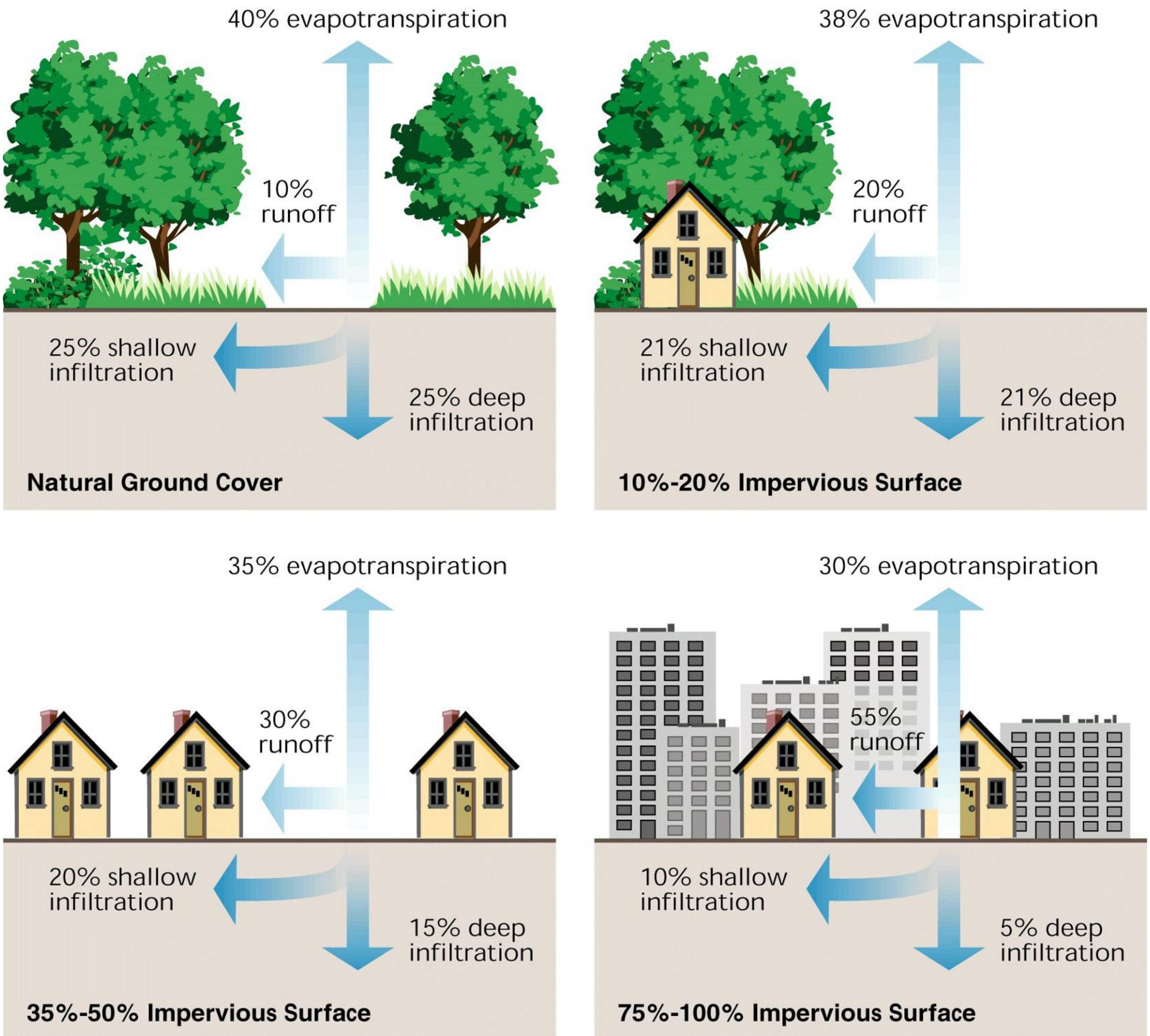
