	3,100	16.1%

- Green roofs
  - Replaces pollutant contributions from conventional roofs
  - Highly effective at storing and filtering pollutants
- Conservative estimate of expected pollutant load reduction
  - Does not include pollutant scouring reductions from peak shaving

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Overall Key Findings

- Substantial reduction in runoff & discharge volumes
- Limited reduction in CSO frequencies
- Reduction in stormwater peak flow & velocity
- Operational savings in CSS
  - Less to be pumped and treated
- Limited stormwater control options in urban areas
- Trees and green roofs complimentary land cover types
- Multiple other benefits for same investment
  - Air quality, urban heat island effect, energy, climate change, public health, social capital, economic development, aesthetics, urban ecology, etc

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Grant Products

- Data Results Display Tool
- Mini-Model
- Final report documentation 5/15/07
  - www.caseytrees.org

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Data Display Tool

Green Build-Out Model Results Display Tool

Quantifying Stormwater Benefits of Trees and Green Roofs in the District of Columbia

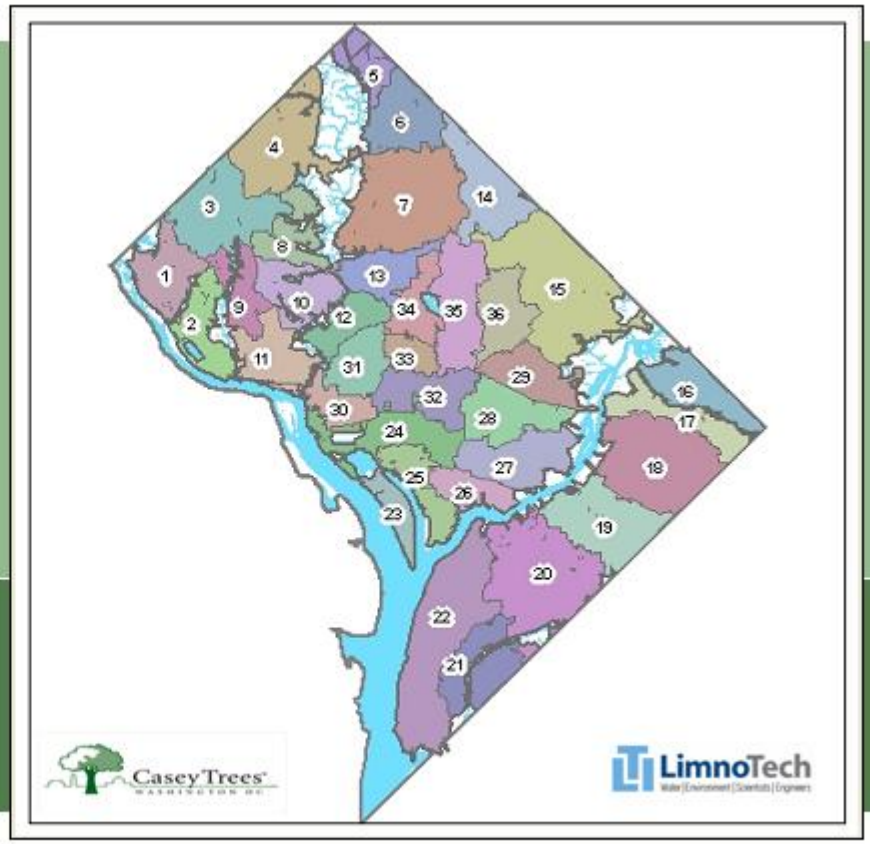
This display tool presents the model results for the Moderate and Intensive Greening scenarios for green roofs and trees. Results are presented as reductions in stormwater flow and can be viewed on a city-wide, neighborhood, or sewershed scale.

To begin, choose an area that you are interested in from the list below.

Choose area from map to view model results:

Friendship Heights

16 Watts Branch North - Deanwood
17 Watts Branch South - Benning
18 Fort Dupont Park
19 Penn Branch - Randle Highlands
20 Buena Vista - Douglas
21 Oxon Run - Congress Heights
22 Bolling AFB
23 Hains Point



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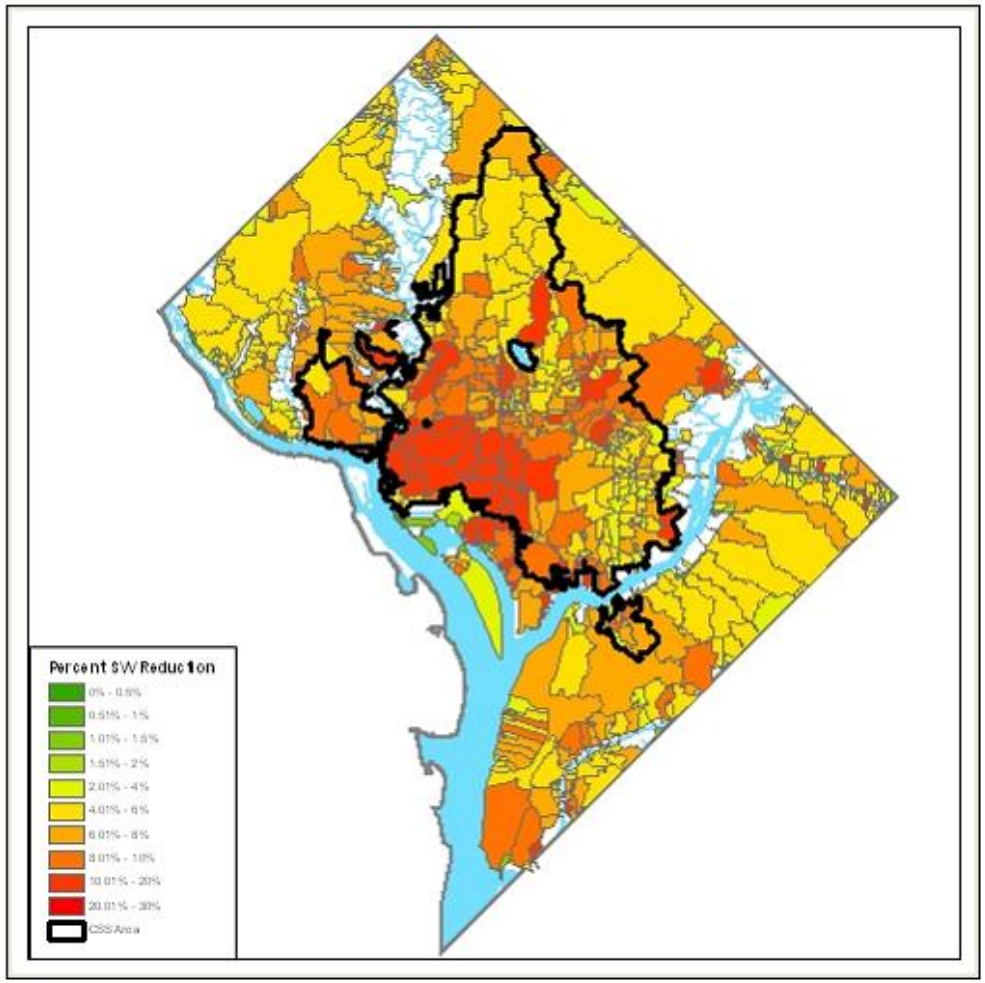
DC Summary

