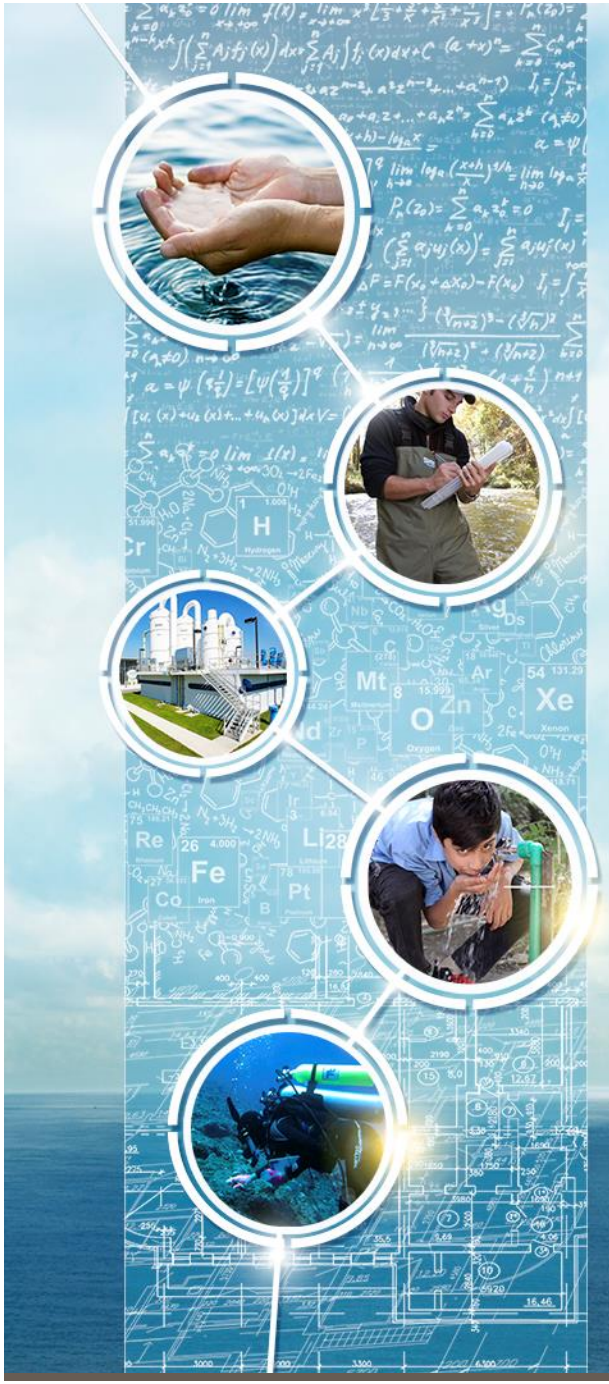

TETRA TECH

# Western Michigan Green Infrastructure Conference

## Green Infrastructure: How did we get here?

## The Past, Present and Future of Green Infrastructure

August 5, 2015

John Kosco, P.E., CPESC
Tetra Tech, Inc.
Fairfax, VA

# What is Green Infrastructure?

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- Green infrastructure uses vegetation, soils, and natural processes to manage water and create healthier urban environments.
- At the *scale of a city or county*, green infrastructure refers to the patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water.
- At the *scale of a neighborhood or site*, green infrastructure refers to stormwater management systems that mimic nature by soaking up and storing water.

Source: http://water.epa.gov/infrastructure/greeninfrastructure/gi_what.cfm

# In other words…

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## How do we make this…

## function more like this?

# Green Infrastructure includes many different types of practices

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Green Roofs

Rain Barrels and Cisterns

Bioswales

Green Space

Permeable Pavements

Trees

Photos: M. Frey

# Related Strategies

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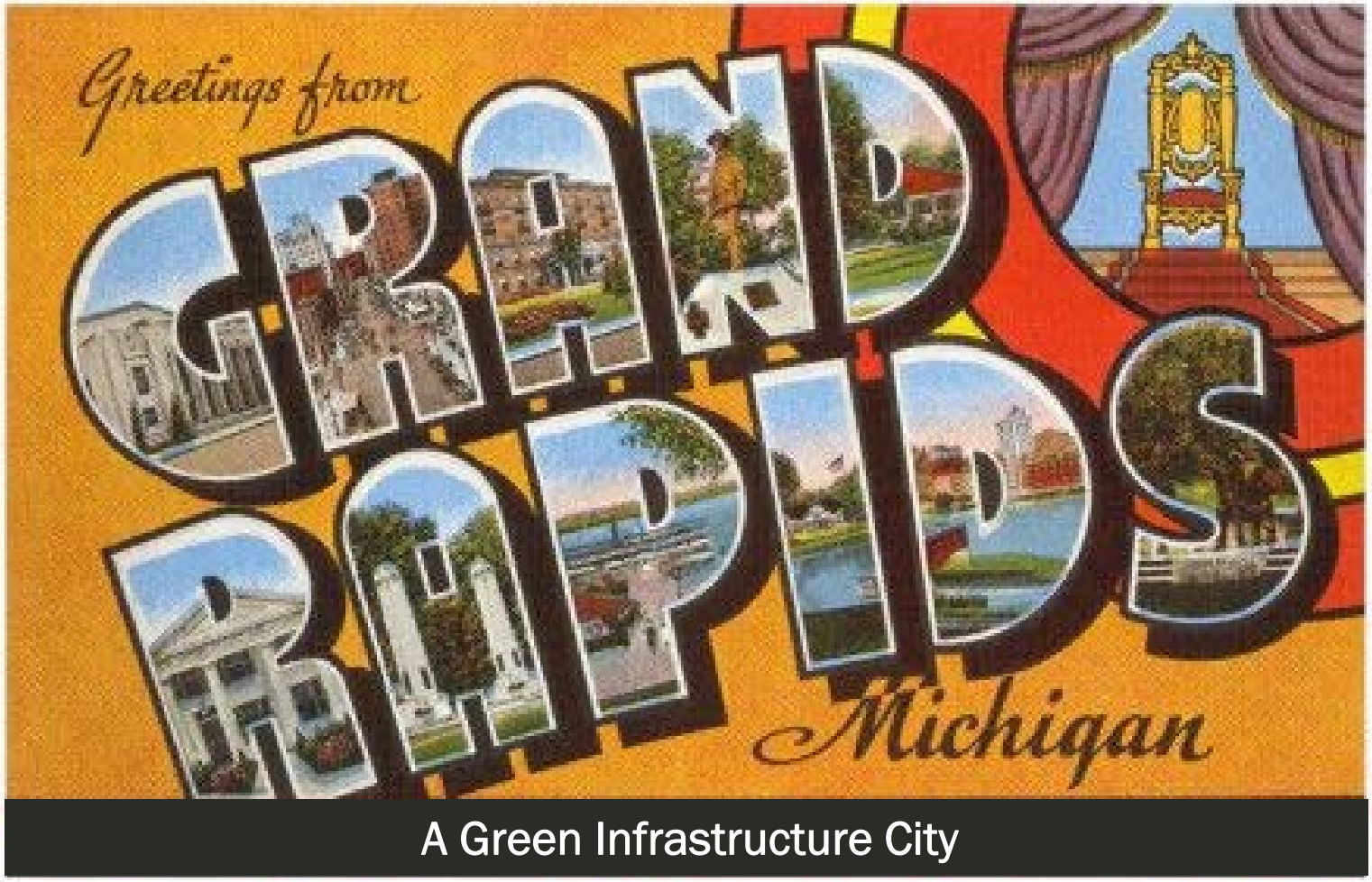
- *Smart Growth – Development that attempts to curb urban sprawl and worsening environmental conditions.*

- *Low Impact Development (LID) – Approach that manages rainfall at the source using uniformly distributed decentralized micro-scale controls*

- *Green Streets – Integrating green techniques into urban transportation right-of-ways*




A Green Infrastructure City

# Green Infrastructure

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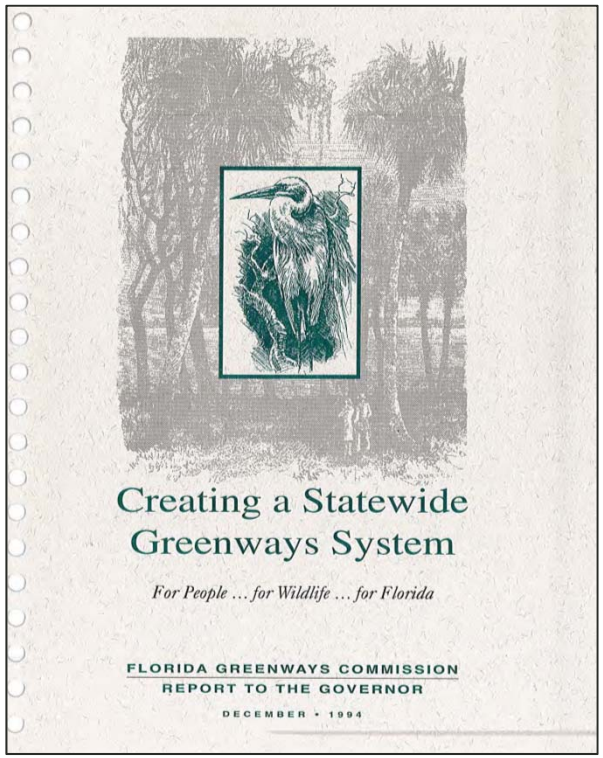
*The Past*

The Present

The Future

# First Use of "Green Infrastructure"

- 1994 Report to Florida's Governor
  - The Commission's recommendations constitute a balanced approach to conserving our state's natural, recreational, and cultural/historic resources through the creation of a statewide system of greenways. This approach links conservationists, recreationists, and businesses in their communities to protect Florida's "green infrastructure" for the state's sustainable future.