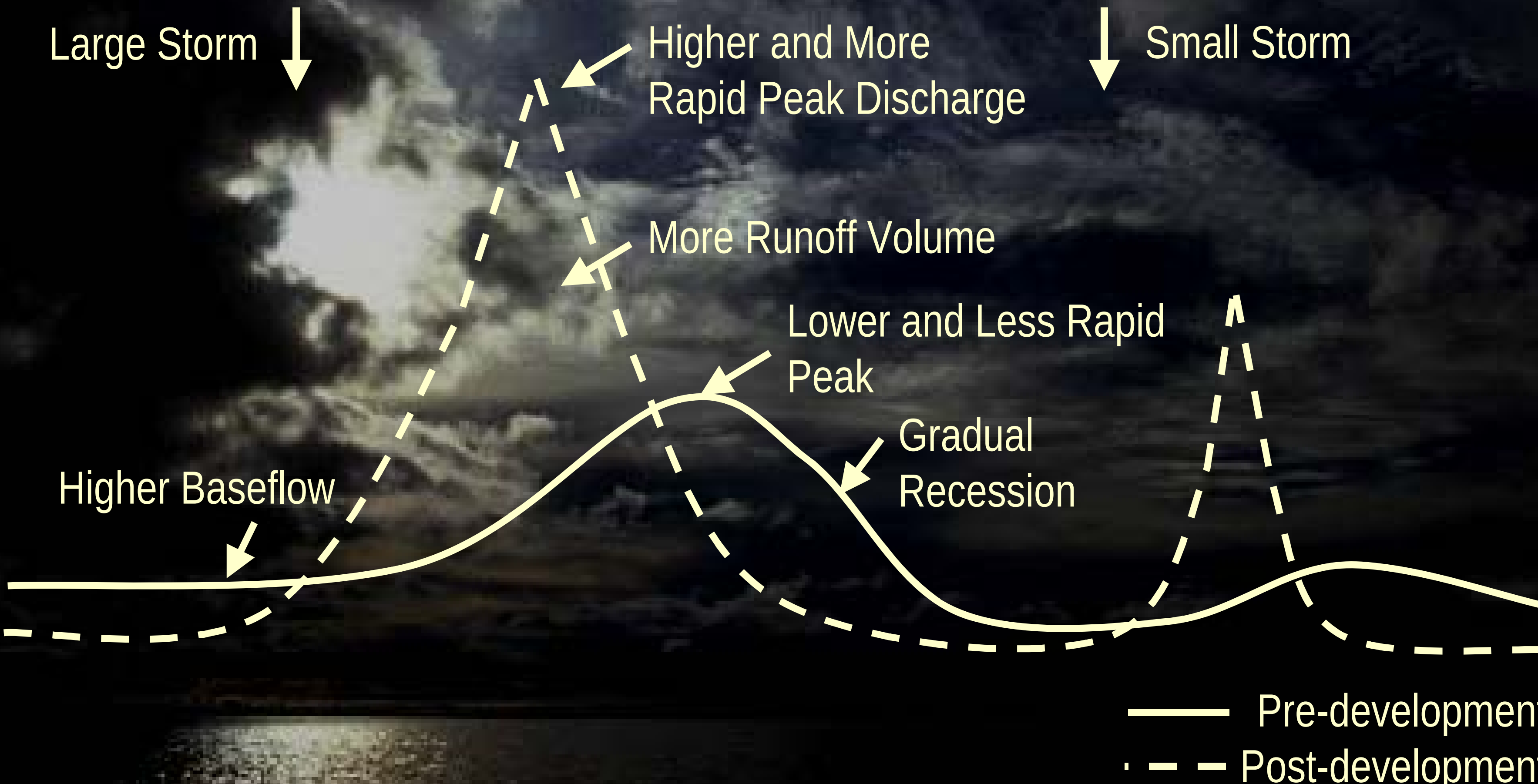