Print Results | Return to Main Map

Choose a green coverage type to view associated data: ○ Green Roofs ○ Trees ○ Tree Boxes ◉ Total



Watershed/Sewer System	Baseline Flow (MGY)	Moderate Greening Scenario Flow (MGY)	Moderate Greening Scenario Flow Reduction	Intensive Greening Scenario Flow (MGY)	Intensive Greening Scenario Flow Reduction
Anacostia CSS	4,219	4,129	2.13%	3,888	7.83%
Potomac CSS	1,013	983	2.96%	902	10.96%
Rock Creek CSS	2,437	2,386	2.09%	2,244	7.92%
Total CSS	7,668	7,498	2.2%	7,034	8.3%
Anacostia MS4	3,719	3,659	1.61%	3,478	6.48%
Potomac MS4	3,177	3,122	1.72%	2,952	7.07%
Rock Creek MS4	1,860	1,833	1.44%	1,744	6.22%
Total MS4	8,755	8,614	1.61%	8,174	6.64%
Anacostia	7,938	7,788	1.88%	7,366	7.20%
Potomac	4,189	4,105	2.02%	3,854	8.01%
Rock Creek	4,296	4,219	1.81%	3,988	7.19%
Total	16,423	16,112	1.90%	15,208	7.40%

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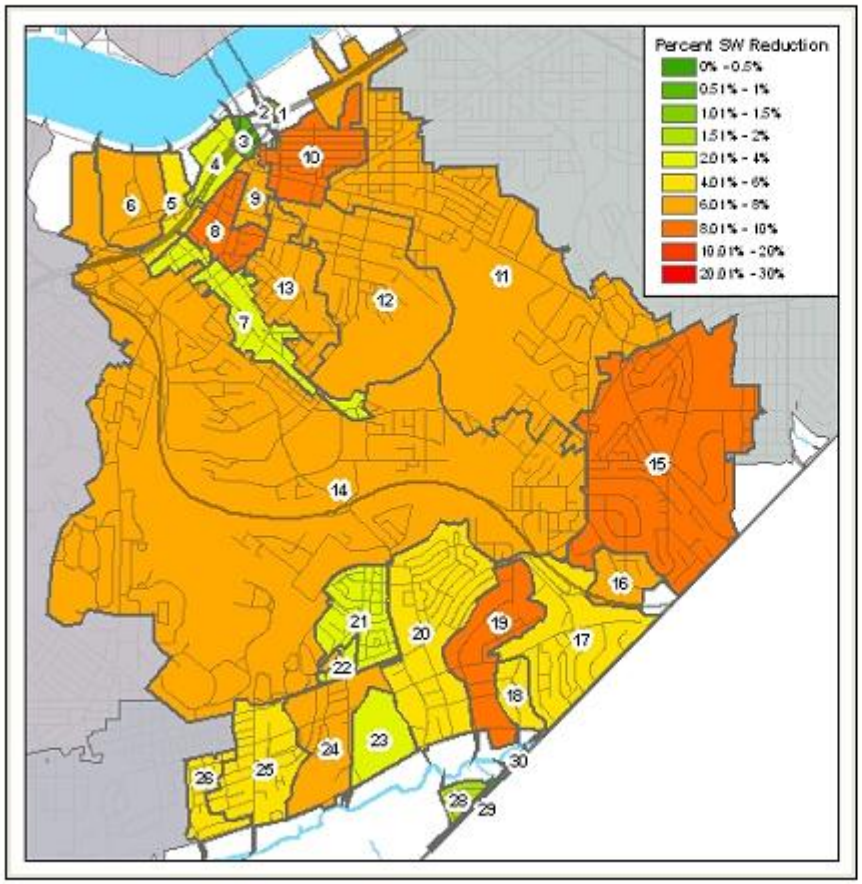
Buena Vista - Douglas