WEF. 2014. *Green Infrastructure Implementation*

http://www.dep.state.fl.us/gwt/fgts_plan/PDF/1994FloridaGreenwaysCommissionPlan.pdf

# Greenways

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- Greenway – a corridor of protected open space that is managed for conservation and/or recreation

- 1991 – Maryland Greenway Commission established
- 1993 – Florida Greenways Commission created
- Mid-1990's – Maryland's Green Infrastructure Assessment program to map and prioritize ecological land

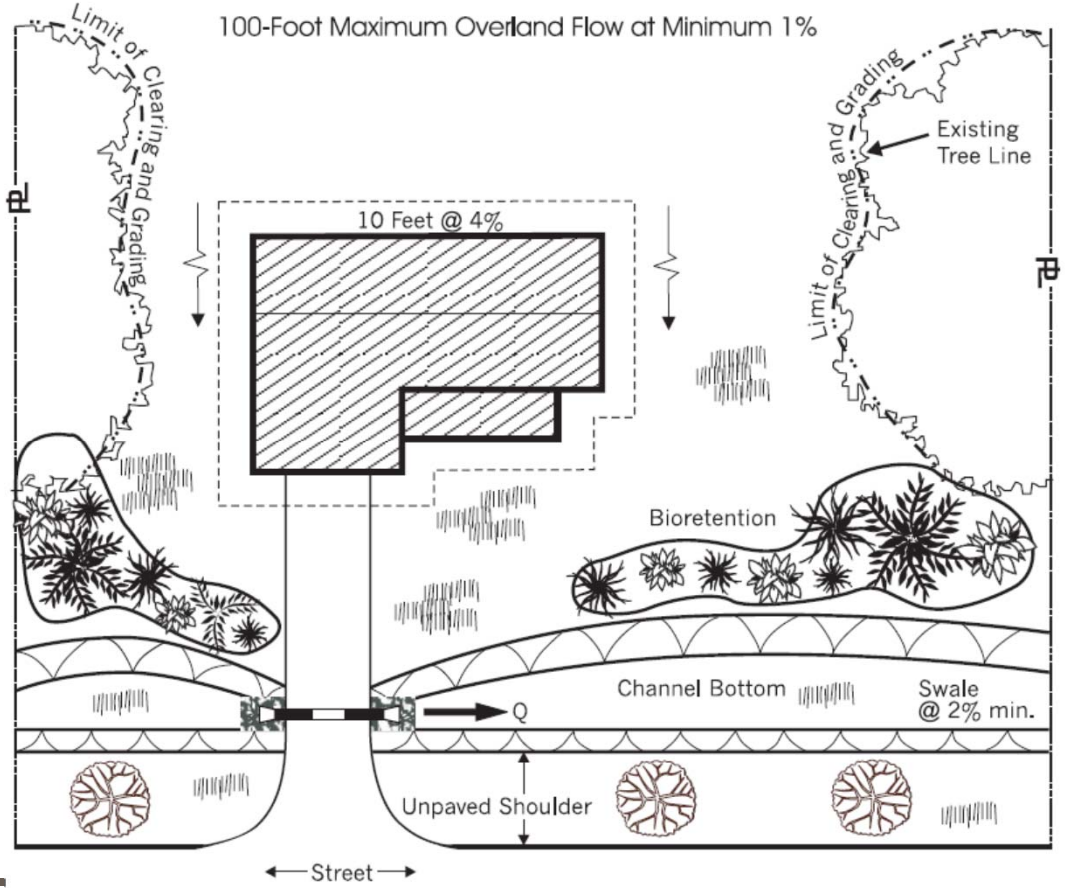
- Programs largely focused on land conservation and linking green spaces for habitat and biodiversity
  - Water quality was not a focus

# Low Impact Development

- 1990 – Prince George's County, Maryland pioneered concept of low impact development
- 1999 – LID Manuals published

Key concepts:

- Using hydrology as the integrating framework
- Thinking micromanagement
- Controlling stormwater at the source
- Remembering simple technologies
- Creating a Multifunctional Landscape and Infrastructure



# Linking Greenways and Low Impact Development

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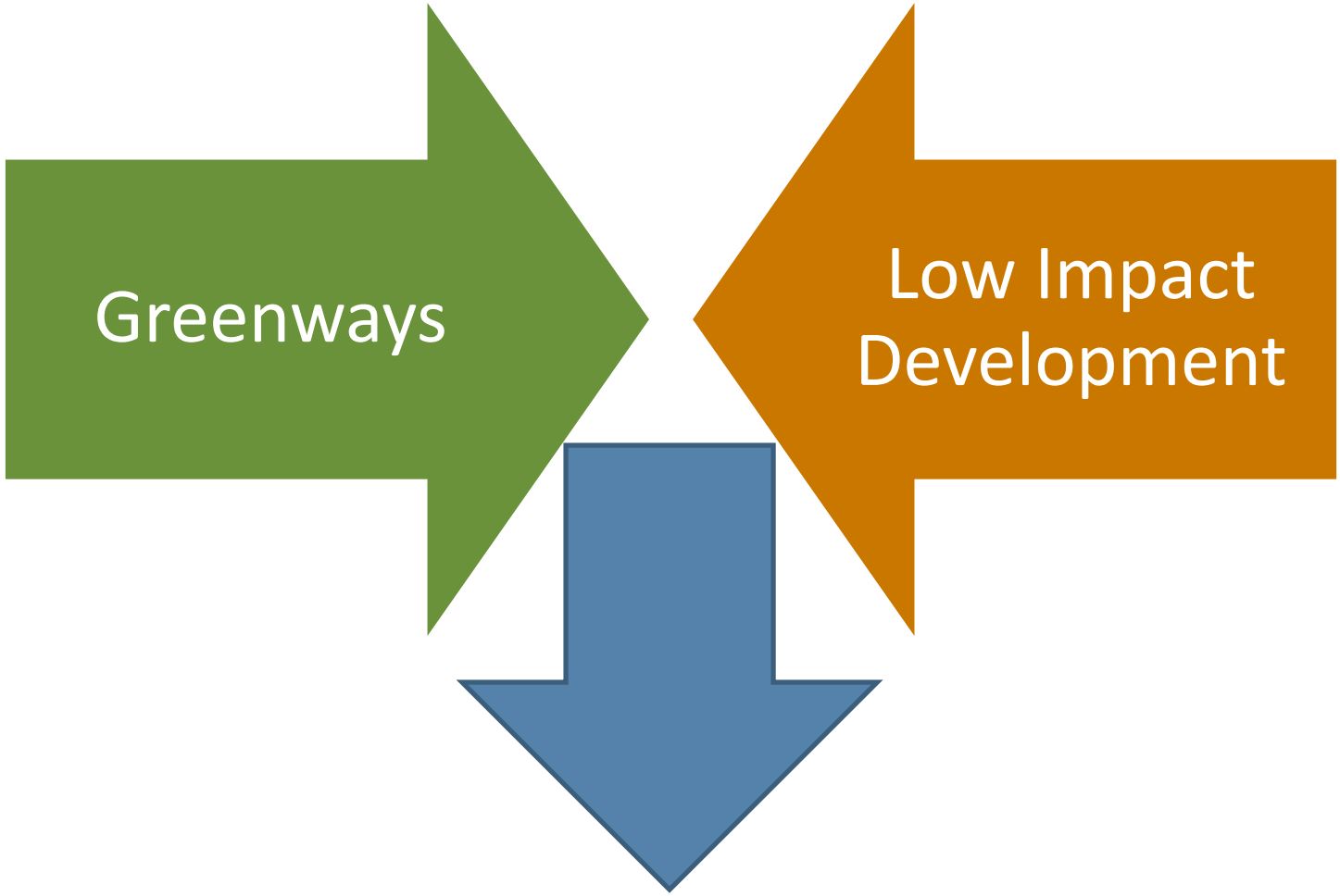

# 2006 NRDC Rooftop to Rivers Report

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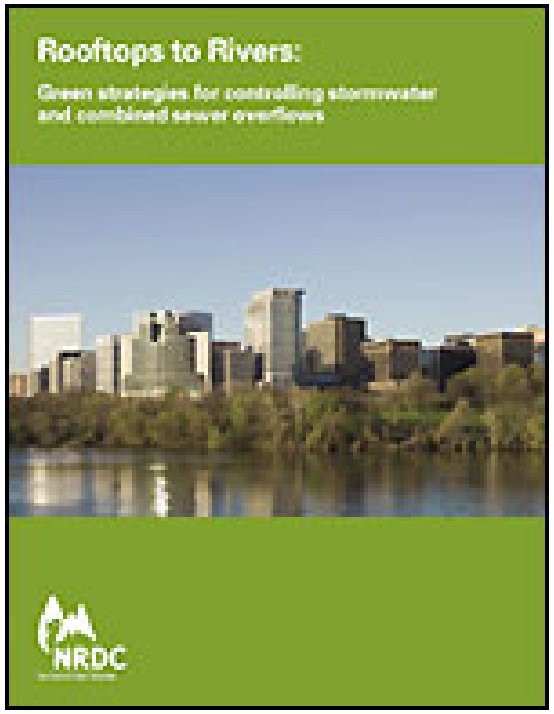
- Primary authors later joined EPA to lead the green infrastructure program
- Report strongly pushed implementation of green infrastructure by cities
- Documented water quality and economic benefits
- Case studies



# EPA Memos/Strategy on Green Infrastructure

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- March 2007 – Memo on Using Green Infrastructure to Protect Water Quality in Stormwater, CSO, Nonpoint Source and other Water Programs
- April 2007 – EPA Green Infrastructure Statement of Intent
  - Signed by EPA and NACWA, NRDC, LID Center, and ASIWPCA
  - Recognized value of and need to develop strategies to promote Green Infrastructure
- August 2007 – Memo on Use of Green Infrastructure in NPDES Permits and Enforcement
- July 2014 – Federal Agency Support for Green Infrastructure