Managing Wet Weather with Green Infrastructure


40% evapotranspiration
10% runoff
25% shallow infiltration
25% deep infiltration
Natural Ground Cover
38% evapotranspiration
20% runoff
21% shallow infiltration
21% deep infiltration
10%-20% Impervious Surface
35% evapotranspiration
30% runoff
20% shallow infiltration
15% deep infiltration
35%-50% Impervious Surface
30% evapotranspiration
55% runoff
10% shallow infiltration
5% deep infiltration
75%-100% Impervious Surface

Consequences of Development to Urban Streams

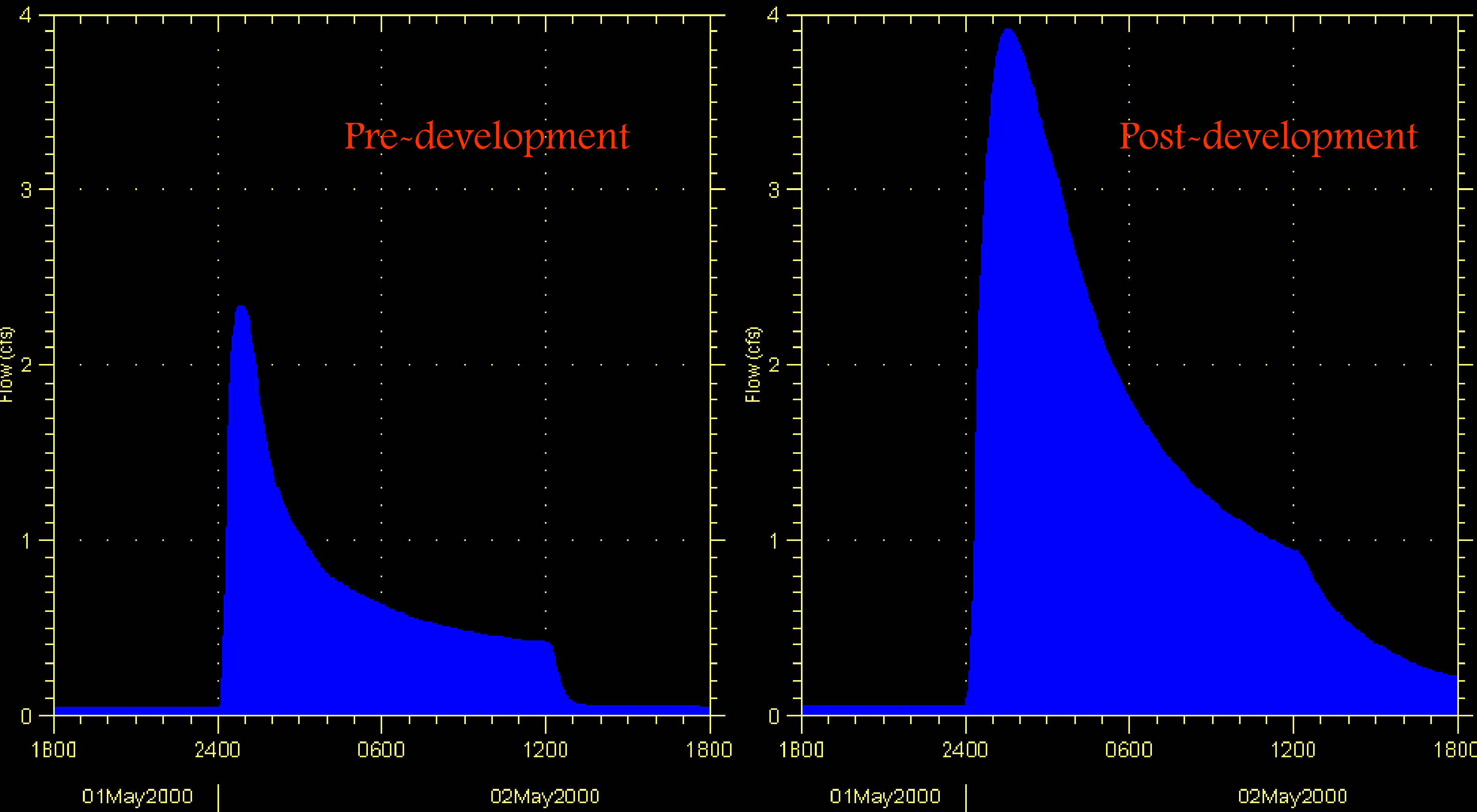


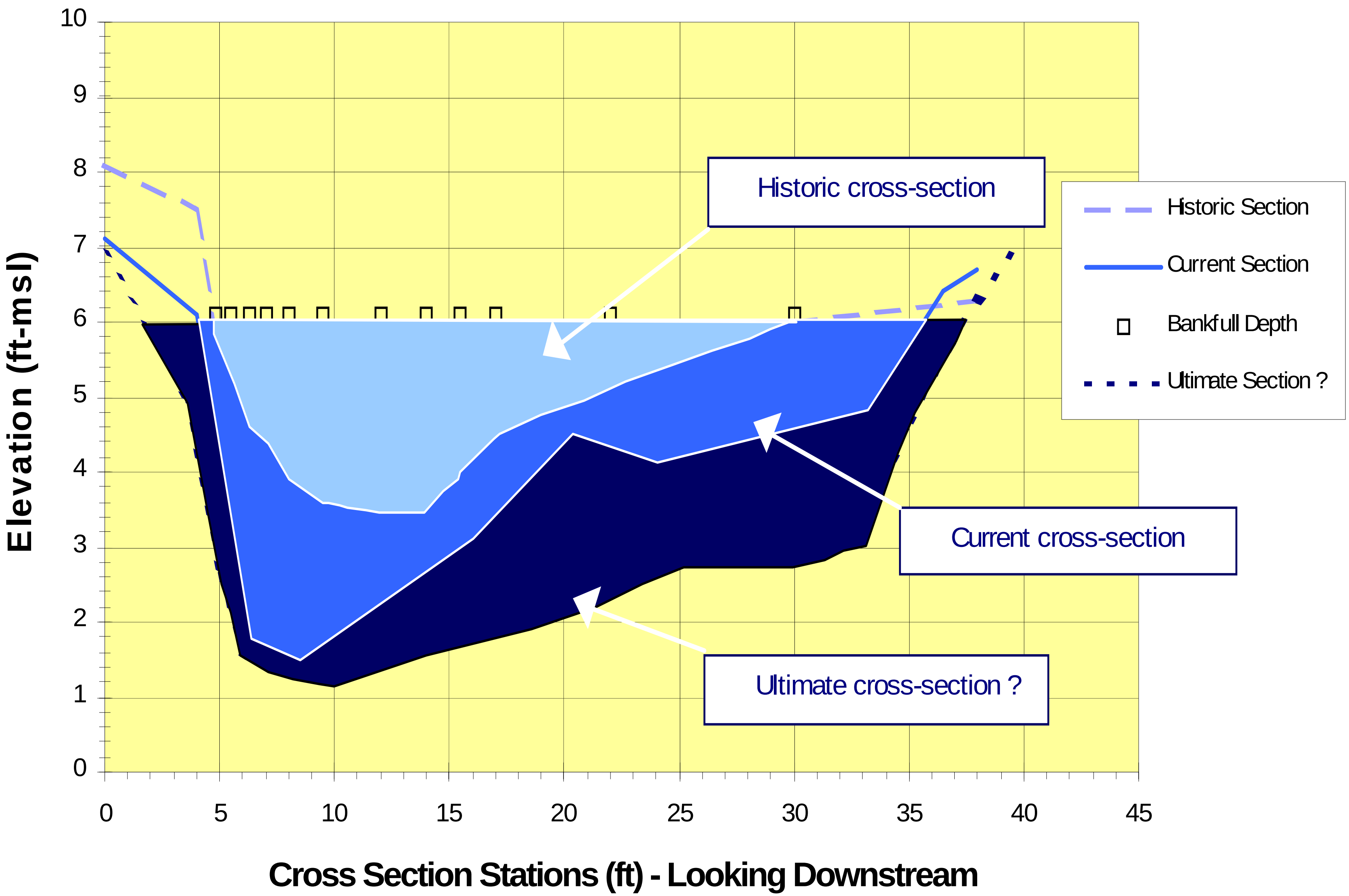
Blakeslee Creek, Michigan

70% increase in peak flow.

170% increase in runoff volume.

Former instantaneous peak flow now lasts ~4 hours.





Increased rates and volumes of storm water discharges lead to stream widening and down-cutting, or incision.