Print Results | Return to Main Map

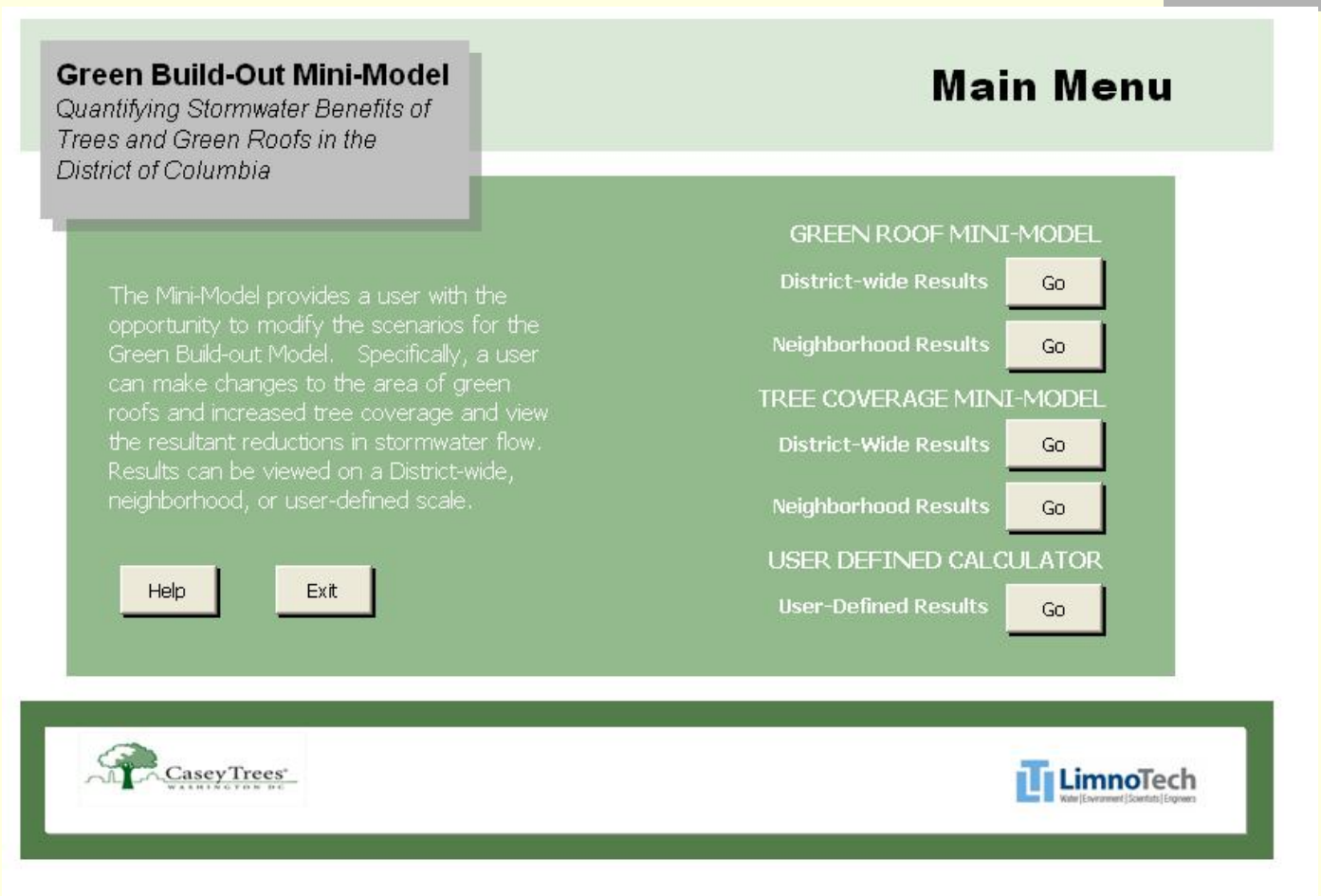
Choose a green infrastructure type to view associated data:* ○ Green Roofs ○ Trees ◉ Total



*Map depicts percent flow reduction associated with Intensive Greening scenario and all green infrastructure types.

ID	Subshed	Sewer Area	Baseline Flow (MGY)	Moderate Greening Scenario Flow (MGY)	Moderate Greening Scenario Flow Reduction	Intensive Greening Scenario Flow (MGY)	Intensive Greening Scenario Flow Reduction
1	SW-ANA61	MS4	0.51	0.51	0.04%	0.51	1.12%
2	CSO 007-a	CSS	0.60	0.59	0.25%	0.59	1.07%
3	CSO 006-a	CSS	1.87	1.86	0.30%	1.85	0.94%
4	SW-ANA54	MS4	5.77	5.70	1.24%	5.59	3.20%
5	CSO 005-a	CSS	5.26	5.19	1.34%	5.05	4.02%
6	SW-ANA52	MS4	12.32	12.08	1.95%	11.57	6.16%
7	CSO 005-b	CSS	17.34	17.17	1.00%	16.71	3.63%
8	CSO 005-c	CSS	15.73	15.30	2.72%	14.27	9.27%
9	CSO 006-b	CSS	7.42	7.27	2.10%	6.88	7.26%
10	CSO 007-d	CSS	24.65	24.15	2.07%	22.62	8.26%
11	SW-ANA30	MS4	116.07	114.06	1.73%	107.99	6.96%
12	CSO 007-c	CSS	35.66	35.12	1.53%	33.41	6.33%
13	CSO 007-b	CSS	20.21	19.89	1.59%	18.97	6.15%
14	SW-ANA50	MS4	241.86	237.12	1.96%	224.26	7.28%
15	SW-OXR46	MS4	79.87	78.36	1.89%	73.37	8.14%
16	SW-OXR47	MS4	6.93	6.82	1.66%	6.48	6.49%
17	SW-OXR1	MS4	30.61	30.19	1.36%	28.96	5.38%
18	SW-OXR3	MS4	4.58	4.51	1.57%	4.36	4.86%
19	SW-OXR4	MS4	19.52	19.09	2.18%	17.67	9.46%
20	SW-OXR5	MS4	35.34	34.89	1.26%	33.46	5.31%
21	SW-OXR32	MS4	4.32	4.27	1.11%	4.17	3.55%
22	SW-OXR33	MS4	2.26	2.24	0.92%	2.17	4.00%
23	SW-OXR6	MS4	3.36	3.34	0.56%	3.26	2.88%
24	SW-OXR7	MS4	17.24	16.98	1.51%	16.05	6.87%
25	SW-OXR8	MS4	21.84	21.54	1.39%	20.60	5.70%
26	SW-OXR9	MS4	7.32	7.21	1.48%	6.91	5.66%
27	SW-OXR20	MS4	27.60	27.01	2.13%	25.71	6.83%
28	SW-OXR2	MS4	3.65	3.63	0.44%	3.58	1.80%
29	SW-OXR38	MS4	2.31	2.31	0.13%	2.30	0.28%
30	SW-OXR34	MS4	0.32	0.32	0.00%	0.32	0.00%

Mini-Model



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Green Roof Mini-Model Editor

Help | View Data Report | Return to Main Menu

Existing Conditions

Roof Type	Available Roof Area (sf)
< 1,000 sf	42,934,330
1,000 - 2,000 sf	46,417,327
2,000 - 5,000 sf	24,765,320
> 5,000 sf	80,738,983
TOTAL	194,855,959

Model Scenario Builder

Choose Green Roof Area for Model Run	Model Greenroof Area (sf)	Model Greenroof %
0% 2% 10% 100%	13,738,985	32%
0% 6% 30% 100%	14,853,545	32%
0% 10% 50% 100%	7,924,902	32%
0% 18% 90% 100%	25,836,475	32%
0% 10.5% 53% 100%	62,353,907	32%

