Right Practice, Right Place: Green Infrastructure Technologies that Work in New England

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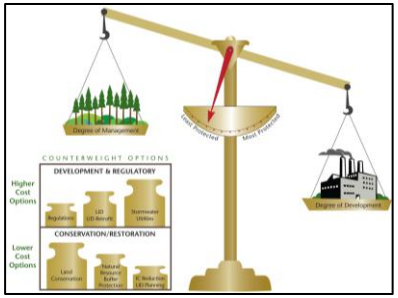
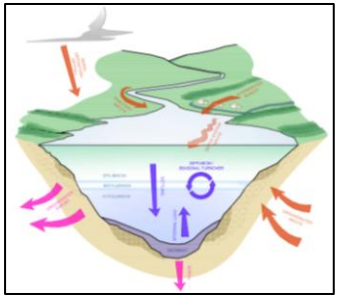




Growing Your Green Infrastructure Program

University of Massachusetts Amherst

UMass Campus Conference Center

1 Campus Center Way, Amherst MA

December 6, 2012

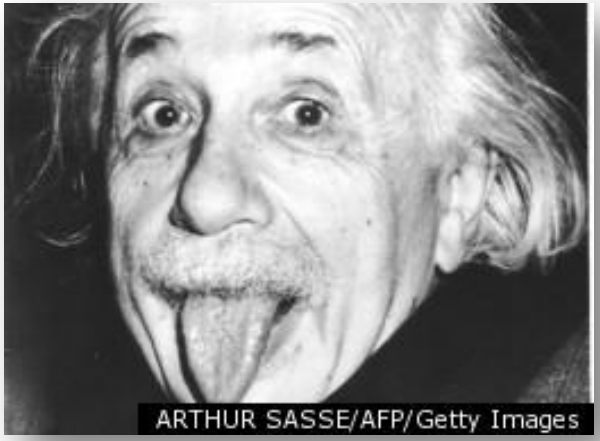
The New Orleans Hurricane Protection System: What Went Wrong and Why-- 1**0 Lessons Learned from Katrina** by the ASCE Hurricane Katrina External Review Panel and the USACE Interagency Performance Evaluation Task Force

1. Failure to think globally and act locally-We must account for climate change
2. Failure to absorb new knowledge
3. Failure to understand, manage, and communicate risk-Need to take rigorous risk based approach,
4. Failure to build quality in
5. Failure to build in resilience
6. Failure to provide redundancy
7. Failure to see that the sum of many parts does not equal a system
8. The buck couldn't find a place to stop--Poor organization, lack of accountability
1. Beware of interfaces: materials and jurisdiction
2. Follow the money-People responsible for design and construction had no control of the monies.

Hurricane Sandy aftermath NYC and NJ Coast, October 2012

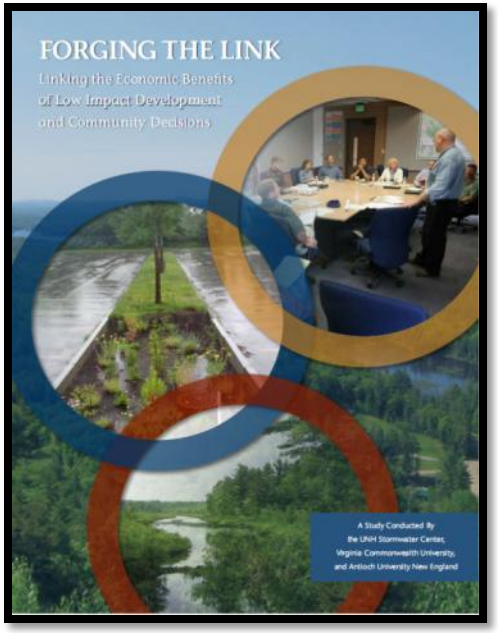
Trust, Legitimacy and Relevance of Science

- Building trust can be accomplished by developing partnerships within local governments and stakeholders
- Participation and familiarity in the process will facilitate a deeper trust in science products.



Benefits of LID and Green Infrastructure

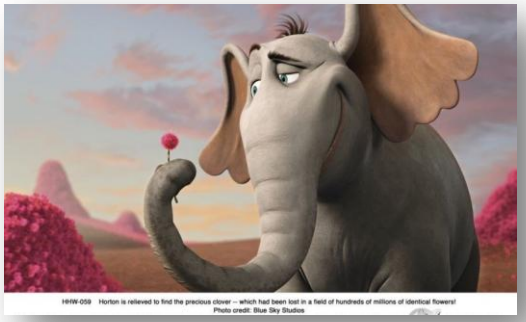
- The environmental and water quality benefits of LID are well established,
- There are considerable economic, infrastructure, and adaptation planning benefits that are NOT WELL KNOWN from using LID-based strategies.



2011, Forging the Link: Linking the Economic Benefits of Low Impact Development and Community Decisions
http://www.unh.edu/unhsc/forgingthelink

Regulatory Drivers

- Consent decrees and Long term control plans for CSO separation
- NPDES MS4 Phase I and Phase II has been largely an issue of due diligence with respect to SWMP
- TMDLs are based on WQ standards—due diligence does not matter
- 80% TSS Removal will not meet “no net increase standard”
- GI and LID will be needed to meet TMDL requirements



In the News…..

Thursday, July 31, 2008

New regs may drown taxpayers

EPA told cost key issue in storm-water plan

By Thomas Caywood TELEGRAM & GAZETTE STAFF
Add a comment

WORCESTER — City officials talked tough and took a few sharp jabs at the U.S. Environmental Protection Agency yesterday morning at a public hearing on proposed steps to curb pollution flowing into area bodies of water from city storm drains.

The city maintains the EPA's proposed regulations, developed in conjunction with the Massachusetts Department of Environmental Protection, would cost a fortune to implement and force steep water and sewer rate hikes for residents and businesses.

March 13, 2012, 1:46 PM

A Greener Strategy for New York's Runaway Sewage

By MREYA NAVARRO

Department of Environmental Protection

A green roof in Long Island City, Queens helps keep storm water out of the sewage system.

Politics & Policy

New York State and city officials announced Tuesday that they had wrapped up an agreement under which the city would commit more than $2 billion in public and private investment to new environmental techniques to help prevent the flow of untreated sewage and storm water into city waterways when it rains.

What is difference between these outcomes?