# 2013 Green Infrastructure Strategic Agenda

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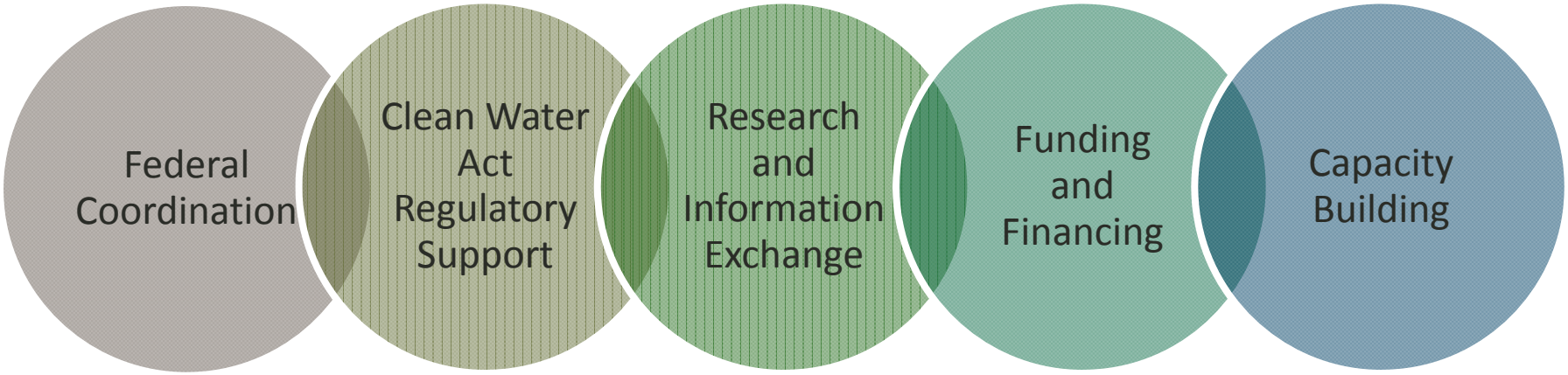
Five Focus Areas:



# Energy Independence and Security Act of 2007 (EISA Sec. 438)

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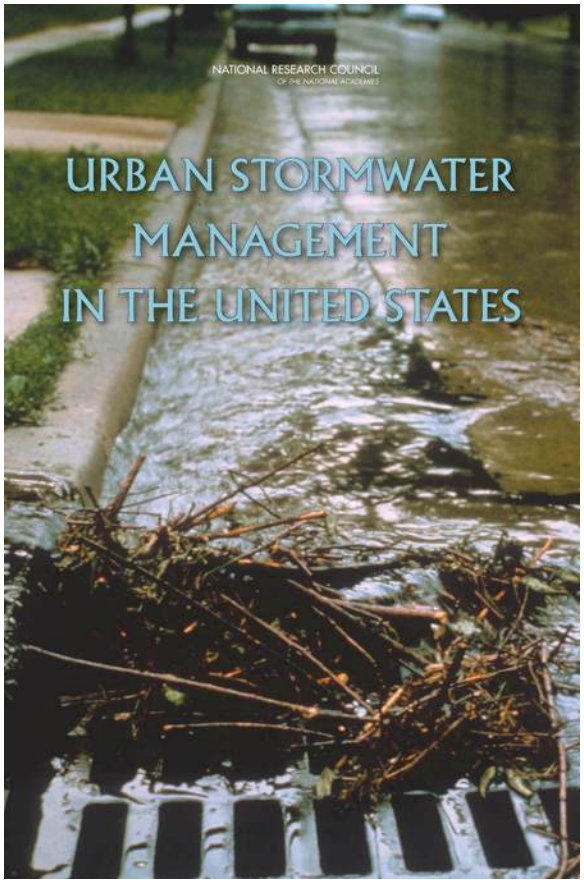
## Sec. 438. Storm Water Runoff Requirements for Federal Development Projects

- Development or redevelopment project involving a Federal facility with a footprint that exceeds 5,000 square feet
- Two options:
  - Option 1: Retain on-site the 95$^{th}$ percentile rainfall event
  - Option 2: Conduct an equivalent analysis of predevelopment hydrology

# NRC 2009 Study on Urban Stormwater

TETRA TECH

- EPA commissioned NRC to:
  - Review its current permitting program for stormwater discharge under the CWA
  - Provide suggestions for improvement



# 2009 NRC Study Findings

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- Current stormwater regulations largely ignore the volume of stormwater discharges
- Use measures that harvest, infiltrate, and evapotranspirate stormwater
- Use flow and impervious cover as proxies for stormwater pollutant loading.
- Move to a watershed-based permitting system

# EPA's Stormwater Rulemaking (2009-2013)

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- Large focus was on developing a national retention standard that would be applied through MS4 and/or construction NPDES permits
- Also looked at expanding MS4 permit coverage, retrofits, and modifying industrial stormwater program
- EPA is currently "deferring action on rulemaking"
- A rule was never proposed

- EPA now working to improve individual state stormwater permits and programs

# Green Infrastructure

TETRA TECH

The Past

*The Present*

The Future

# EPA moving toward specific, measurable MS4 permits

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- Washington, DC 2011 MS4 permit
  - On-site retention of 1.2 inch storm
  - Retrofit 18 million square feet of impervious surfaces during permit term
  - New annual tree planting rate of 4,150 plantings annually within the District MS4 area (to achieve urban tree canopy coverage of 40% by 2035).
- Middle Rio Grande 2014 MS4 permit (Albuquerque, NM)
  - On-site retention of 90th percentile storm for new development sites
  - On-site retention of 80th percentile storm for redevelopment sites

# Examples of specific, measurable small MS4 general permits from States

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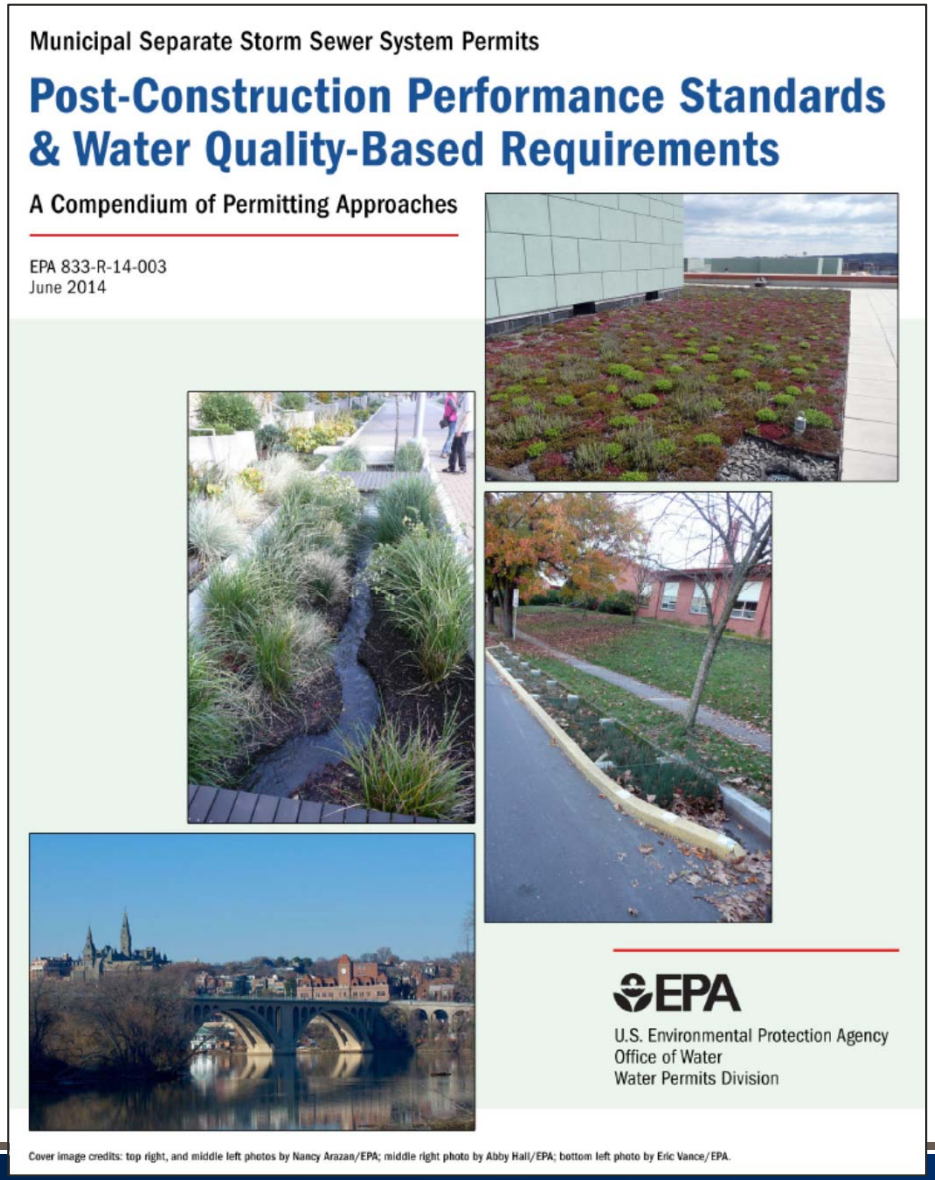
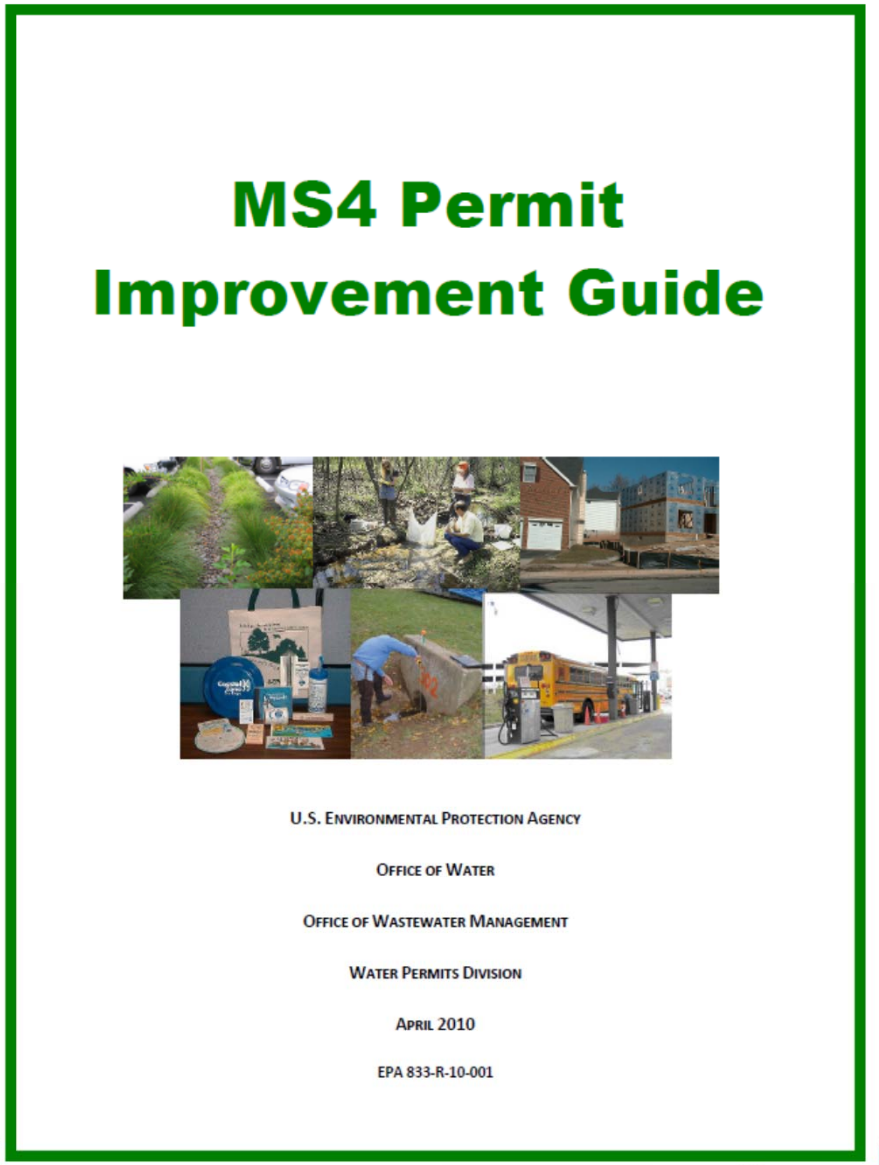
- Ohio small MS4 General Permit:
  - Public education program shall target at least five different stormwater themes or messages and shall reach at least 50 percent of your population over the permit term.
- Maine small MS4 General Permit:
  - Inspect construction activity at least three times with one inspection just prior to or within 24 hours of a rain event greater than 0.2 inches, and one inspection at project completion.
- Tennessee small MS4 General Permit
  - Must infiltrate, evapotranspire, harvest and/or use, at a minimum, the first inch of every runoff event… this first inch of runoff must be 100% managed with no stormwater runoff being discharged to surface waters.