Intensive Greening Scenario

Moderate Greening Scenario

District-Wide Model Results

System/ Watershed	Runoff Volume Without Green Roofs (MG)	Runoff Volume With Green Roofs (MG)	Reduction In Runoff Volume (MG)	Percent Reduction In Runoff Volume
CSS Total	7,668	7,379	289	3.8%
MS4 Total	8,755	8,480	275	3.1%
Anacostia Total	7,938	7,673	265	3.3%
Potomac Total	4,189	4,050	140	3.3%
Rock Creek Total	4,296	4,137	160	3.7%
TOTAL	**16,423**	**15,859**	**564**	**3.4%**

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Advisory Team Policy Recommendations

- Stormwater & sewer fee, incentive program
- Impervious surface limits
- Greenroof Cover Objectives, Strategy, & Leadership
- District-wide Urban Tree Canopy goals & Management Plan
- Tree cover objectives by land cover area e.g. Parking Lots = 40%
- Increase tree box size from minimum 3x5 ft to 6x20 ft
- Fill and maintain all street tree spaces
- GIS database for tracking & monitoring

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Areas for Further Study

- Demonstration of “Intensive Greening” in target sewershed(s)
- Add other LID in model
- Re-run Mike Urban model with research findings for the LTCP
- Comprehensive cost/ benefit analysis for implementation
- Performance & maintenance standards
- GIS database to track performance
- Implementation tools for site scale

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Contact Information

Barbara Deutsch
bdeutsch@post.harvard.edu
202.550.3679

Mike Sullivan
msullivan@limno.com
202.833.9140

Heather Whitlow
hwhitlow@caseytrees.org
202.833.4010

Brian Busiek
bbusiek@limno.com
202.833.9140

www.caseytrees.org

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Backup slides

Casey Trees Programs

- Education
  - Citizen Forester
  - Schools Programs
  - Internships
- Data Gathering & Analysis
  - Inventory
  - Tree Map: www.caseytrees.org/treemap
  - Green Infrastructure Mapping Collaborative
  - Urban Tree Canopy Goals
- Tree Planting & Stewardship
  - Community Plantings & Request for Plantings (RFP)
  - Other Plantings
  - Tree Stewardship
- Planning & Design
  - Policy & Design Input to Comp Plan, Great Streets, New Communities, Tree Bill
  - Tree Space Design
  - Work with BIDs & Developers

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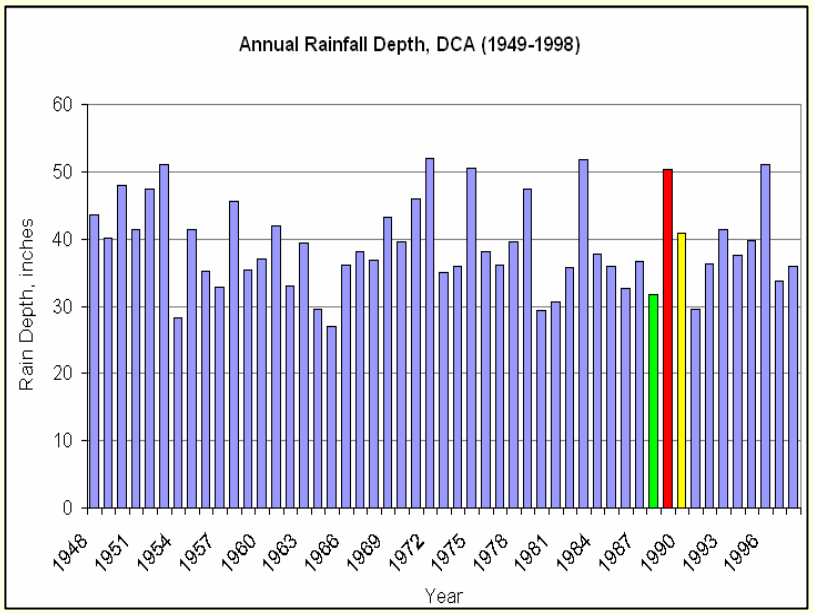
Model input is based on hourly data



- Typical rainfall conditions
  - 1988 – representative dry year (green)
  - 1989 – representative wet year (red)
  - 1990 – representative average year (yellow)
- Actual data

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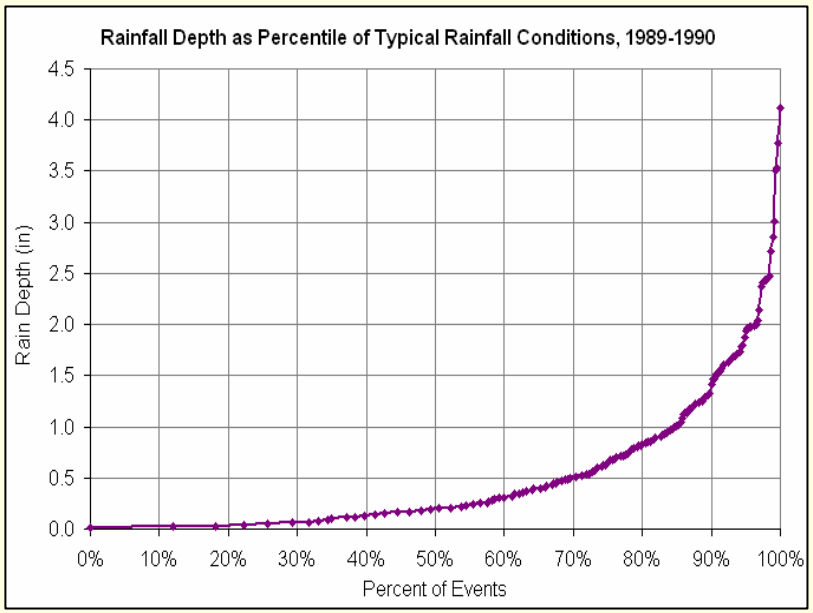
Model Input: Precipitation



- 70% of rain events < 0.5 inches
- 85% of rain events < 1 inch
- 97% of rain events < 2 inches