Era of the Big Basin

Stormwater management designs that manage only discharge rates often exacerbate the problem.

Natural systems respond to runoff volumes, frequencies, durations and temperatures as well.

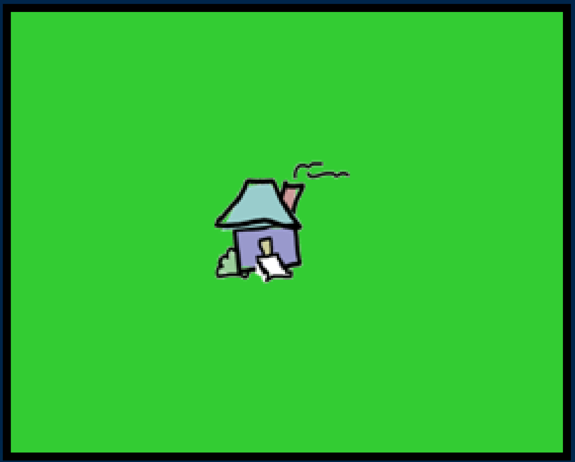
Scale is also Critical. Well designed sites in poorly planned communities generate more runoff.

Housing like this . . .

…is, by design, served by retail and roads like this

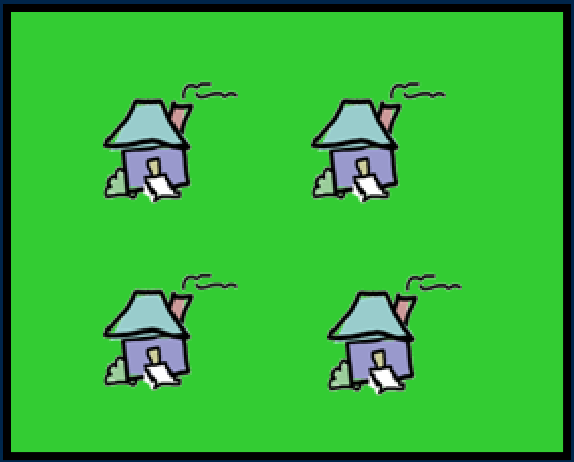
Development Density & Runoff

Scenario A:
1 unit/acre



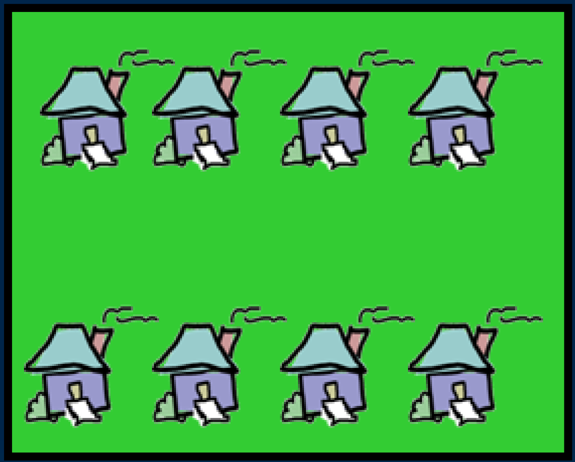
- Impervious cover = 20%
- Runoff/acre = 19,000 ft3/yr
- Runoff/unit = 19,000 ft3/yr

Scenario B:
4 units/acre



- Impervious cover = 38%
- Runoff/acre = 25,000 ft3/yr
- Runoff/unit = 6,000 ft3/yr