# EPA Guidance to State MS4 Permit Writers

TETRA TECH

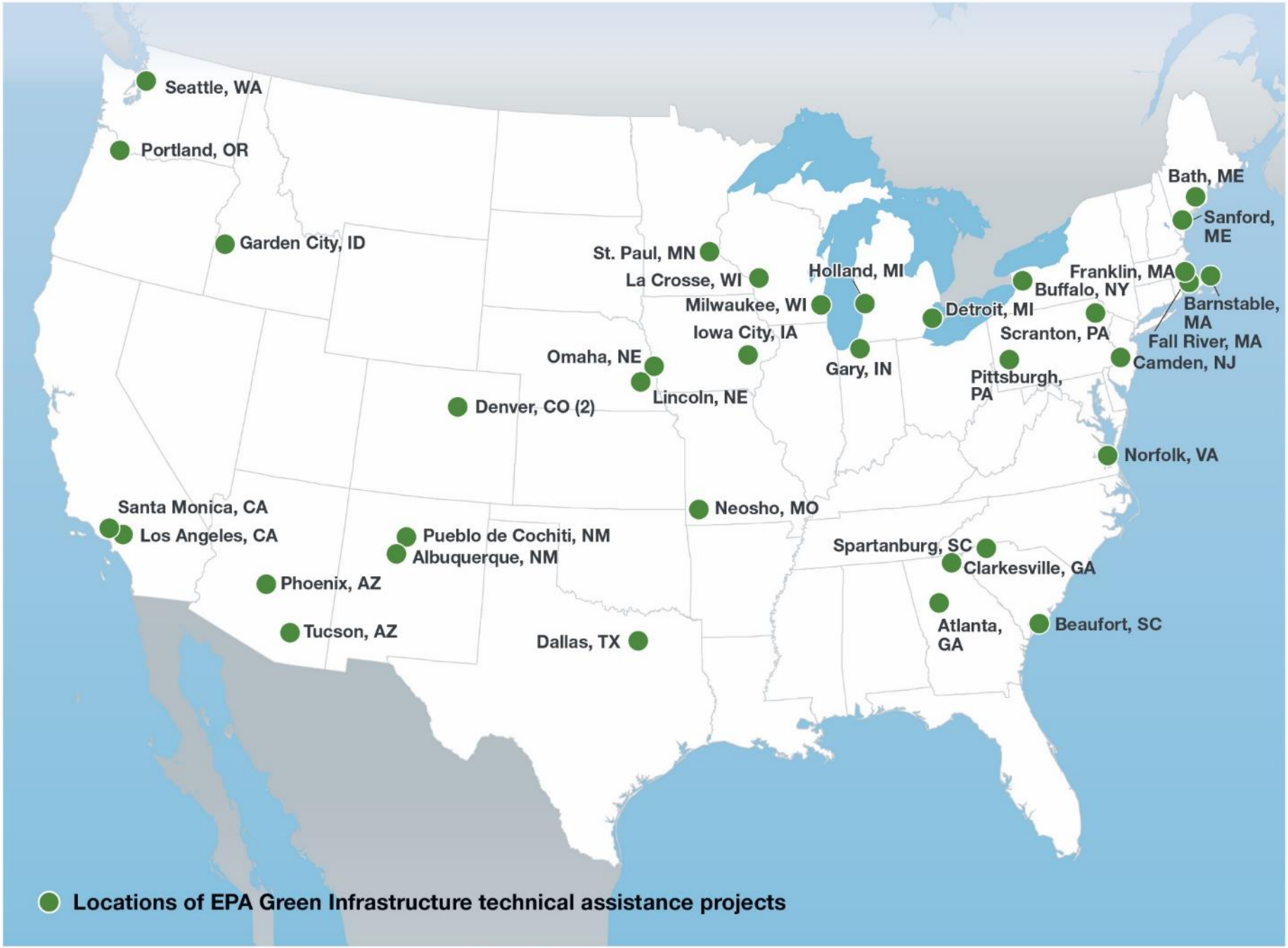


# EPA Green Infrastructure Technical Assistance Projects

TETRA TECH

- 37 projects from 2012-2014; ~$2.1M
- Creating green infrastructure conceptual designs
- Modeling the effects of green infrastructure
- Quantifying the benefits of green infrastructure
- Developing locally tailored technical guidance
- Exploring options for green infrastructure outreach
- Removing barriers in codes and ordinances
- Tackling institutional issues like financing and maintenance


Seattle, WA
Portland, OR
Garden City, ID
St. Paul, MN
La Crosse, WI
Milwaukee, WI
Holland, MI
Iowa City, IA
Omaha, NE
Lincoln, NE
Denver, CO (2)
Gary, IN
Detroit, MI
Buffalo, NY
Franklin, MA
Bath, ME
Sanford, ME
Barnstable, MA
Fall River, MA
Scranton, PA
Pittsburgh, PA
Camden, NJ
Norfolk, VA
Neosho, MO
Santa Monica, CA
Los Angeles, CA
Pueblo de Cochiti, NM
Albuquerque, NM
Phoenix, AZ
Tucson, AZ
Dallas, TX
Spartanburg, SC
Clarkesville, GA
Atlanta, GA
Beaufort, SC
Locations of EPA Green Infrastructure technical assistance projects

# Example Conceptual Design – Boise, ID

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# Code Review – Phoenix, AZ; Macatawa, MI

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**Degree of Importance Key to Symbols:**

- ● Essential
- ◑ Very important
- ○ Important
- NI Not important to the City of Phoenix

## GOAL #1: MINIMIZE EFFECTIVE OR CONNECTED IMPERVIOUS AREA

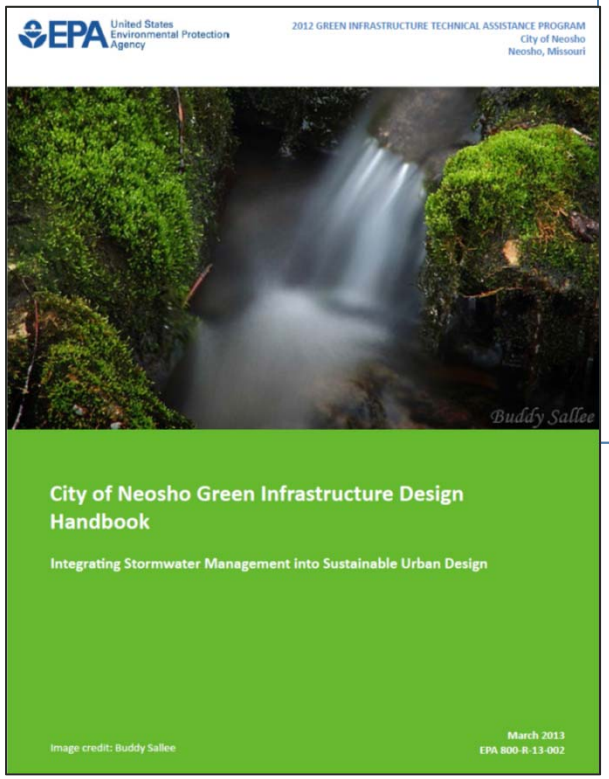
Objective: Minimize impervious area associated with streets.
Objective: Minimize impervious area associated with parking.
Objective: Minimize impervious area associated with driveways and sidewalks.
Objective: Clustering development.
Objective: Incorporate sustainable hydrology practices into urban redevelopment.