Negotiated plans using Green Infrastructure to reduce reliance on Gray Infrastructure

Line in sand drawn over wastewater

By **Charles McMahon**
cmcmahon@seacoastonline.com

PORTSMOUTH — City officials on Friday criticized state and federal environmental regulators over a perceived "lack of sincere effort" in working with local communities on wastewater treatment testing.

Criticism of both the state Department of Environmental Services and U.S. Environmental Protection Agency can be found in a memorandum that City Manager John Bohenko released to the City Council in advance of their meeting Monday night.

In the memorandum, Bohenko asks the City Council to authorize him to continue working with local communities belonging to the Great Bay Coalition to ensure regulators follow state law when it comes to setting permit limits for nitrogen.

Amended

Clean Waters

The City of Philadelphia's Program for Combined Sewer Overflow Control

Program Summary

Amended by the Philadelphia Water Department
June 1, 2011

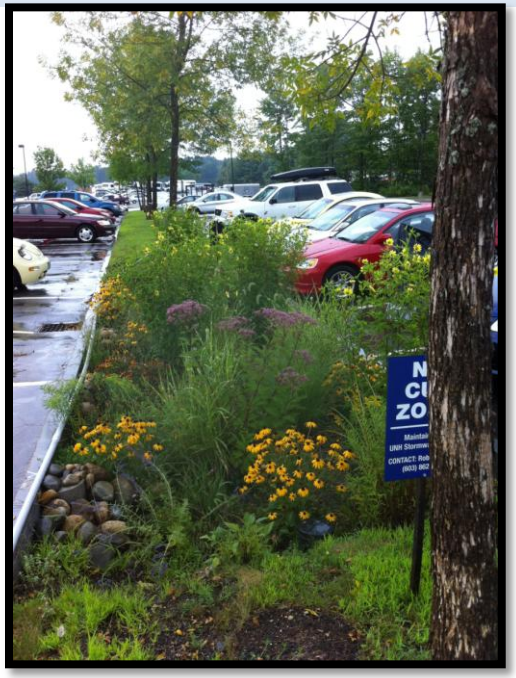
Green Infrastructure and Low Impact Development

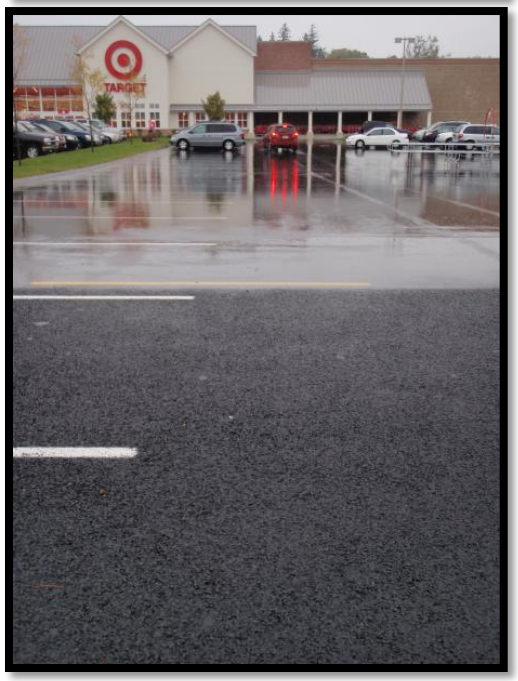
Modeling designs after natural systems

High Performance Green Infrastructure

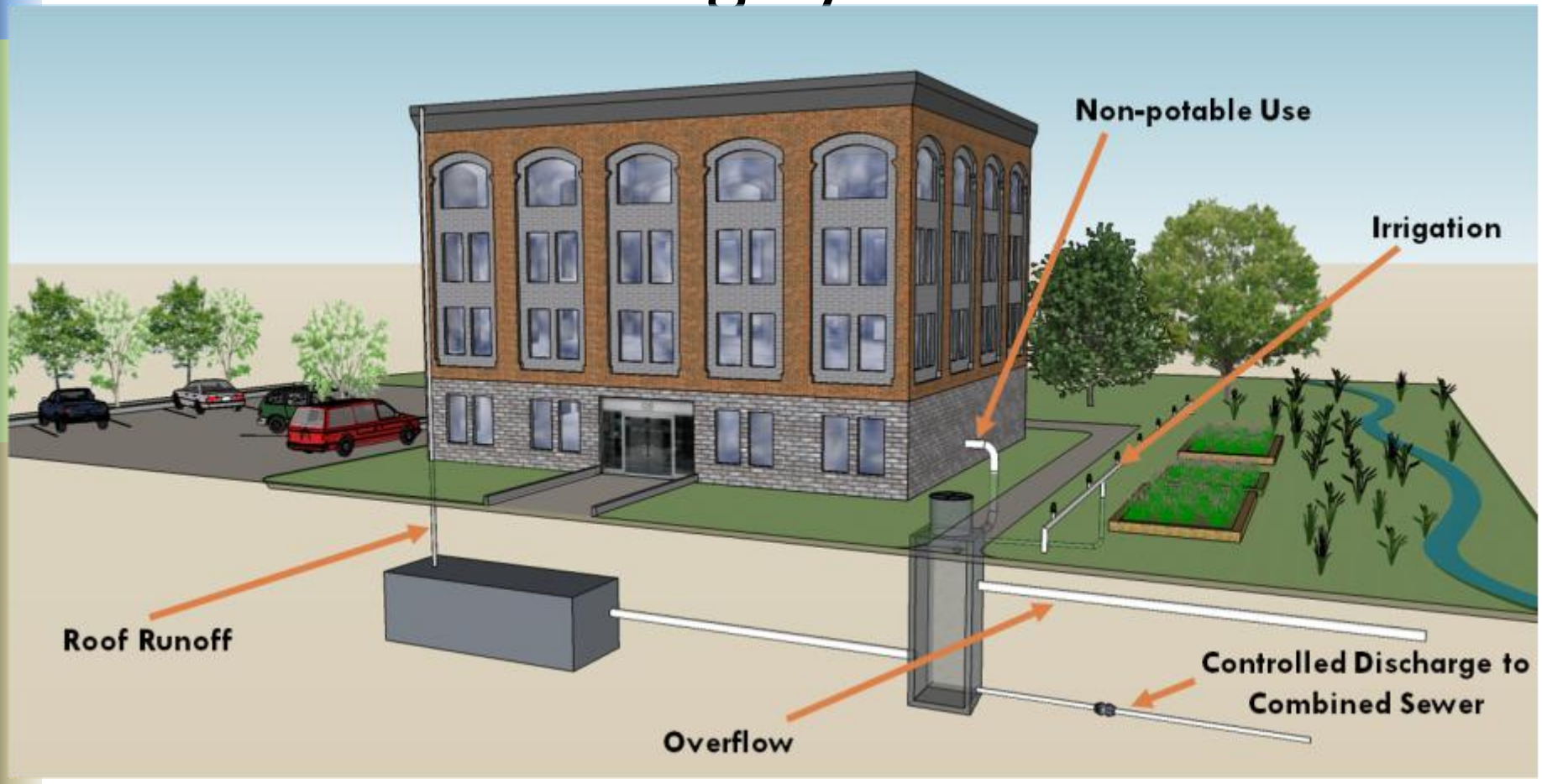
GI Real-time controls and smart systems to optimize performance