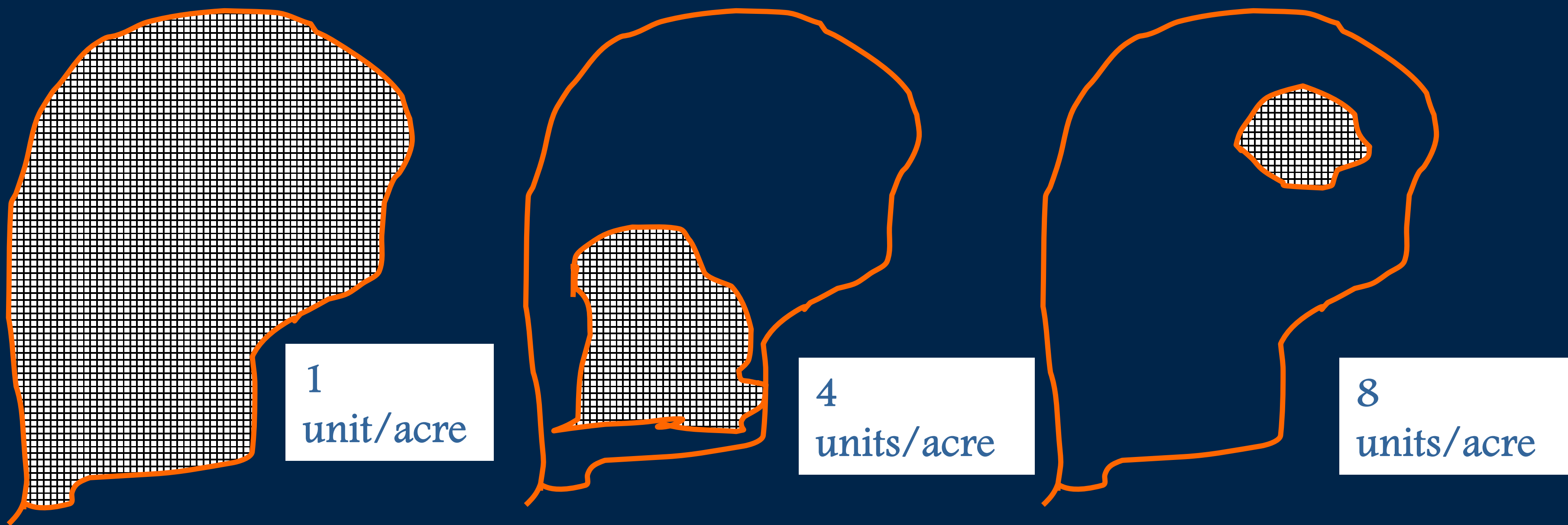
Scenario C:
8 units/acre



- Impervious cover = 65%
- Runoff/acre = 40,000 ft3/yr
- Runoff/unit = 5,000 ft3/yr

Watershed Scale

Accommodating 10,000 units on a 10,000 acre watershed at different densities



10,000 houses on 10,000 acres produce 187 million ft3 /yr stormwater runoff	10,000 houses on 2,500 acres produce 62 million ft3 /yr stormwater runoff	10,000 houses on 1,250 acres produce 49.5 million ft3 /yr stormwater runoff
Site: 20% impervious Watershed: 20% impervious	Site: 38% impervious Watershed: 9.5% impervious	Site: 65% impervious Watershed: 8.1% impervious

The lower density scenario creates more run-off and consumes 2/3 more land than the higher density scenario

What needs to change?

Paradigm Shift:
<u>Rain is a Resource, Not a Waste</u>

- Drinking water
- Ground water recharge
- Stream baseflow
- Trees & other plants
- Aesthetic qualities






Paradigm Shift:
Get away from the curb and gutter, big basin approach

- Shift from the concept of moving stormwater as far away as quickly as possible in large, buried collection and conveyance systems.

↓

- Shift towards the concept of managing stormwater the way mother nature would do it: where it falls; plants & soils.

Paradigm Shift:
Trifocal Approach to Stormwater Management

Region or Watershed

Neighborhood

Site

Approaches to Flow Management

- Good Site Design
- Good Neighborhood and Community Design
- Water Conservation & Reuse

Infiltration ~ Evapotranspiration ~ Capture & Use

Green Infrastructure

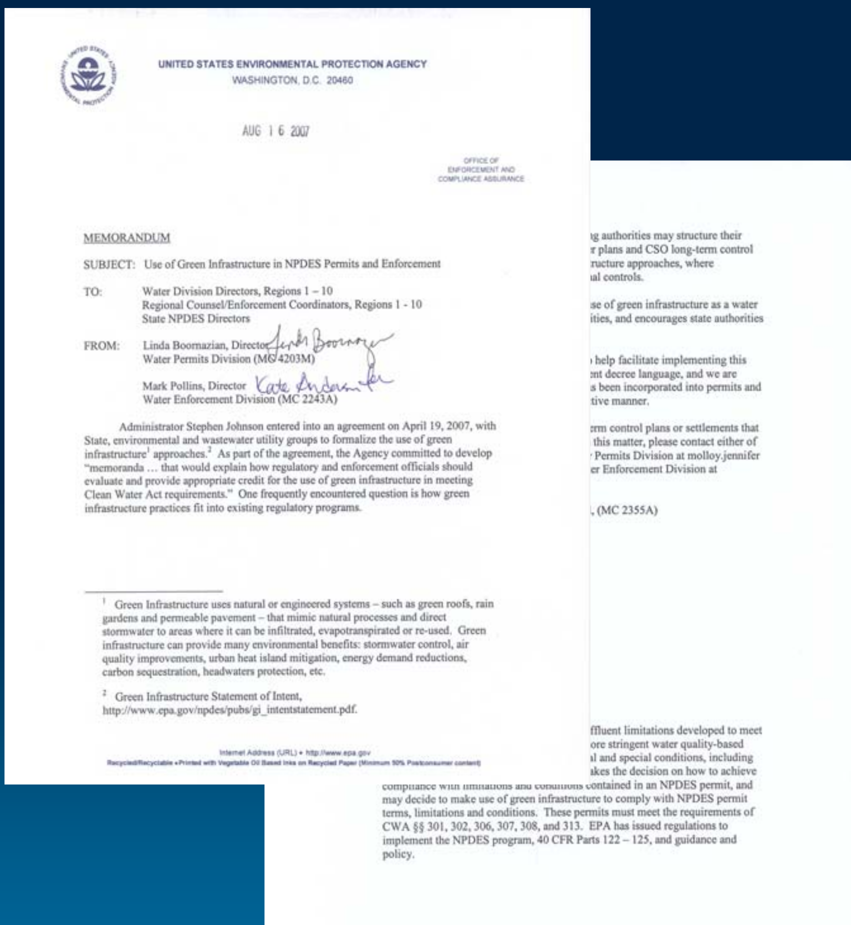
- Green infrastructure uses vegetation and soils in urban and suburban areas to manage and treat precipitation naturally rather than collecting it in pipes.
- It preserves natural systems and uses engineered systems such as green roofs, rain gardens, and vegetated swales to mimic natural functions.
- Green infrastructure includes approaches that capture and re-use stormwater.