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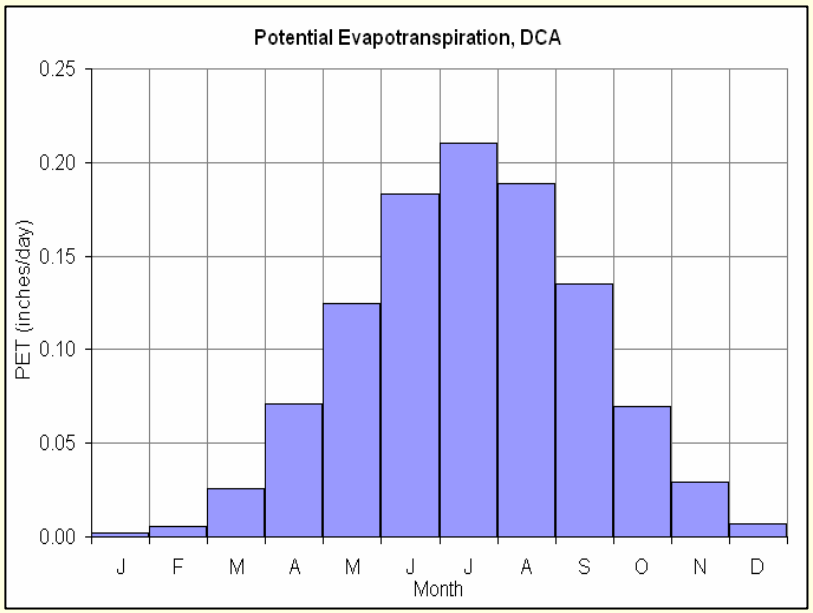
Model Input: Potential Evapotranspiration



- Water budget loss mechanism
- Published by VA climatology office

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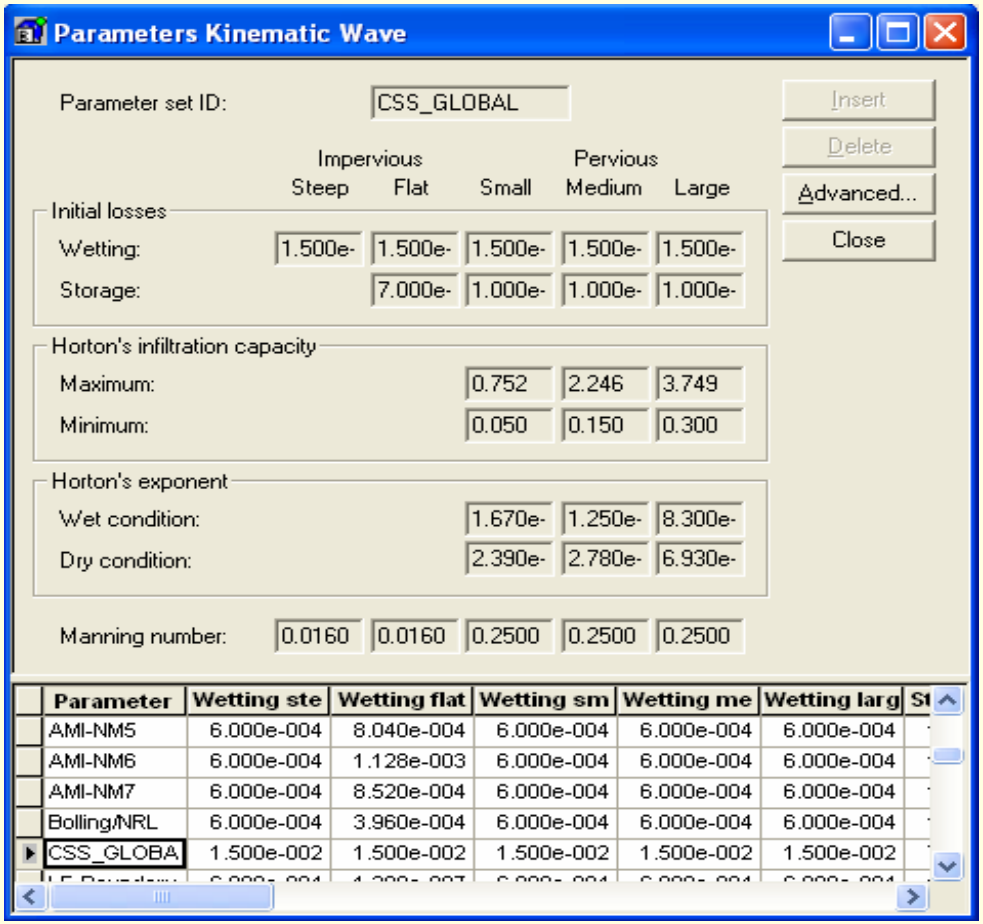
Mike Urban: Hydrologic Parameters



- Interception storage
  - Trees = 0.03 inch
  - Green roofs = 1 inch
- Infiltration capacity and recovery
- Surface roughness
- Calibrated to actual flow data