Low Impact Development



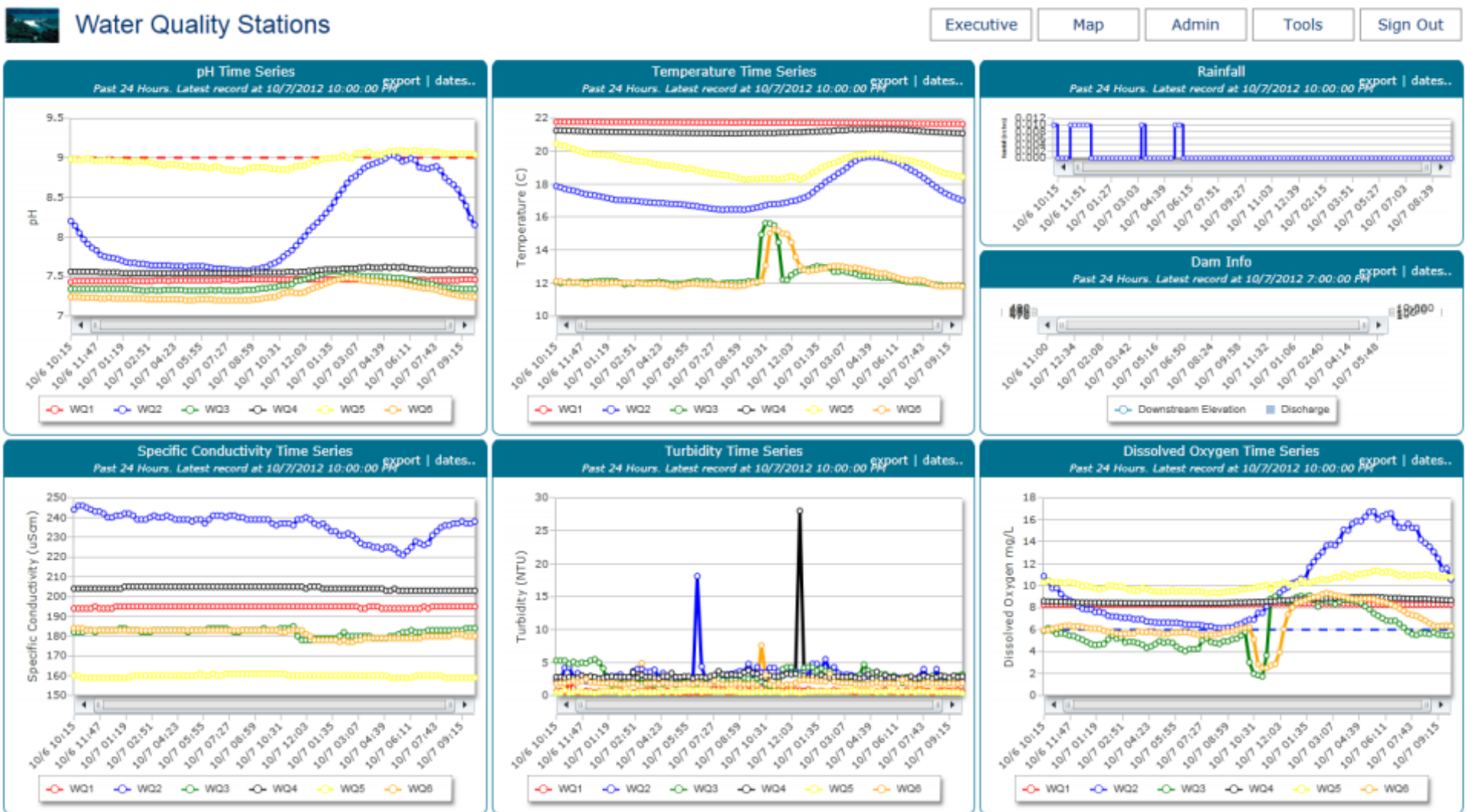

TARGET

High Performance Green Infrastructure: Advanced Rainwater Harvesting and Harvesting System Retrofits



Simplest Definition: Drain storage in advance of predicted rainfall or other trigger

High Performance Green Infrastructure: Smart Detention/Retention/Flood Control Retrofits



Triple Bottom Line Analyses

Is the quantification of the economic benefits of

- **Social**

- **Economic**

- **Environmental**

Indicators may include:

- Job creation
- Reduced infrastructure
- Reduced pumping costs
- Increased property values
- Improved quality of life and aesthetics
- Increased recreational opportunities
- Reduced stormwater volume
- Reduced sediment loading
- Increased groundwater recharge
- Increased carbon sequestration and
- Reduced energy use/heat island effect

Integrated Watershed Planning

- **October 2011 Stoner-Gyles Memo was released detailing an EPA commitment to integrated permitting**
- **Flexible and combined WW and stormwater NPDES permits**
- **Encourages Green infrastructure**
- **More cost effective**
- **Treating stormwater was a resource**

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

OCT 27 2011

MEMORANDUM

SUBJECT: Achieving Water Quality Through Integrated Municipal Stormwater and Wastewater Plans

FROM: Nancy Stoner
Acting Assistant Administrator
Office of Water (OW)

Cynthia Giles
Assistant Administrator
Office of Enforcement and Compliance Assurance (OECA)