Green Infrastructure Approaches

- Amended soils
- Impervious cover removal
- Bioretention
- Permeable pavements
- Green roofs
- Cisterns & rain barrels
- Trees & expanded tree boxes
- Reforestation & restoration
- Redevelopment
- Infill development
- Alternative parking & street designs
- Water Conservation

Federal Regulatory Context for Green Infrastructure

Use of Green Infrastructure in NPDES Permits and Enforcement



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

AUG 1 6 2007

OFFICE OF
ENFORCEMENT AND
COMPLIANCE ASSURANCE

MEMORANDUM

SUBJECT: Use of Green Infrastructure in NPDES Permits and Enforcement

TO: Water Division Directors, Regions 1 – 10
Regional Counsel/Enforcement Coordinators, Regions 1 - 10
State NPDES Directors

FROM: Linda Boornazian, Director
Water Permits Division (MC 4203M)

Mark Pollins, Director
Water Enforcement Division (MC 2243A)

Administrator Stephen Johnson entered into an agreement on April 19, 2007, with State, environmental and wastewater utility groups to formalize the use of green infrastructure[1] approaches.[2] As part of the agreement, the Agency committed to develop "memoranda … that would explain how regulatory and enforcement officials should evaluate and provide appropriate credit for the use of green infrastructure in meeting Clean Water Act requirements." One frequently encountered question is how green infrastructure practices fit into existing regulatory programs.

[1] Green Infrastructure uses natural or engineered systems – such as green roofs, rain gardens and permeable pavement – that mimic natural processes and direct stormwater to areas where it can be infiltrated, evapotranspirated or re-used. Green infrastructure can provide many environmental benefits: stormwater control, air quality improvements, urban heat island mitigation, energy demand reductions, carbon sequestration, headwaters protection, etc.

[2] Green Infrastructure Statement of Intent, http://www.epa.gov/npdes/pubs/gi_intentstatement.pdf.

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g authorities may structure their
r plans and CSO long-term control
ructure approaches, where
al controls.

se of green infrastructure as a water
ities, and encourages state authorities

help facilitate implementing this
nt decree language, and we are
s been incorporated into permits and
tive manner.

rm control plans or settlements that
this matter, please contact either of
Permits Division at molloy.jennifer
er Enforcement Division at

, (MC 2355A)

ffluent limitations developed to meet
ore stringent water quality-based
l and special conditions, including
akes the decision on how to achieve
compliance with limitations and conditions contained in an NPDES permit, and may decide to make use of green infrastructure to comply with NPDES permit terms, limitations and conditions. These permits must meet the requirements of CWA §§ 301, 302, 306, 307, 308, and 313. EPA has issued regulations to implement the NPDES program, 40 CFR Parts 122 – 125, and guidance and policy.

- Memo issued August 16, 2007 by EPA
- Clarifies that green infrastructure controls can be implemented within current regulatory framework

West Virginia Proposed MS4 Permit

- Site performance standards for all new and redevelopment that require, in combination or alone, management measures that infiltrate, evapotranspire and reuse of, at a minimum, the first 1 inch of rainfall from a 24-hour storm preceded by 48 hours of no measurable precipitation.
- Also, incentives for redevelopment, high density development, etc.

Draft Ventura County MS4 Permit

- 1. Integrated Water Quality/ Flow Reduction/ Resources Management Criterion

  (a) Permittees shall require that all New Development and Redevelopment projects identified in subpart 5.E.II control pollutants, pollutant loads, and runoff volume emanating from impervious surfaces through percolation, infiltration, storage, or evapotranspiration, by reducing the percentage of Effective Impervious Area to less than 5 percent of total project area

Ohio Big Darby Watershed Construction Stormwater Permit

- Groundwater Recharge Requirements: post-development groundwater recharge equals or exceeds the pre-development groundwater recharge.
- Protection (i.e., preservation) of open space (infiltration areas) shall be by binding conservation easements that identify a third party management agency, such as a homeowners association, political jurisdiction or third party land trust.