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Tree Storage

- Storage = LAI * 0.2mm
- LAI = 4.10
- Storage = 0.032 inches

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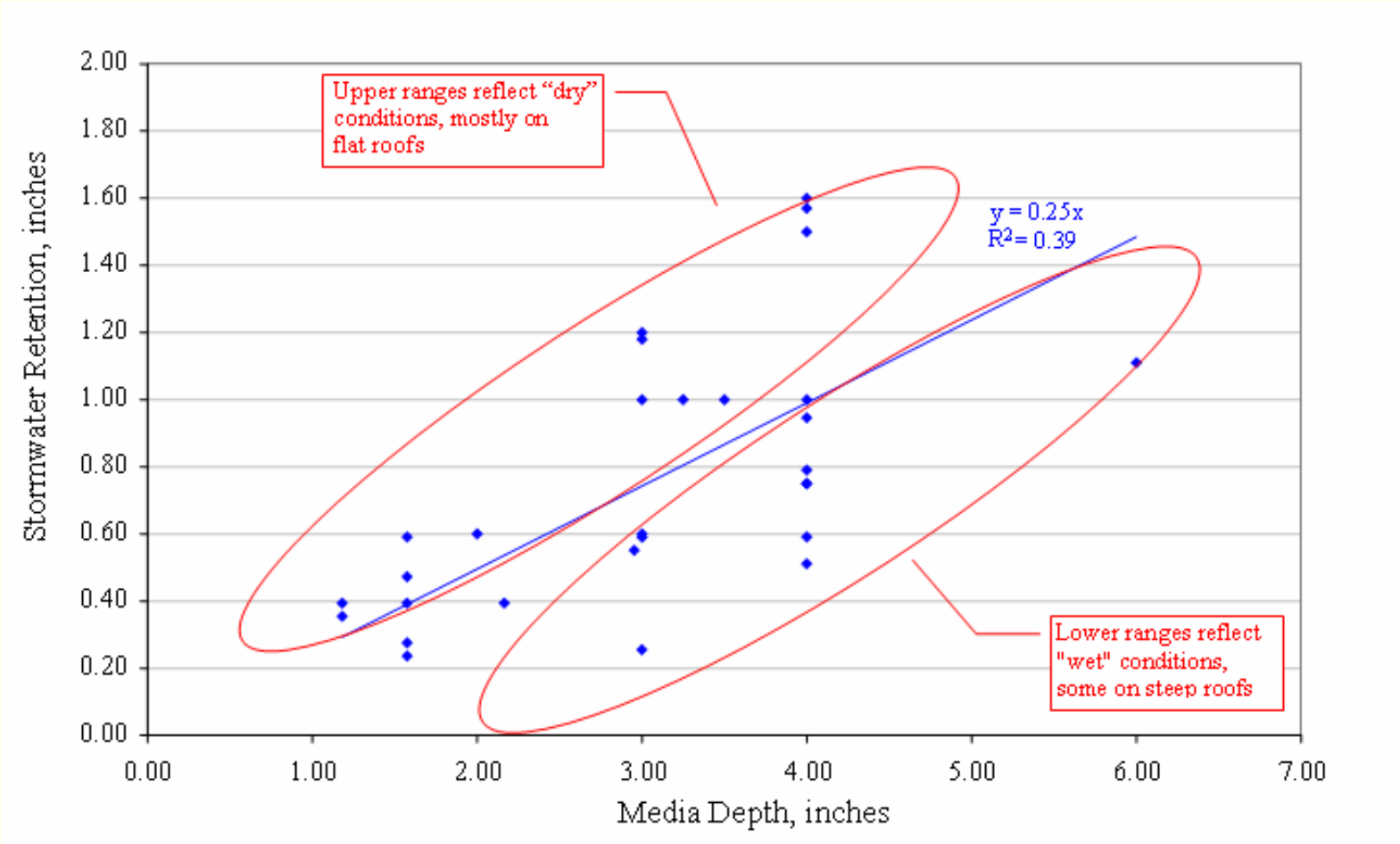
Interception Storage (1 inch, for 3-4” extensive)



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Type of Green Roof

- Extensive 3-4 inches soil media depth
  - Literature review
  - Purpose as a stormwater BMP
  - Design consistency
  - Opportunity
  - Costs
  - Market trends
  - Conservatism

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Grant Method

	Uncontrolled Flow	Flow with Intensive Greening Scenario	Flow with Moderate Greening Scenario
	MG	MG (% reduction)	MG (% reduction)
Combined Sewer System			
Anacostia CSS	1,608	1,341	1,548
		(16.6%)	(3.7%)
Potomac CSS	628	472	595
		(24.8%)	(5.2%)
Rock Creek CSS	56	43	53
		(22.3%)	(4.6%)
Total	2,292	1,856	2,196
		(19.0%)	(4.2%)
Storm Sewer System			
Anacostia Storm Flow	3,719	3,545	3,684
		(16.6%)	(3.7%)
Potomac Storm Flow	3,177	2,996	3,140
		(24.8%)	(5.2%)
Rock Creek Storm Flow	1,860	1,768	1,841
		(22.3%)	(4.6%)
Total	8,756	8,309	8,665
		(19.0%)	(4.2%)
Entire System			
Anacostia Total Wet Weather Flow	5,327	4,886	5,232
		(8.3%)	(1.8%)
Potomac Total Wet Weather Flow	3,805	3,468	3,735
		(8.9%)	(1.8%)
Rock Creek Total Wet Weather Flow	1,916	1,811	1,894
		(5.5%)	(1.1%)
Total Wet Weather Flow	11,048	10,165	10,861
		(8.0%)	(1.7%)

- Run Scenario Options
  - Tree cover alone
  - Green roof cover alone
  - Larger tree boxes
  - All green infrastructure combined
- How look at results
  - By watershed, sewershed
  - By CSS/MS4
  - Average year rainfall (1990) (same as LTCP)
  - Design storm (6-hr/ 1”)
- Determine Significance
- Develop Policy recommendations

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What We Expected to Find

- Trees and Greenroofs provide significant stormwater benefit for small storms (85% of all rain events in DC are < 1 inch)
- Still need tunnels for large storm events
- Trees & greenroofs may not pencil-out on stormwater alone
  - Other benefits (air quality, urban heat island, increased property values & rents)
  - Comprehensive solutions (e.g. total water budget, not just stormwater)
- Other
  - Greenroofs intercept & store more rainwater than trees, per unit area
  - Trees provide their most benefit over impervious
  - Increasing tree box size significant benefit because reducing impervious cover

Findings– Trees, Discharge Volume

AVERAGE YEAR POINT DISCHARGE VOLUME			
Scenario:	BASELINE	Intensive Greening	Moderate Greening
Year:	AVG (1990)	AVG (1990)	AVG (1990)
Units:	MG	MG (% reduction)	MG (% reduction)
Anacostia	5,327	5,221 (2.0% reduction)	5,288 (0.7% reduction)
Potomac	3,804	3,741 (1.7% reduction)	3,778 (0.7% reduction)
Rock Creek	1,915	1,891 (1.3% reduction)	1,907 (0.4% reduction)
Total	11,046	10,853 (1.8% reduction)	10,973 (0.7% reduction)

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Findings– Trees, Cumulative Frequency

AVERAGE YEAR CUMULATIVE POINT DISCHARGE FREQUENCY			
Scenario:	BASELINE	Intensive Greening	Moderate Greening
Year:	AVG (1990)	AVG (1990)	AVG (1990)
Units:	No.	No. (% reduction)	No. (% reduction)
Anacostia	592	585 (1.2% reduction)	592 (0.0% reduction)
Potomac	391	388 (0.8% reduction)	389 (0.5% reduction)
Rock Creek	119	119 (0.0% reduction)	119 (0.0% reduction)
Total	1,102	1,092 (0.9% reduction)	1,100 (0.2% reduction)