TO: EPA Regional Administrators, OW & OECA Office & Division Directors

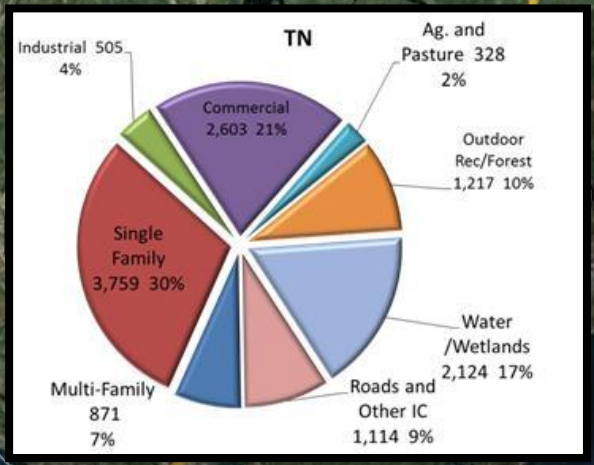
One of the most basic objectives of the Clean Water Act (CWA) is to keep raw sewage and pollutants carried by stormwater out of our nation's waters. We have made tremendous strides towards achieving that objective, but much work remains to be done. As we move forward with our work, we must be mindful that many of our state and local government partners find themselves facing difficult financial conditions. Their ability to finance improvements by raising revenues or issuing bonds has been significantly impacted during the ongoing economic recovery. We write this memorandum to make sure that we proceed as one EPA to ensure that we work with states and communities to get the most effective as well as cost-effective approaches for meeting our shared objective of clean water that protects public health and the environment.

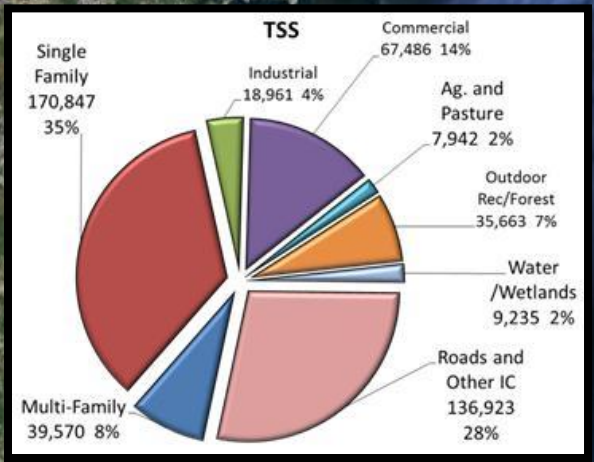
Integrated Planning for Cost Effective Solutions

Today, the EPA, states and municipalities often focus on each CWA requirement individually for protecting water quality. As a result, we sometimes assess and implement the best alternative to solve one problem at a time without full consideration of all CWA obligations. This approach may have the unintended consequence of constraining a municipality from implementing the most cost-effective solution in a sequence that addresses the most serious water quality issues first. We encourage regions to work with the states to engage our local partners regarding all of their National Pollutant Discharge Elimination System (NPDES) related obligations in an orderly manner. A comprehensive and integrated planning approach to a municipal government's CWA wastewater and stormwater obligations offers the greatest opportunity for identifying cost-effective and protective solutions and implementing the most important projects first. The CWA and its implementing regulations, policy and guidance provide us

How do we plan for this?

Identifying Areas for Management





Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Not All Costs are Equal

When implementing stormwater improvements, it is important to consider:

who **pays, how, and when.**

1. **Existing municipal programs and long-term bonds**
2. **Stormwater Utilities—fees upon amount of SW generated**
3. **Developer, Owner, Consumer**

Economic Case Studies

Boulder Hills, Pelham, NH

- 2009 Installation of 1300’ of first PA private residential road in Northeast
- Site will be nearly Zero discharge
- LID subdivision 55+ Active Adult Community
- Large sand deposit
- Cost 25% greater per ton installed

LID Design

Built on 9% grade

1.3 acres less of land clearing

Conventional Site Design

Avoided use of 1616' of curbing, 785' pipe, 8 catch-basins, 2 detention basins, 2 outlet control structures

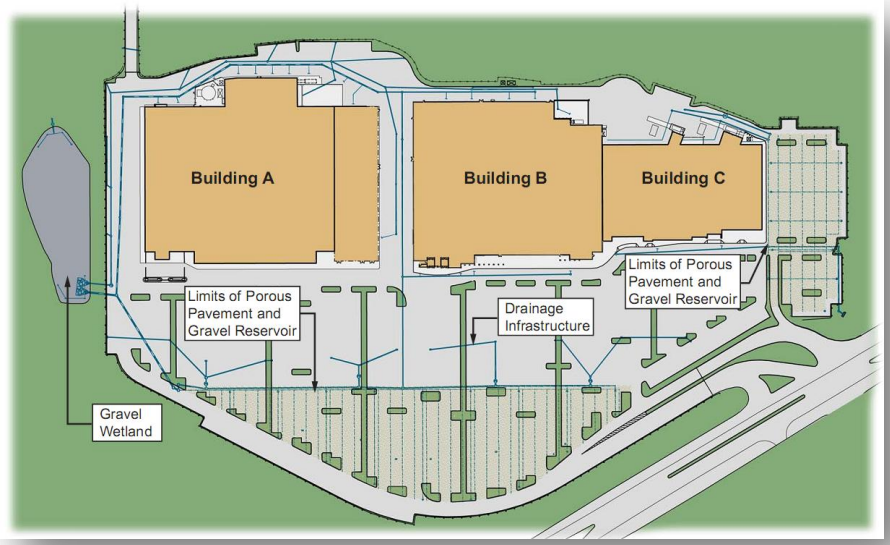
Comparison of Unit Costs

Item	Conventional	LID	Difference
SITE PREPARATION	$23,200.00	$18,000.00	–$5,200.00
TEMP. EROSION CONTROL	$5,800.00	$3,800.00	–$2,000.00
DRAINAGE	$92,400.00	$20,100.00	–$72,300.00
ROADWAY	$82,000.00	$128,000.00	$46,000.00
DRIVEWAYS	$19,700.00	$30,100.00	$10,400.00
CURBING	$6,500.00	$0.00	–$6,500.00
PERM. EROSION CONTROL	$70,000.00	$50,600.00	–$19,400.00
ADDITIONAL ITEMS	$489,700.00	$489,700.00	$0.00
BUILDINGS	$3,600,000.00	$3,600,000.00	$0.00
PROJECT TOTAL	$4,389,300.00	$4,340,300.00	–$49,000.00

6% savings on total cost of SW infrastructure for a ~zero discharge site

Greenland Meadows Commercial, Greenland, NH

- "Gold-Star" Commercial Development
- Cost of doing business near Impaired Waters/303D
- Brownfields site, ideal location, 15yrs
- Proposed site >10,000 Average Daily Traffic count on >30 acres