| GOAL #1 KEY QUESTIONS | DEGREE OF IMPORTANCE | COMMENTS (INDICATE ORDINANCE FINDINGS "YES" OR "NO". WHEN "NO", NOTE SPECIFIC LOCATION OF BARRIER IN CODE) |
|---|---|---|
| **Effective Impervious Area** | | |
| 1. Does the code distinguish between pervious paved areas and impervious paved areas in the determination of onsite stormwater requirements? | ◑ | Code Findings: No |
| 2. Does the code definition of impervious area distinguish between impervious area connected to the storm drain system (effective impervious area) and disconnected impervious area? | ◑ | Code Findings: Yes<br>City of Phoenix Stormwater Policies and Standards. 6.8.3. First Flush. Normally, the City's water quality treatment standard (first flush) minimum is met by following the City retention requirements to capture the 100-year, 2-hour storm. In the event there is a discharge into a structure owned or operated by the City, the applicant must also comply with the First Flush policy. |

# Other Technical Assistance Projects

TETRA TECH

- Fact sheets
  - Pittsburgh, PA Green Infrastructure barriers
- LID design guidance manuals
  - Camden, New Jersey
  - Neosho, Missouri
- Modeling
- Benefit analysis

# Technical Assistance to EPA's National Estuary Program

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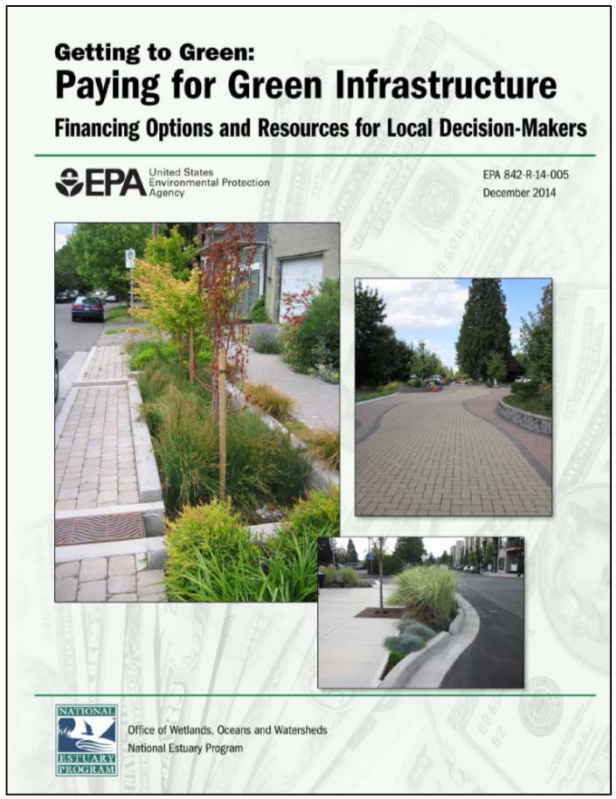


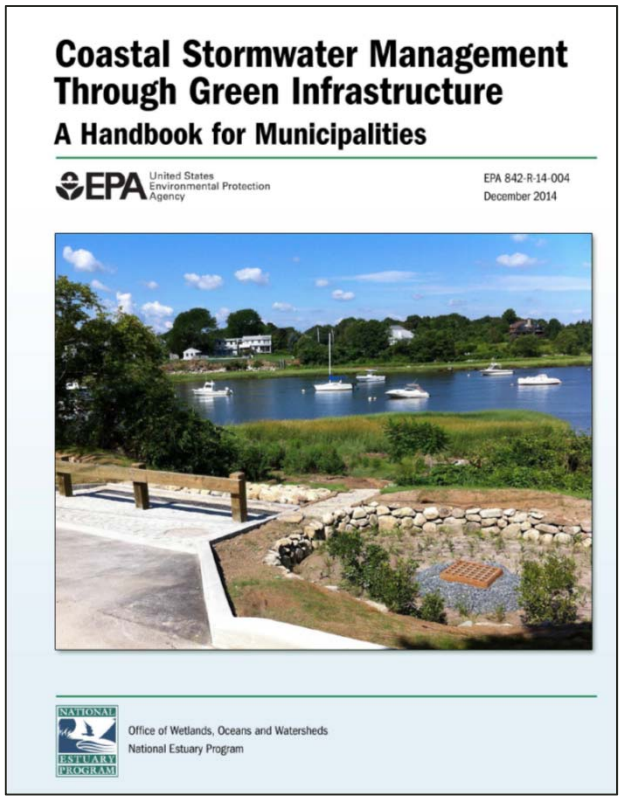


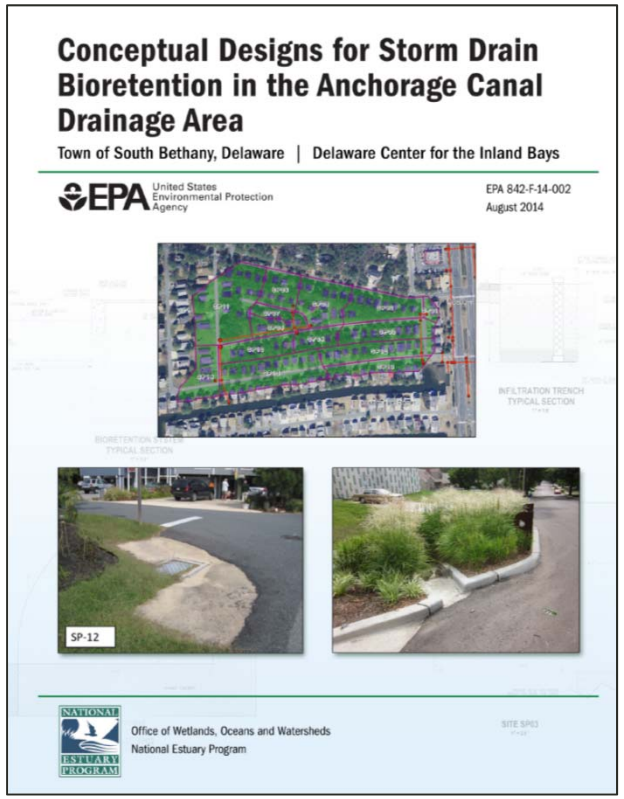


http://water.epa.gov/type/oceb/nep/resources.cfm

# Green Infrastructure Opportunities that Arise During Municipal Operations

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**Green Infrastructure Opportunities that Arise During Municipal Operations**

EPA United States Environmental Protection Agency

EPA 842-R-15-002

January 2015

NATIONAL ESTUARY PROGRAM

Office of Wetlands, Oceans and Watersheds

National Estuary Program

http://epa.gov/owow/ocpd/green_infrastructure_roadshow.pdf

# Steps to Implement Green Infrastructure Projects

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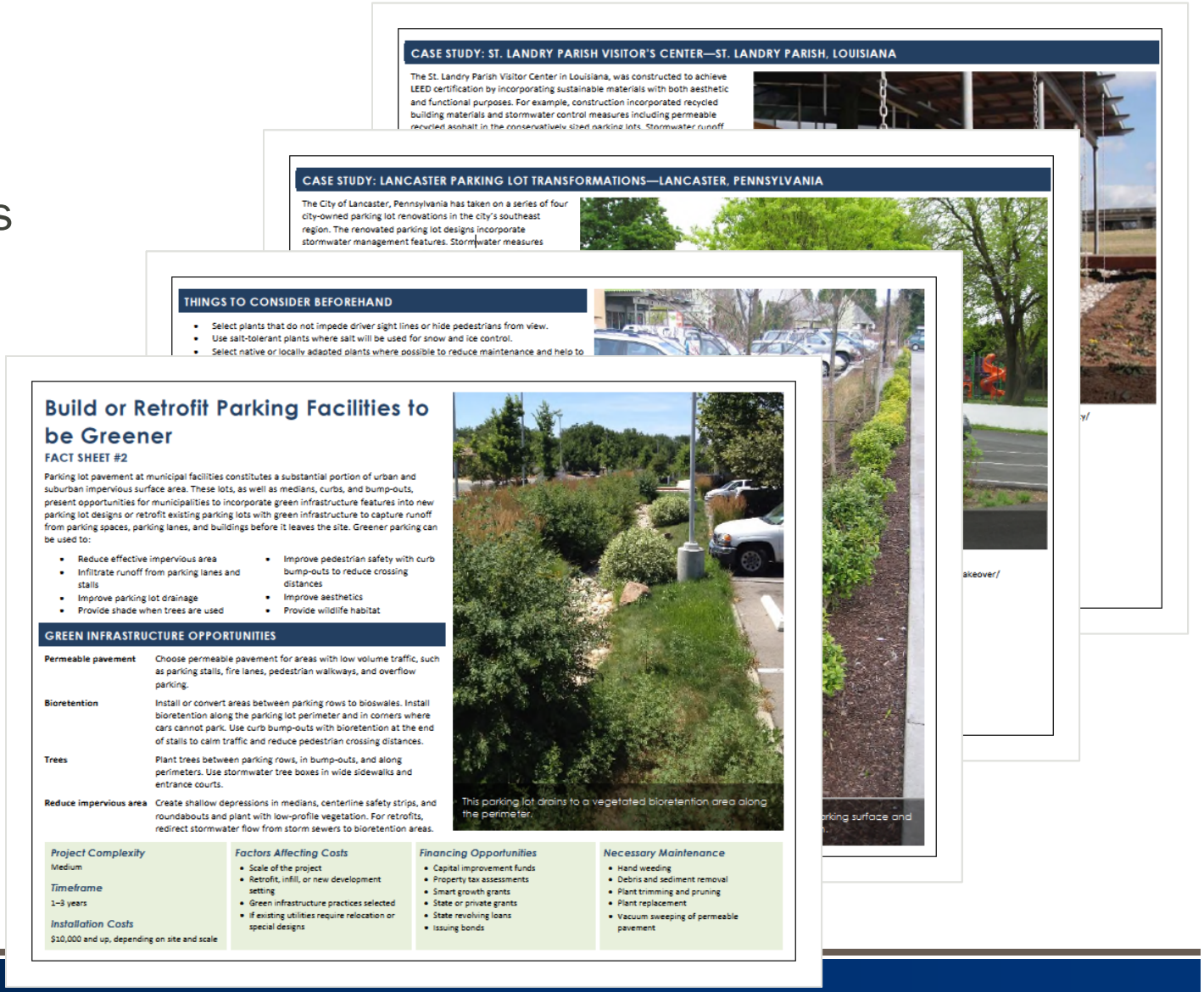
| Review Planning Documents and Codes | Identify Funding to Implement and Maintain Projects | Plan for Maintenance | Train Staff | Identify High-Visibility Projects |
|---|---|---|---|---|
| Identify green infrastructure opportunities and verify that green infrastructure can be readily incorporated into municipal projects | A variety of funding sources are available to build and maintain green infrastructure | Ensure the effectiveness of green infrastructure over the long term by coordinating between multiple agencies | Bring plan reviewers and maintenance staff up to speed on what is needed | Look for projects that will show the public the benefits of green infrastructure |