New Jersey Stormwater Rules

Any development project that disturbs at least 1 acre of land or creates at least 0.25 acres of new or additional impervious surface must comply with one of the following two groundwater recharge requirements:

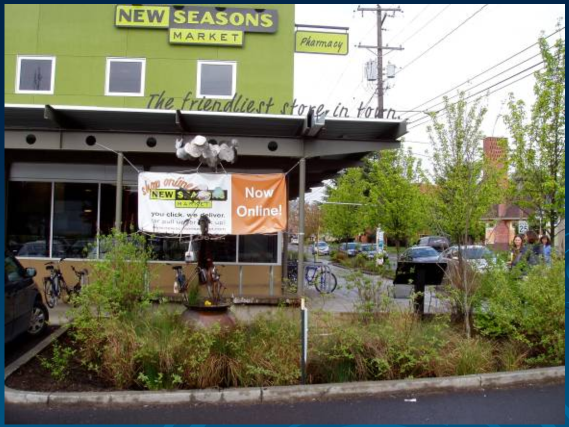
- *Demonstrate through hydrologic and hydraulic analysis that the site and its stormwater management measures maintain 100 percent of the average annual preconstruction groundwater recharge volume for the site; or*
- *Demonstrate through hydrologic and hydraulic analysis that the increase of stormwater runoff volume from pre-construction to post-construction for the two year storm is infiltrated.*

Energy Independence and Security Act of 2007

“**Sec. 438. Storm Water Runoff Requirements for Federal Development Projects.** The sponsor of any development or redevelopment project involving a Federal facility with a footprint that exceeds 5,000 square feet shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow.”

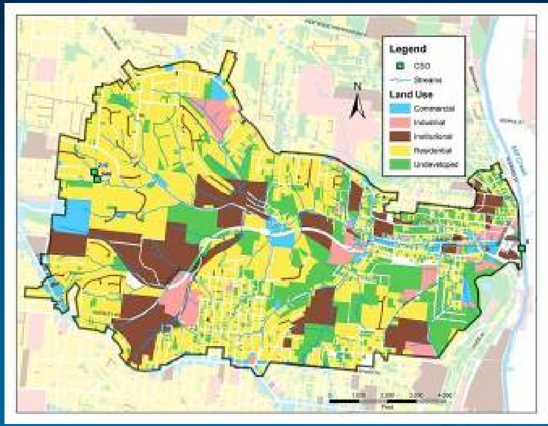
Common Elements of a Wet Weather Management Plan

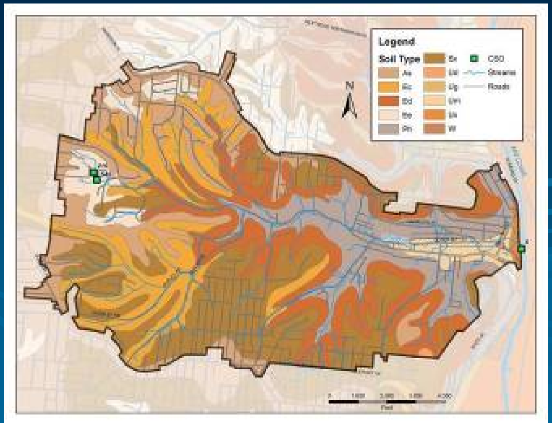
- Initial Analysis of Reduction Potential
- Implementation Tasks and Activities
- Appropriate Schedules
- Metrics & Evaluation
- Reporting
- Enforceable Mechanisms for Operation & Maintenance
- Plan for Adjustments



Analysis: Establishing a Green Infrastructure Implementation Target

- *STEP 1:* Detailed characterization of existing land use/land cover & hydrology/hydraulics.
- *STEP 2:* Determine pervious areas, roof surfaces, directly connected impervious road surfaces, parking areas, and general land use.





Analysis: Establishing a Green Infrastructure Implementation Target

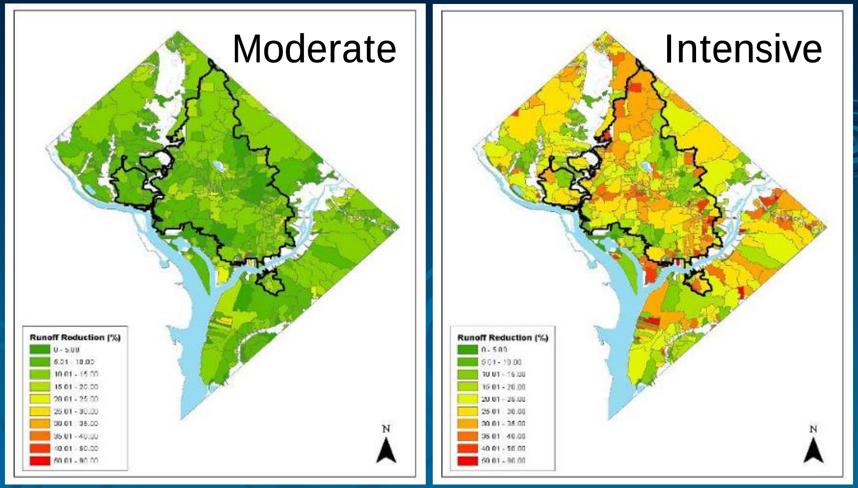
- *STEP 3:* Identify green infrastructure opportunities.
- *STEP 4:* Estimate the approximate benefits associated with installation of various G.I. measures.
  - Estimated reductions in annual peak runoff flows and pollutant loads.
- *STEP 5:* Extrapolate across the Service Area.
- *STEP 6:* Evaluate the effects of green and grey infrastructure together in terms of meeting WQS and other objectives.