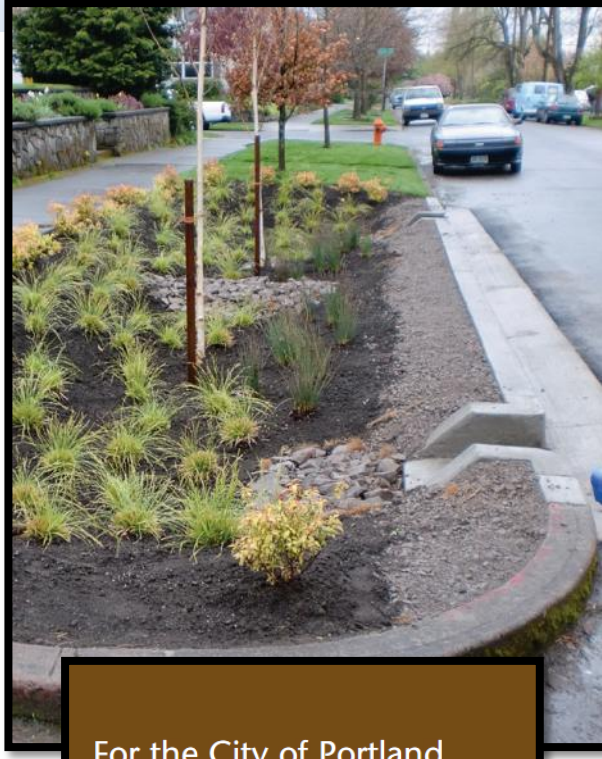
Comparison of Unit Costs

		Conventional	LID	Cost
TABLE 3-3 Conventional Option Piping		**TYPE**	**QUANTITY**	**COST**
	Distribution	6 to 30-inch piping	9,680 linear feet	$298,340
	Detention	36 and 48-inch piping	20,800 linear feet	$1,356,800
TABLE 3-4 LID Option Piping		**TYPE**	**QUANTITY**	**COST**
	Distribution	4 to 36-inch piping	19,970 linear feet	$457,780
	Detention*	—	0	$0
ADDITIONAL WORK-RELATED ACTIVITY (utilities, lighting, water & sanitary sewer service, fencing, landscaping, etc.)		$2,720,000	$2,720,000	$0
PROJECT TOTAL		$10,590,300	$9,660,300	–$930,000

26% savings on total cost of SW infrastructure for a ~zero discharge site

Portland, OR
Tabor to the River: Brooklyn Creek Project

- Program sought to rectify CSO, street and basement flooding
- The original cost estimate using gray infrastructure was $144 million (2009 dollars).
- Gray-Green design including a total of $11 million allocated for green solutions, the cost estimate for this integrated approach was $81 million, a savings of $63 million for the city

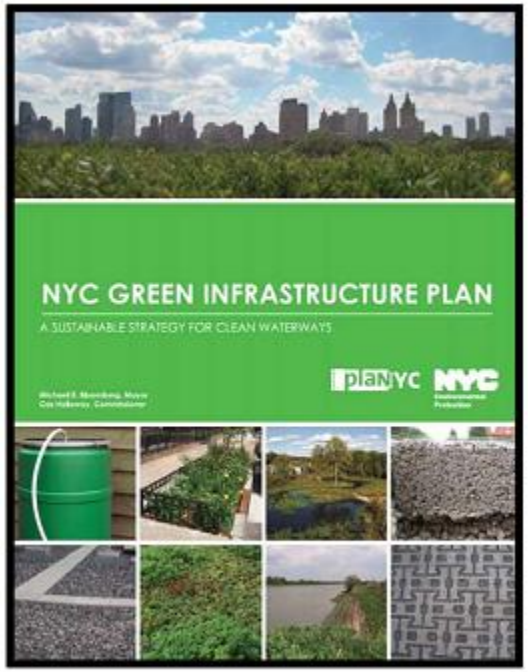


For the City of Portland, utilizing green streets is the preferred strategy for helping relieve sewer overflow conditions because it is the most cost-effective and eliminates the need for expensive below-ground repairs, which often involve replacing infrastructure.

TABLE 3-7 CSO Control Alternatives Costing for Portland, Oregon.

Project/Program	Effective Imp. Acres Controlled	Est. 3-year Volume Removed (MG)	Capital Cost	Marginal Cost ($/ Gallon)	Cumulative Volume Removed (MG)	Cumulative Capital Cost
Extended Downspout Disconnection Program (can include LID)	284	7.45	$6,633,000	$0.89	7.45	$6,633,000
School Disconnection*	68	1.77	$1,954,000	$1.10	9.22	$8,587,000
Church Disconnection*	32	0.96	$2,031,000	$2.12	10.18	$10,618,000
Beech-Essex Sewer Separation	37	1.40	$3,889,000	$2.78	11.58	$14,507,000
ES Curb Extensions (LID)	349	4.29	$12,323,000	$2.87	15.87	$26,830,000
Tanner Phase 3 Sewer Separation	85	3.10	$10,767,616	$3.47	18.97	$37,598,000
ES Roof & Parking IC (LID)	475	17.64	$72,047,000	$4.08	36.61	$109,645,000
NWN Pre-design – Tanner North Sewer Separation	14	0.22	$1,127,000	$5.12	36.83	$110,772,000
Carolina Stream & Storm Separation	93	1.02	$5,319,000	$5.21	37.85	$116,091,000
NWN Pre-design – Tanner South Sewer Separation	13	0.26	$1,602,000	$6.16	38.11	$117,693,000
NWN Pre-design – Tanner Central Sewer Separation	2	0.04	$269,000	$7.60	38.14	$117,962,000
NWN Pre-design – Nicolai/ Outfall Sewer Separation	34	0.54	$6,321,000	$11.76	38.68	$124,283,000
NWN Pre-design – Nicolai/ Outfall 13 Sewer Separation	52	0.68	$8,217,000	$12.04	39.36	$132,500,000
Green Roof Legacy Project (LID)	20	1.04	$14,179,000	$13.65	40.40	$146,679,000
NWN Pre-design – Nicolai/ Outfall 15 Sewer Separation	24	0.36	$6,546,000	$17.98	40.77	$153,225,000
Holladay Sewer Separation	125	0.69	$14,360,000	$20.94	41.45	$167,585,000
NWN Pre-design – Balch Neighborhood Sewer Separation	8	0.14	$7,664,000	$55.06	41.59	$175,249,000
NWN Pre-design – Balch/ Forest Park Storm Separation	5	0.13	$12,026,000	$93.82	41.72	$187,275,000