# Green Infrastructure Opportunity Fact Sheets

TETRA TECH

Fact Sheet 2:

Build or retrofit parking facilities to be greener



# Green Infrastructure

TETRA TECH

The Past

The Present

*The Future*

# Integrated Planning

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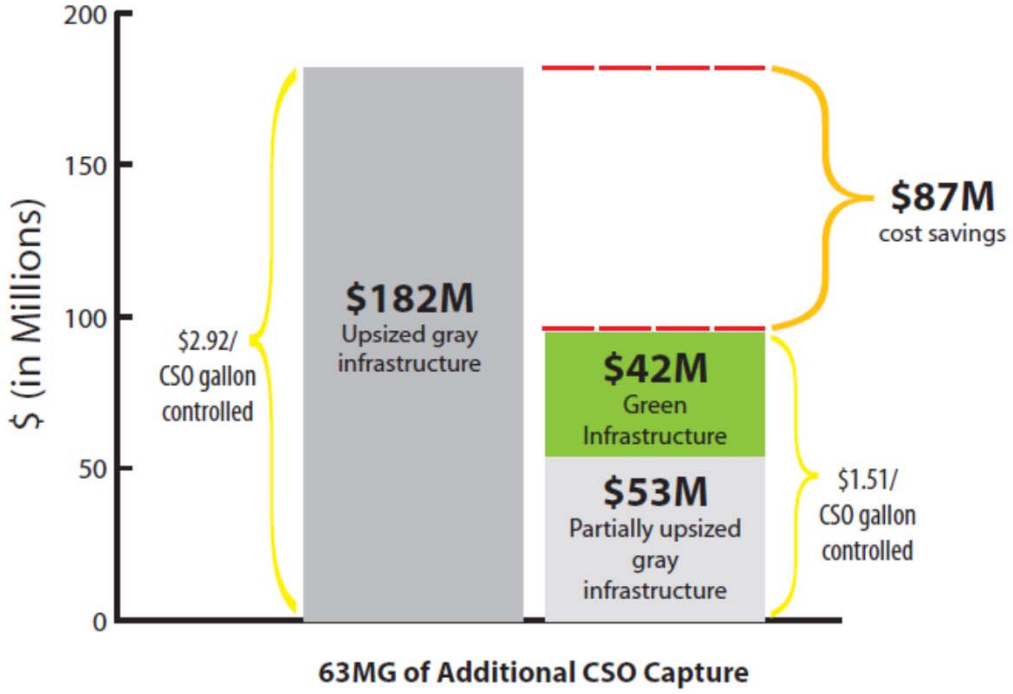
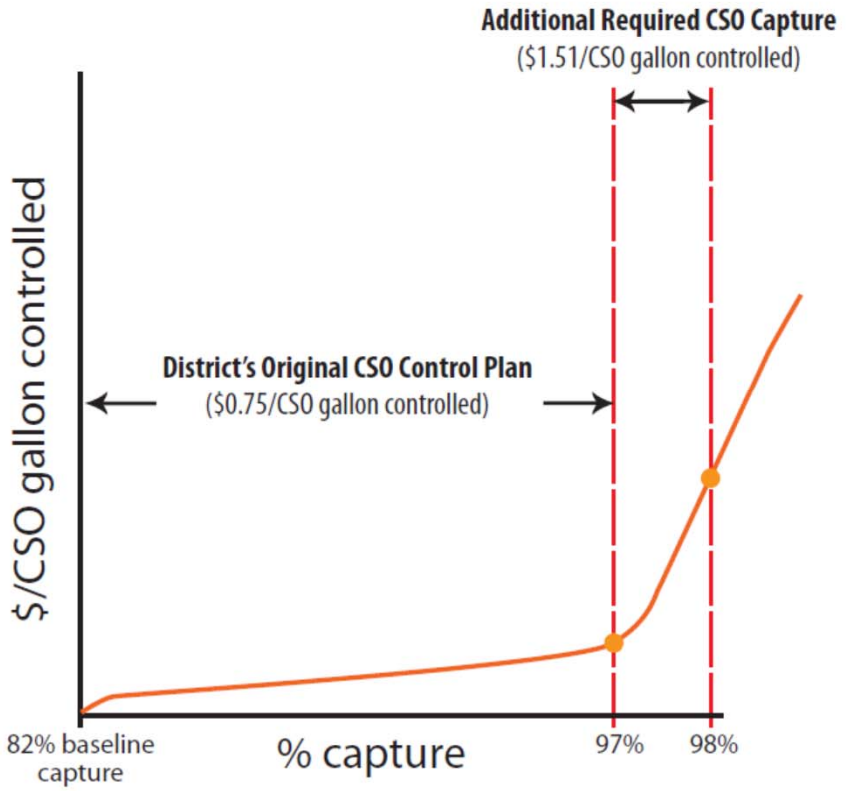
- October 2011 – EPA memo on Achieving Water Quality Through Integrated Municipal Stormwater and Wastewater Plans
- June 2012 – Integrated Municipal Stormwater and Wastewater Planning Approach Framework
- 6 Elements of an Integrated Plan:
  - Describe WQ and regulatory issues
  - Describe existing wastewater/SW systems
  - Stakeholder process
  - Identify alternatives
  - Propose implementation schedules
  - Measure success and process for improving plan

# Northeast Ohio Consent Decree

TETRA TECH

- 2010 CSO consent decree – first to include green infrastructure requirements as part of injunctive relief.