Quantifying the Degree of Green Infrastructure Implementation

- Number / Magnitude of BMPs
- BMP Capture Analysis
  - Spreadsheets / Calculators
- Modeling to Project Reductions in CSO Events / Volumes

Example Analysis: Green Build-Out Model Washington, D.C.

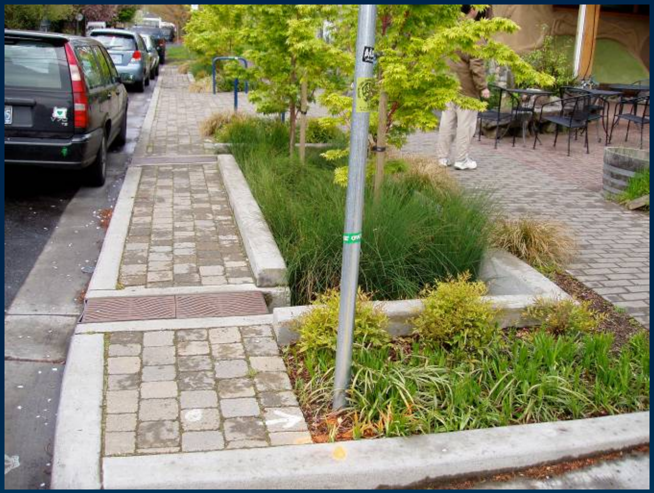
- With the intensive greening scenario, installing 55 million sq. ft. of green roofs in the CSS area would reduce CSO discharges by 435 million gallons or 19% each year
- WASA could potentially realize between $1.4 and $5.1 million/year in operational savings in the CSS area due to reduced pumping and treatment costs



Implementation Tasks & Activities

Types of Elements, with Appropriate Schedules:

- Adoption of (performance) standards
- Ordinances review and revisions
- New & redevelopment targets
- Retrofit targets
- Establishment of site plan reviews, inspection procedures, tracking systems, O&M protocols



Example Performance Standard: Washington, DC Anacostia River Redevelopment

- Stormwater standard requires on-site retention of the first inch of rainfall for new development and re-development and water quality treatment for up to the two-year storm volume.
- Option for offsets if on-site control is not possible.
- Stated preference for vegetated controls.

Example Performance Standard: Philadelphia, PA First Inch Capture

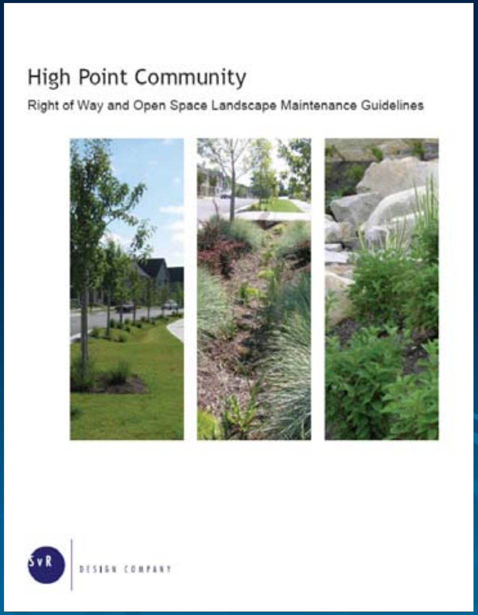
	2006		20 years
Re-development Rate (1 mi^2/ yr)	1 mi^2		20 mi^2
Captured Runoff (per 1" event)	17 MG		340 MG
Avoided Tank Costs (@ $2/gal)	$34 M		$680 M

Metrics & Evaluation

- Number of projects implemented, with estimates of volume of wet weather removed from or kept out of the system
- Discharge reduction, e.g., number or volume of discharges (CSOs)
- Flow reduction end-of-pipe
- Receiving water indicators of system integrity, e.g., wqs, biotic, geomorphologic

Mechanisms for Operation and Maintenance

- For control measures on private property ensure appropriate mechanisms are in place, e.g., agreements, ordinances, inspections, enforcement procedures.
- Standard operating procedures for maintenance of control measures in public rights-of-way are also critical.



Plan for Adjustments

- Through evaluation we will learn a great deal about green infrastructure implementation and effectiveness
- We can end up with a clear, solid green infrastructure implementation target, but provide for opportunities to fine-tune approaches in terms of exactly how the target is met
- Include milestones for checking progress against targets, and plans for how controls will be adjusted based on results of evaluations.