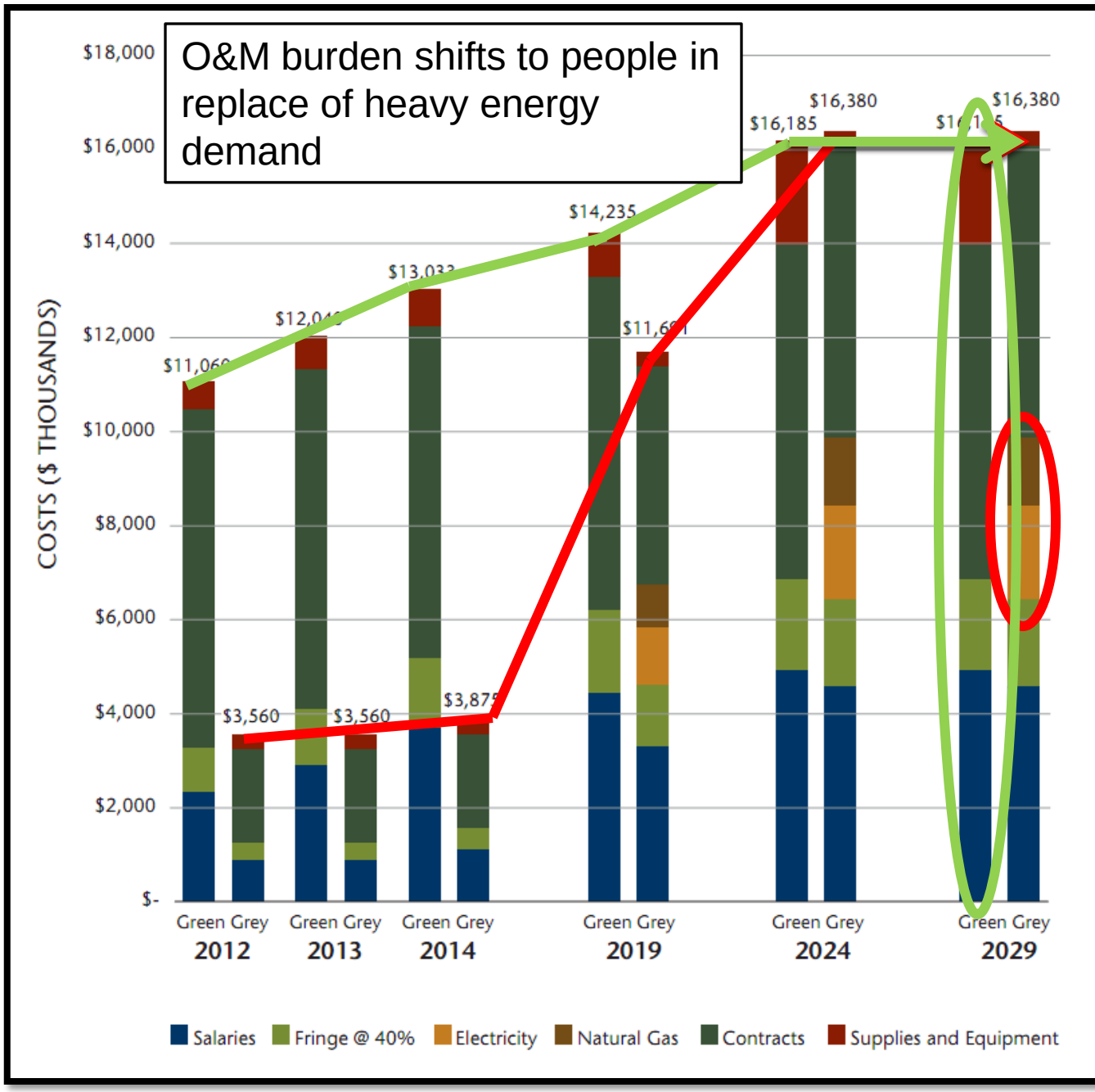
New York City, New York



Taking it to the next level…..jobs and added value

O&M Costs CSO Control Scenarios

- GI will provided a 22% reduction in LTCP capital cost
- Funds for labor, supplies, and equipment
- Replacing energy demands of grey infrastructure



Economic Conclusions

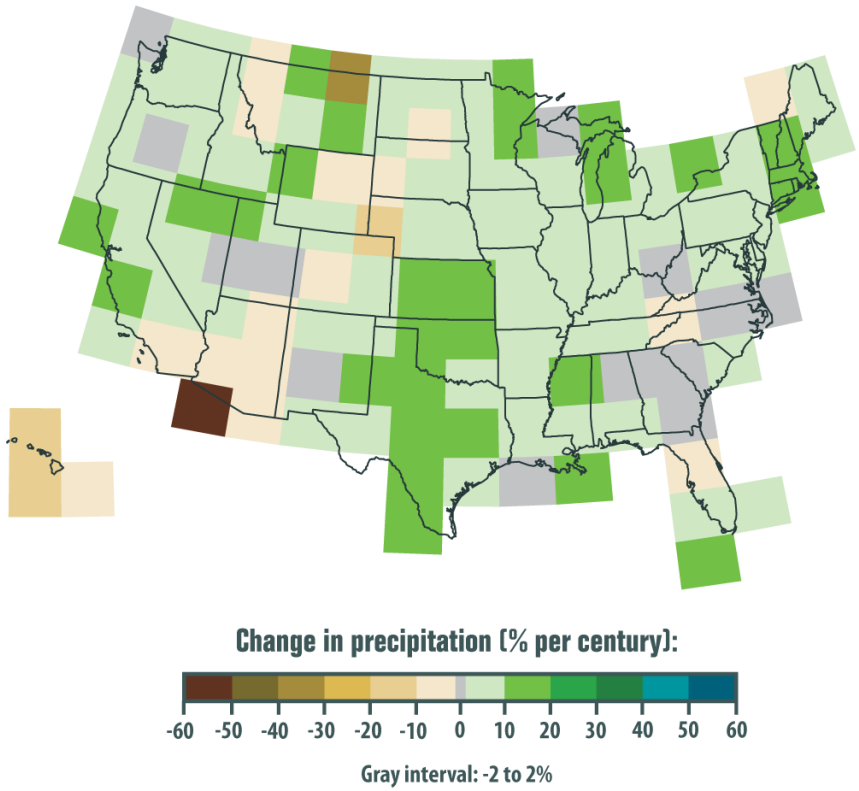
- Green Infrastructure is being embraced nationally due to reduced demand on gray infrastructure
- GI has value for social and economic in addition to environmental
- LID may add expense on a per item basis
- Project cost reductions were observed from 6% in residential developments to as high as 26% in commercial projects.
- Municipal use of GI reported cost reductions of 21% to as high as 44%.
- Benefits extend to municipal, private, and commercial entities
- Transfer of monies from infrastructure to jobs associated with the maintenance activities.
- From a sustainability perspective, a range of benefits includes reductions in flood damage and increased resiliency of drainage infrastructure;
- Reductions of 33 to 50% in energy demands for heating and cooling.
- A 50% reduction in time to sale, and increased property values of 12-16%.
- Other benefits were incentives in the form of rebates, cost-sharing, and tax credits. IE. Impervious cover charge