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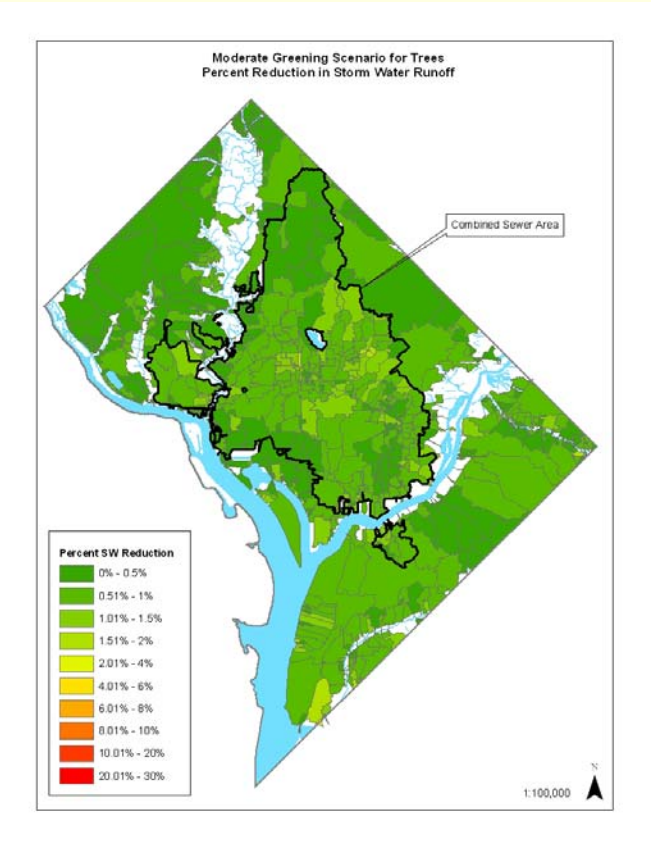
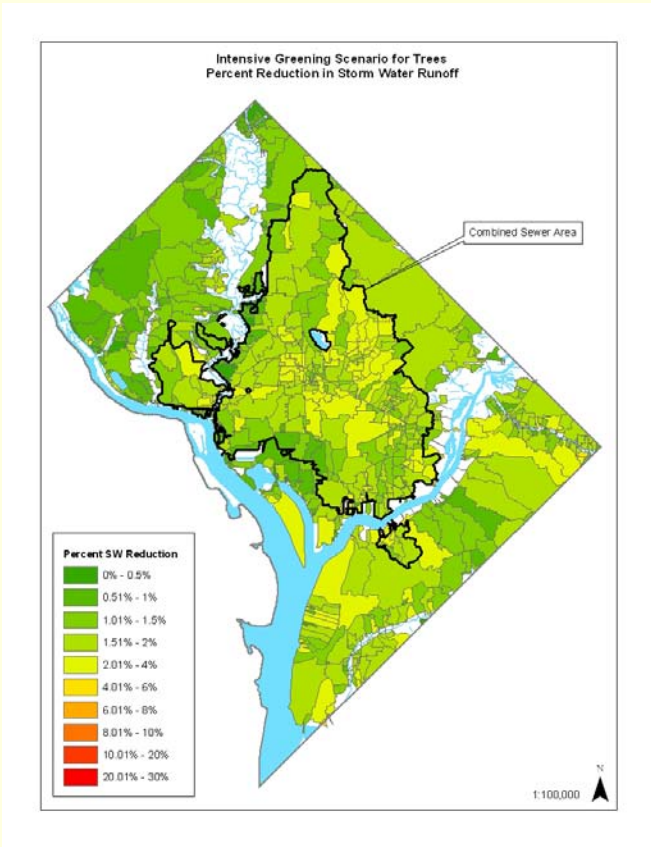
% Runoff Reduction: Trees





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Findings– Green Roofs Discharge Volume

AVERAGE YEAR POINT DISCHARGE VOLUME			
Scenario:	BASELINE	Intensive Greening	Moderate Greening
Year:	AVG (1990)	AVG (1990)	AVG (1990)
Units:	MG	MG (% reduction)	MG (% reduction)
Anacostia	5,327	4,886 (8.3% reduction)	5,232 (1.8% reduction)
Potomac	3,804	3,467 (8.9% reduction)	3,735 (1.8% reduction)
Rock Creek	1,915	1,811 (5.5% reduction)	1,894 (1.1% reduction)
Total	11,046	10,164 (8.0% reduction)	10,862 (1.7% reduction)

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Findings – Green Roofs Cumulative Frequency

AVERAGE YEAR CUMULATIVE POINT DISCHARGE FREQUENCY			
Scenario:	BASELINE	Intensive Greening	Moderate Greening
Year:	AVG (1990)	AVG (1990)	AVG (1990)
Units:	No.	No. (% reduction)	No. (% reduction)
Anacostia	592	547 (7.6% reduction)	583 (1.5% reduction)
Potomac	391	368 (5.9% reduction)	385 (1.5% reduction)
Rock Creek	119	113 (5.0% reduction)	118 (0.8% reduction)
Total	1,102	1,028 (6.7% reduction)	1,086 (1.5% reduction)