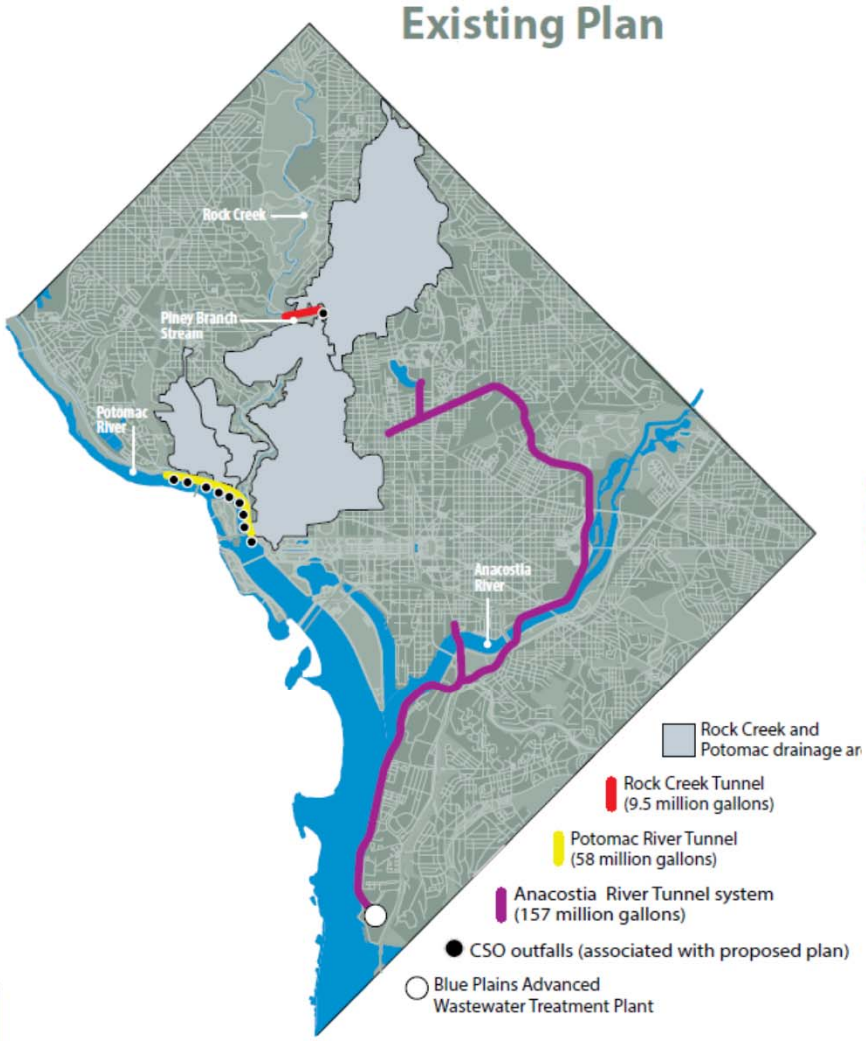



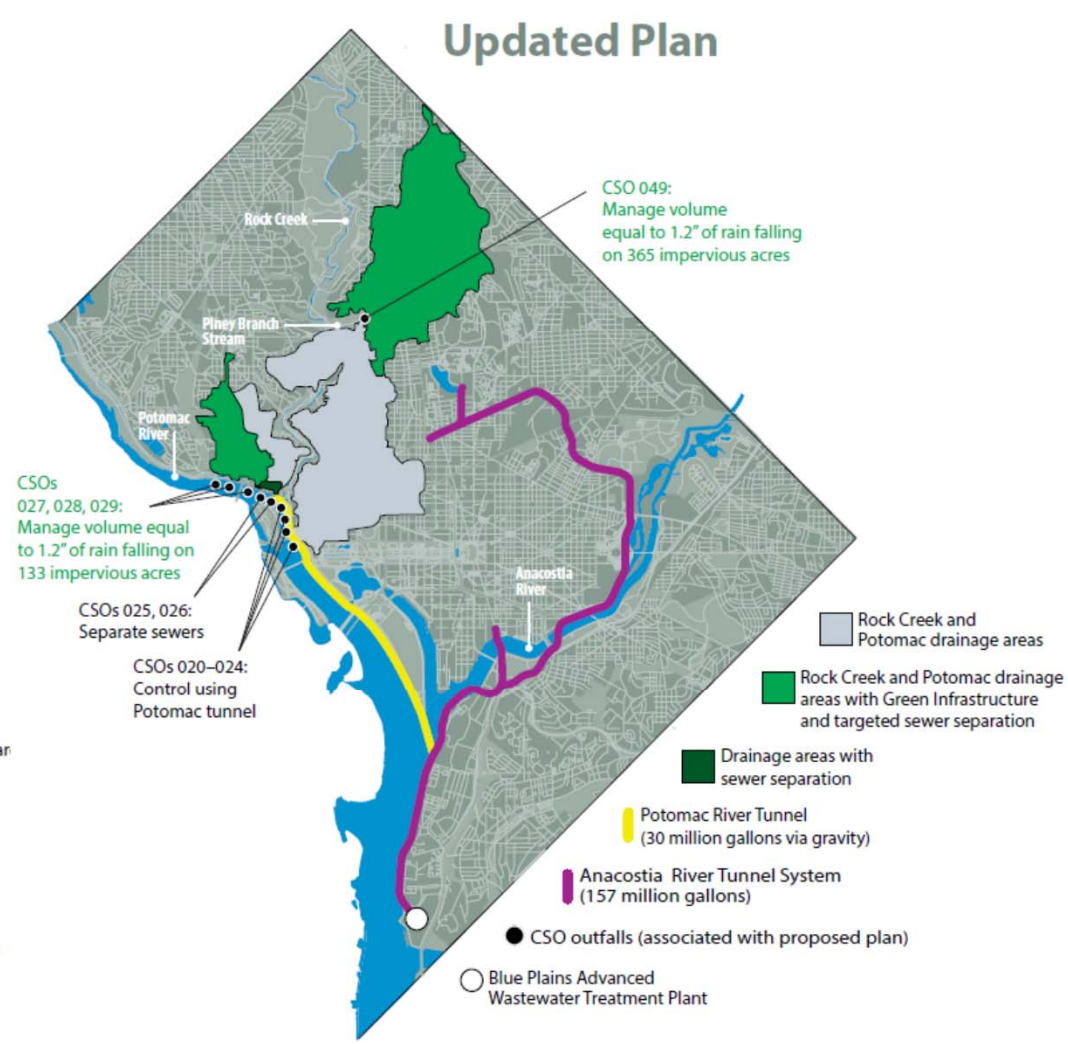
# Washington DC May 2015 Green Infrastructure/CSO Consent Decree

TETRA TECH

- Eliminate tunnel, sewer separation, build green infrastructure

https://www.dcwater.com/green



# Many Cities are Now Developing Green Stormwater Infrastructure Strategies

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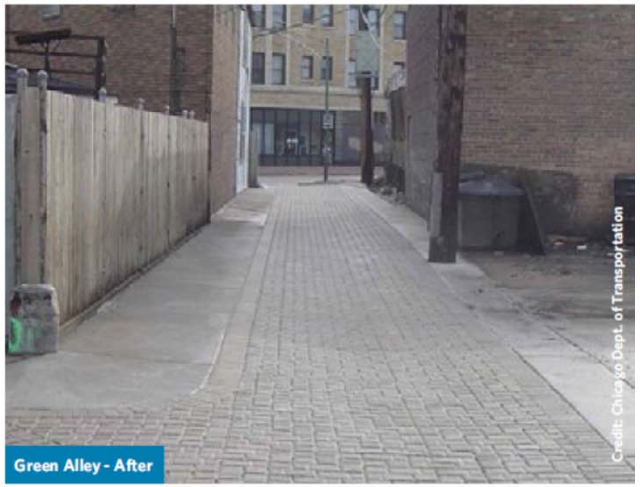
- Seattle (2015 draft)
- Philadelphia (2009)
- Chicago (2014)
- Newark, NJ (2015)
- Milwaukee (2012)
- New York (2010)


New York's Green Infrastructure Plan (2010)

- $2.4B on green, $2.9B on grey infrastructure over 20 years
- Saving $1.4B from all grey infrastructure
- Will capture first 1 inch rainfall from 10% of impervious surfaces in CSO areas

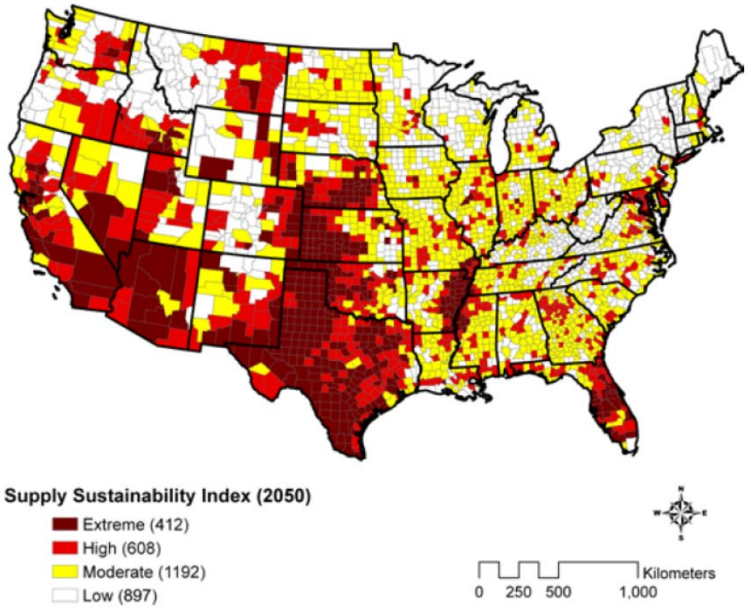
# Green Infrastructure in Parks

- Canal Park, Washington, DC
- ~3 acre, 3 block long park (formerly bus depot)
- Cisterns with water reuse for bathrooms/irrigation/fountains
- Rain gardens, green roof on café, tree planters

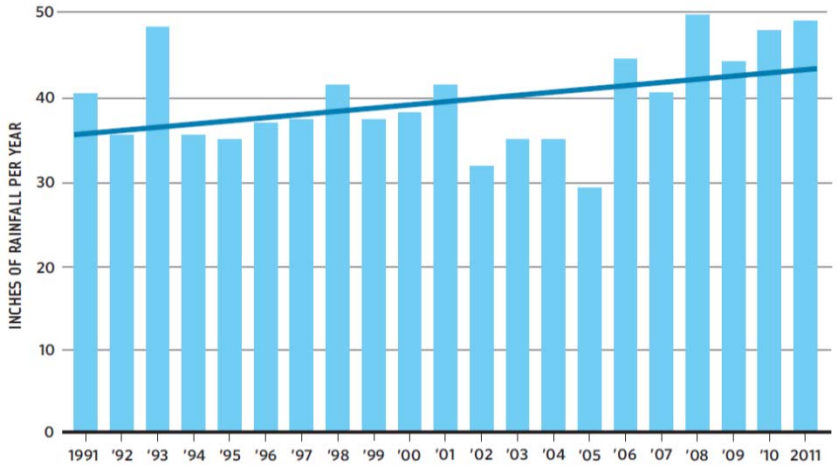
# Climate change/climate resiliency

TETRA TECH

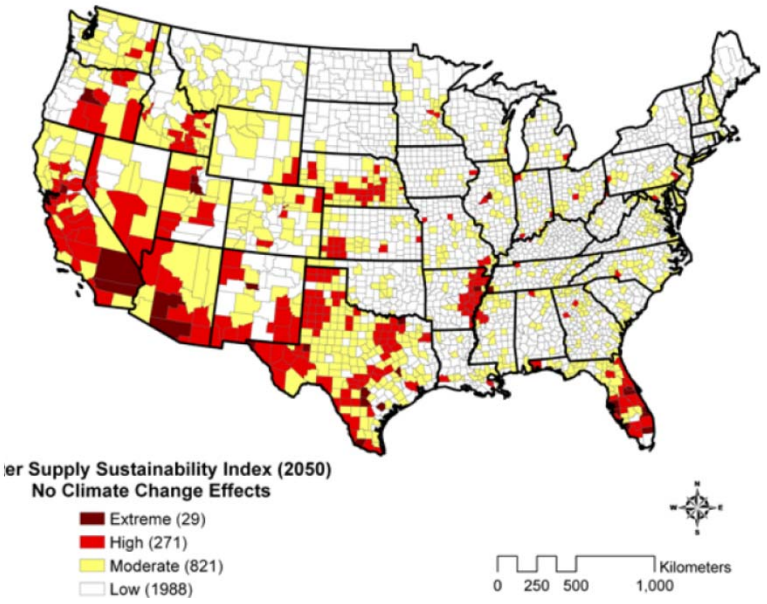
A




**Average Annual Rainfall in Chicago: 1991-2011**
Illinois State Water Survey Cook County Precipation Network Station 10




Source: Illinois State Water Survey



# Green Infrastructure for Climate Resiliency

Climate change is impacting urban areas in many ways, from exacerbating the urban heat island effect to elevating flood risk. Build green infrastructure to help improve community resilience.