Land Use, Low Impact Development, and Community Resiliency

Mill Pond Rd after dam failure at Nottingham Lake, 4/18/2007

Changing Trends

Increase in Precipitation

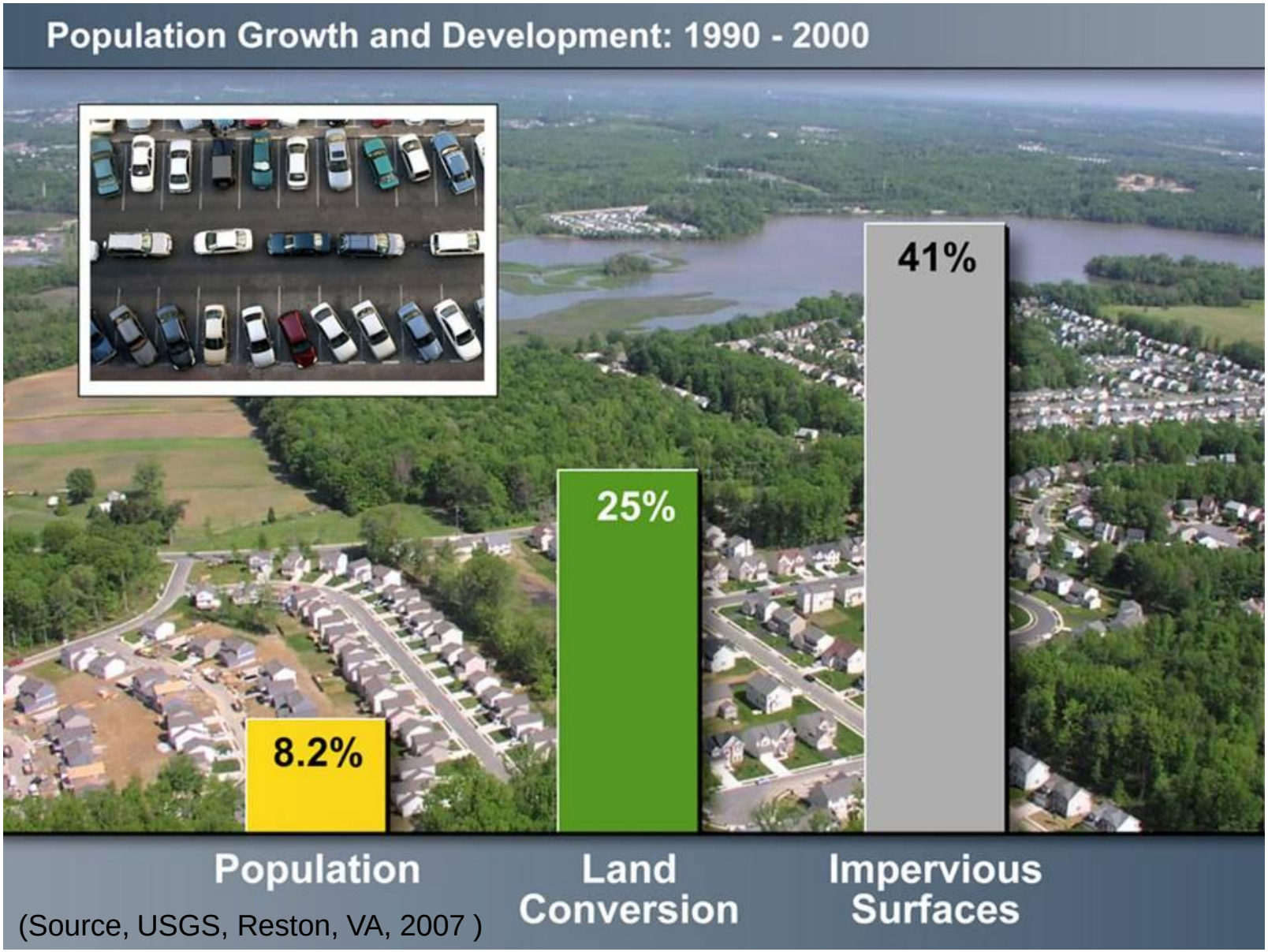


County	Historic 100-Yr	NRCC 100-Yr	% Incr.
Rockingham	6.4	8.8	27%
Strafford	6.3	8.2	23%

(Source, NOAA Climatic Data Center)