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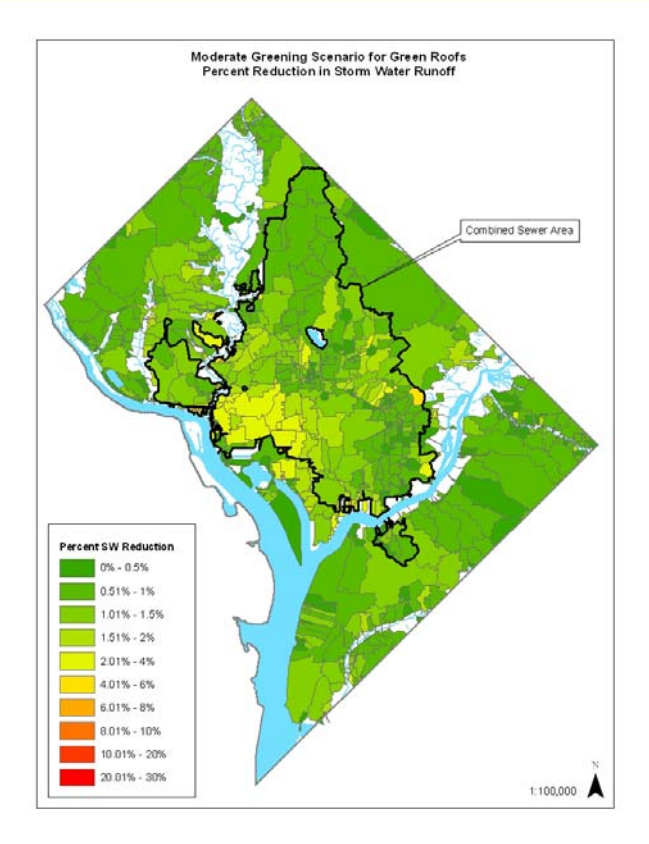
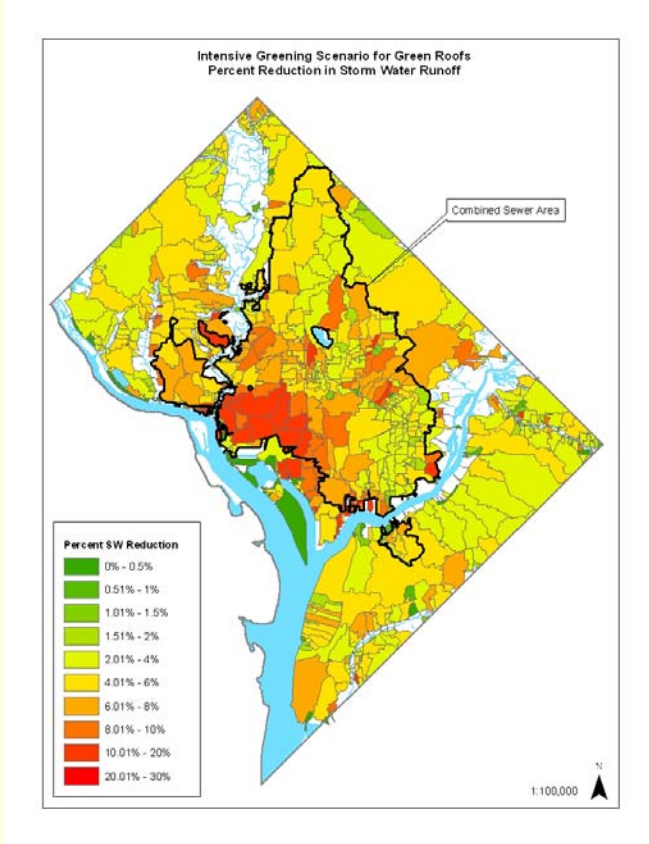
% Runoff Reduction: Green Roofs





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Findings – Treeboxes Downtown Character Area

AVERAGE YEAR RESULTS		
Scenario:	BASELINE	Moderate/Intensive
Year:	AVG (1990)	AVG (1990)
Total Point Discharge Volume	1,441 MG	1,418 MG (1.57% reduction)
Cumulative Point Discharge Frequency	205	203 (0.98% reduction)

Note: The downtown character area includes portions of CSO 010, 012, 019, 020, 034, and 035

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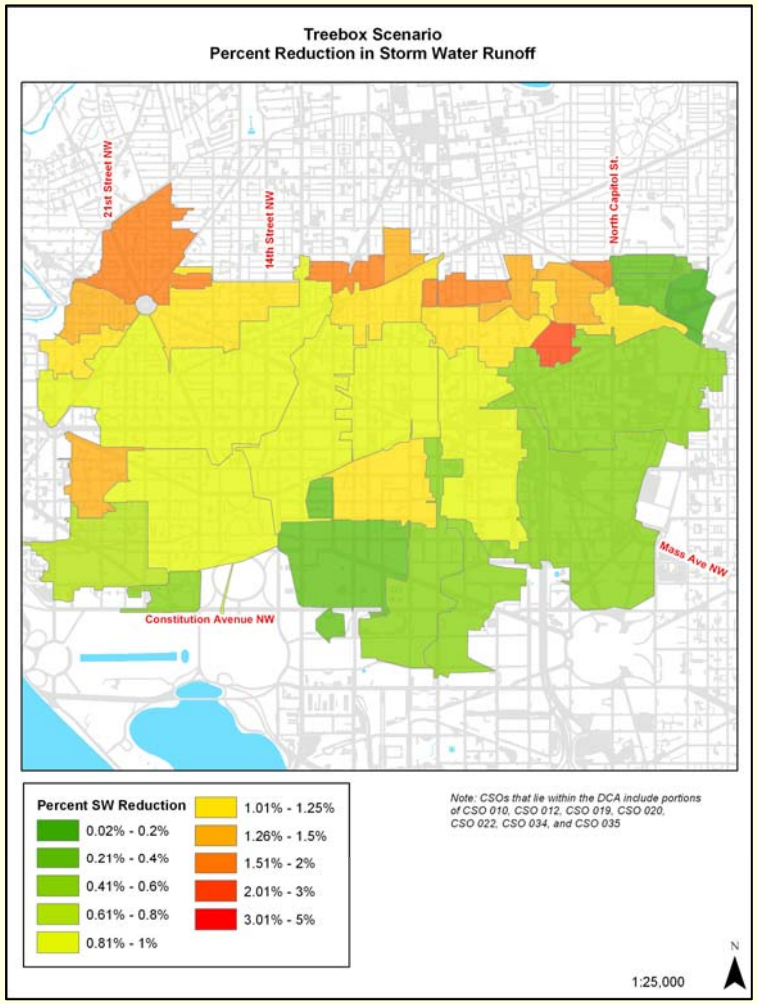
Percent Runoff Reduction - Treeboxes



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WASA Participation

- WASA was invited to participate in the Work Group; staff have attended all 3 sessions to date
- LimnoTech was a WASA subcontractor during the LTCP development process on modeling, and used WASA hydraulic model for this project
- WASA input:
  - This is an important study & will stimulate green technology implementation in DC
  - Impact on LTCP tunnel size probably would be minimum; but, volume reductions would be 'bonus' and save in pumping & treatment costs
  - Technologies such as tree boxes, if properly managed, would help with storm water NPDES permit compliance
  - Require regulatory agencies' approval as technologies sufficient to meet TMDLs and water quality standards.