## FLOODING

By the end of the century, annual damages from flooding in the U.S. are projected to **increase by 30%** [1]

## DROUGHT

**1 out of 3** **U.S. counties** in the lower 48 states face higher risks of water shortages by mid-century.[2]

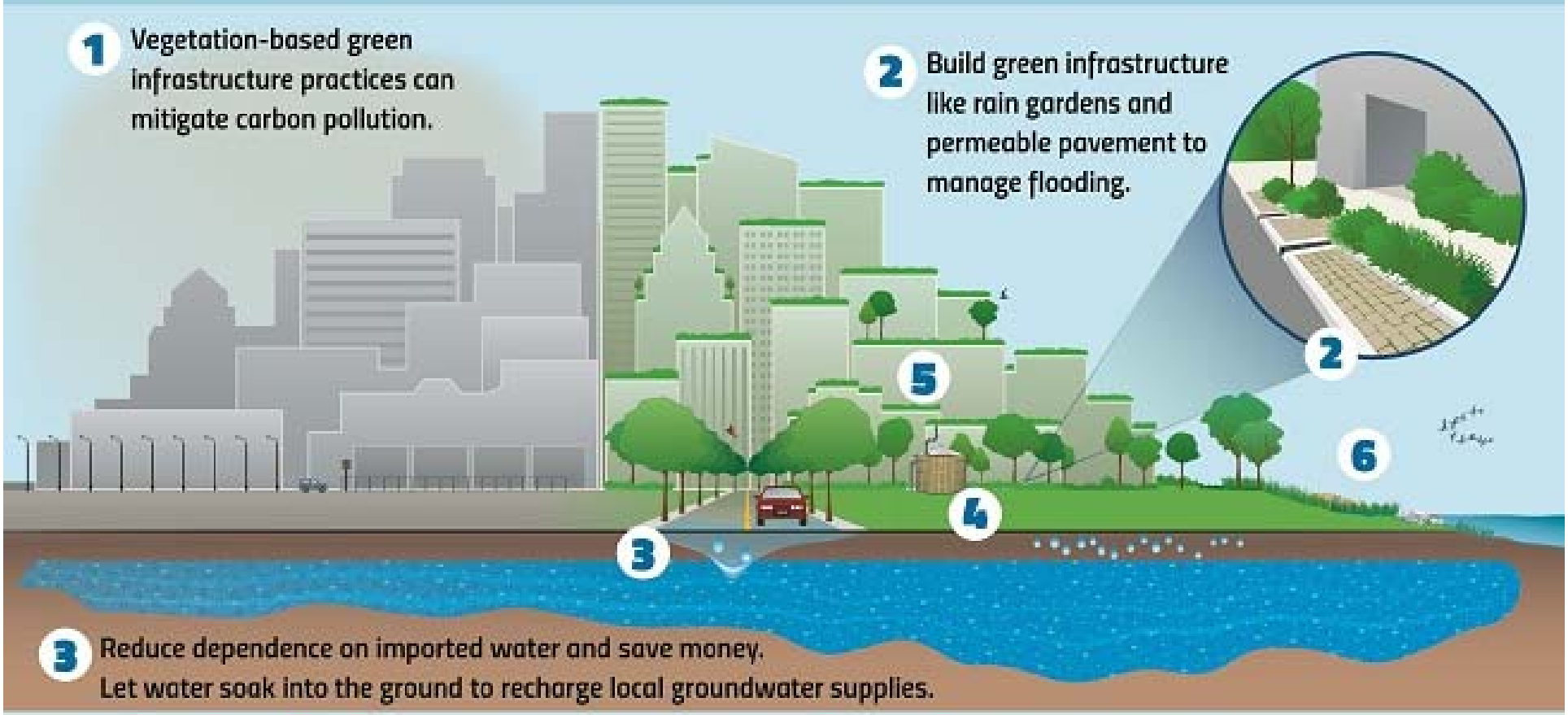
## COASTAL DAMAGE

**50%** **of Americans live in coastal counties**, where water and energy infrastructure are increasingly vulnerable to higher sea levels.[3]

## URBAN HEAT

Climate change will likely lead to **more frequent and severe** heat waves during summer months.[4]

# Green Infrastructure Builds Resiliency



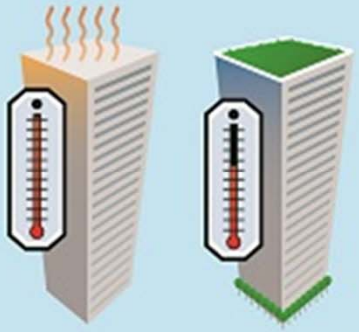

4 Keep water local. Capture runoff in cisterns and rain barrels to reduce municipal water use.

5 Plant trees and green roofs to mitigate the urban heat island effect.

6 Use living shorelines, buffers, dunes and marsh restoration to reduce the impact of storm surges.

# Green Infrastructure at Work

## LOWER URBAN HEAT ISLAND EFFECTS



Studies show that green roofs can **reduce the energy** needed for cooling on the floor below the roof by more than **50%**[5]

## KEEP WATER LOCAL

By capturing rain where it falls, urbanized Southern California and the San Francisco Bay area could boost water supplies by up to **200 billion gallons per year** – as much water as the city of Los Angeles uses annually.[6]

## BUILD COASTAL RESILIENCY

Research suggests that **wave height can be reduced by 50%** within the first 16 feet of marsh and 95% after crossing 100 feet of marsh.[7]

## MANAGE FLOOD RISK

A study in Burnsville, MN showed a **93% reduction** in runoff volume after the installation of 17 rain gardens in a 5.3 acre neighborhood.[8]

## USE LESS ENERGY


Give your air conditioner a rest! One young, healthy tree can produce cooling effects **equivalent to ten room-size air conditioners** operating 20 hours a day.[9]

EPA
United States Environmental Protection Agency

For more information on green infrastructure, see:
*www.epa.gov/greeninfrastructure*

# EPA Climate Resiliency Charrettes

TETRA TECH

- EPA hosting a series of 1-2 day charrettes to discuss how green infrastructure can help build climate resiliency
  - Albuquerque – August 11-12
  - New Orleans – August 11
  - Los Angeles – Sept. 23-24
  - Grand Rapids – Early October

- What do we mean by "climate resiliency?"

  "Improving community resiliency to threats posed by climate change to critical infrastructure, water quality, and human health."

# Consider incentives for green infrastructure

TETRA TECH

- Retrofit incentives
  - Rebates/installation cost sharing
  - Stormwater fee discounts
- New Development incentives
  - Reduction in code requirements (FAR bonus, density bonus, increased building height allowance, decreased parking requirements)
  - Increased allowable development

# Consider benefits of green infrastructure

TETRA TECH

| Benefit | Reduces Stormwater Runoff | | | | Increases Available Water Supply | Increases Groundwater Recharge | Reduces Salt Use | Reduces Energy Use | Improves Air Quality | Reduces Atmospheric $CO_2$ | Reduces Urban Heat Island | Improves Community Livability | | | | | Improves Habitat | Cultivates Public Education Opportunities |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reduces Water Treatment Needs | Improves Water Quality | Reduces Grey Infrastructure Needs | Reduces Flooding | | | | | | | | Improves Aesthetics | Increases Recreational Opportunity | Reduces Noise Pollution | Improves Community Cohesion | Urban Agriculture | | |
| Practice | | | | | | | | | | | | | | | | | | |
| Green Roofs | ● | ● | ● | ● | ○ | ○ | ○ | ● | ● | ● | ● | ● | ◒ | ● | ◒ | ◒ | ● | ● |
| Tree Planting | ● | ● | ● | ● | ○ | ◒ | ○ | ● | ● | ● | ● | ● | ● | ● | ● | ◒ | ● | ● |
| Bioretention & Infiltration | ● | ● | ● | ● | ◒ | ◒ | ○ | ○ | ● | ● | ● | ● | ● | ◒ | ◒ | ○ | ● | ● |
| Permeable Pavement | ● | ● | ● | ● | ○ | ◒ | ● | ◒ | ● | ● | ● | ○ | ○ | ● | ○ | ○ | ○ | ● |
| Water Harvesting | ● | ● | ● | ● | ● | ◒ | ○ | ◒ | ◒ | ◒ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ● |

● Yes ◒ Maybe ○ No

CNT. 2010. The Value of Green Infrastructure

# Public Private Partnerships

TETRA TECH

Prince George's County, Maryland

- County must retrofit 15,000 impervious acres by 2025
- Private company handles all planning, design, construction and maintenance of LID practices under 30-year partnership
- Initial three-year period will retrofit up to 4,000 acres for $100 million
- Company must use local small and minority-owned businesses for at least 35 percent of the total project scope
- http://www.princegeorgescountymd.gov/sites/EnvironmentalResources/News/Pages/WhiteHouseEPA.aspx

# Where is EPA going next?

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- Revise regulations to address public comment and permitting authority review of stormwater Phase II MS4 NOIs/SWMPs
- Strengthen MS4 permits (individual and general, including DOT-specific permits)
- Address compliance with NPDES permits
  - Integrated Plans
  - CSO consent decrees with green infrastructure
  - Inspections/audits
- Address climate change/climate resiliency

# Parting thoughts

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- Municipal properties – streets, rights-of-way, municipal facilities – represent the best opportunity for green infrastructure
- Codes and standards need to change to encourage/require green infrastructure techniques
- Cities must consider climate impacts and design for climate resiliency with projects
- A major challenge is maintenance/long-term administration of green infrastructure practices

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# Thank you!

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