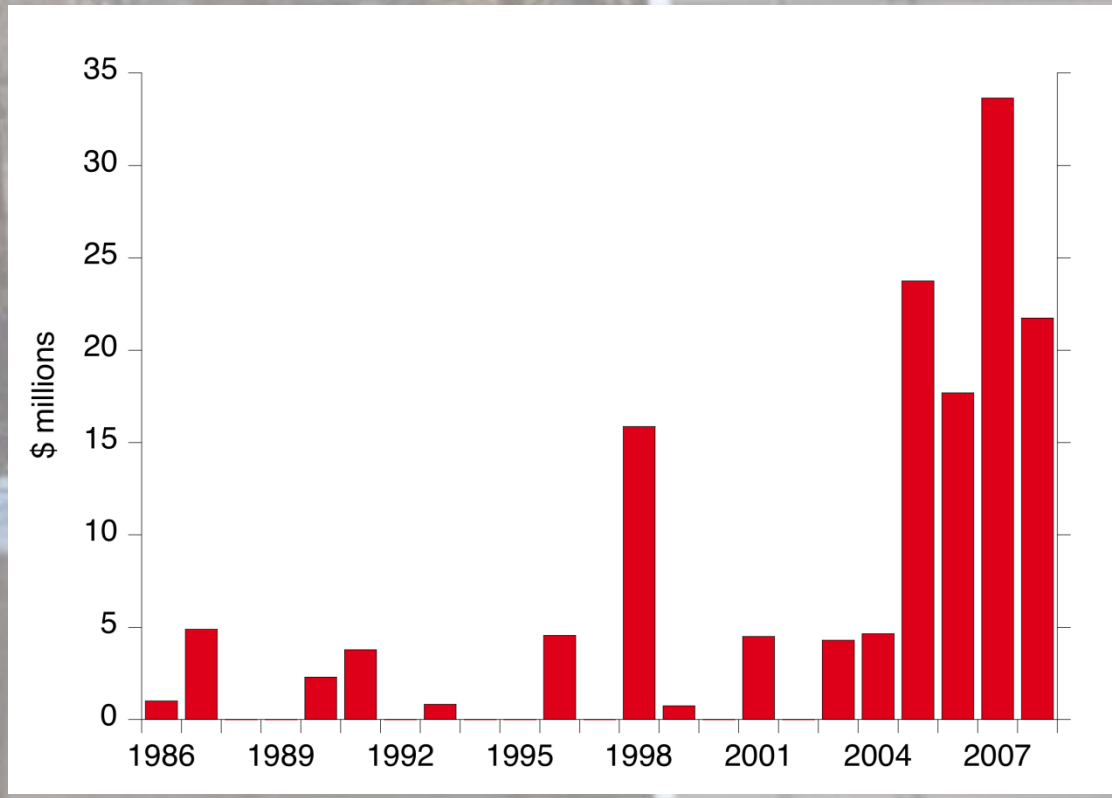
Powered by ACIS
Northeast Regional Climate Center

Increasing Impervious Surfaces



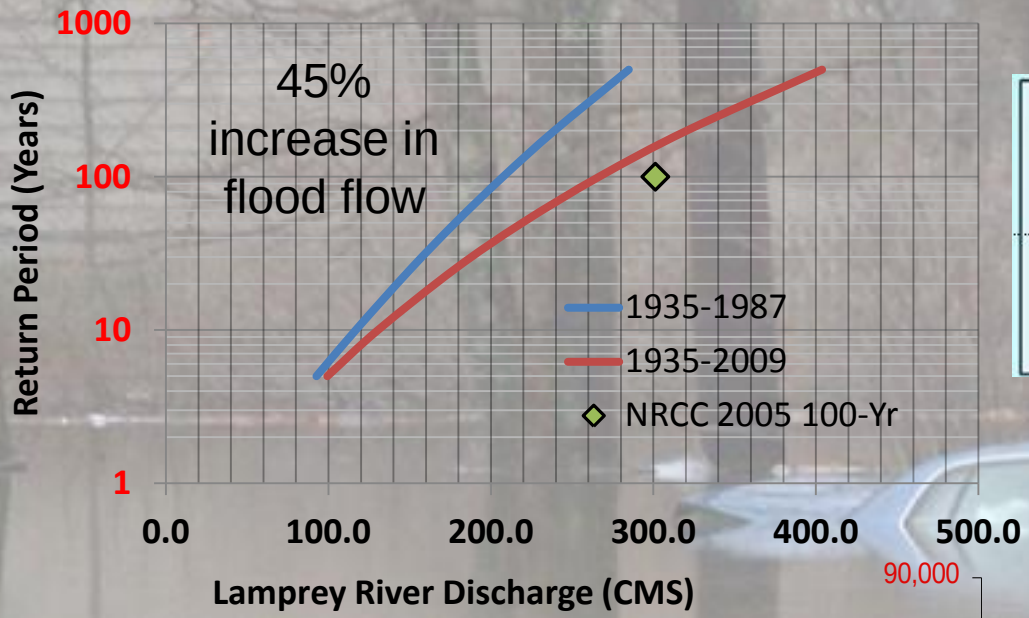
(Source, USGS, Reston, VA, 2007)

Costs from Presidentially Declared Disasters in NH



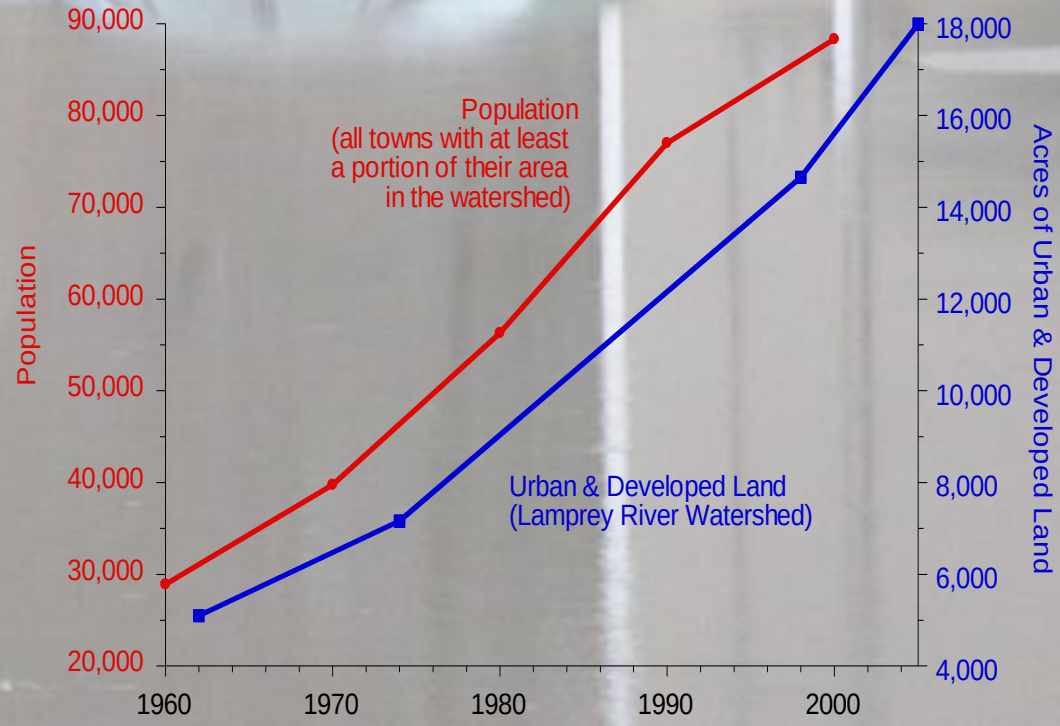
We can decide not to prepare, but we are then choosing to increase our risk

Population Growth, Development, and Changing Climate



Of 15 largest events since 1934:
11 have occurred in last 25 years
10 have occurred in last 15 years
7 have occurred in last 5 years

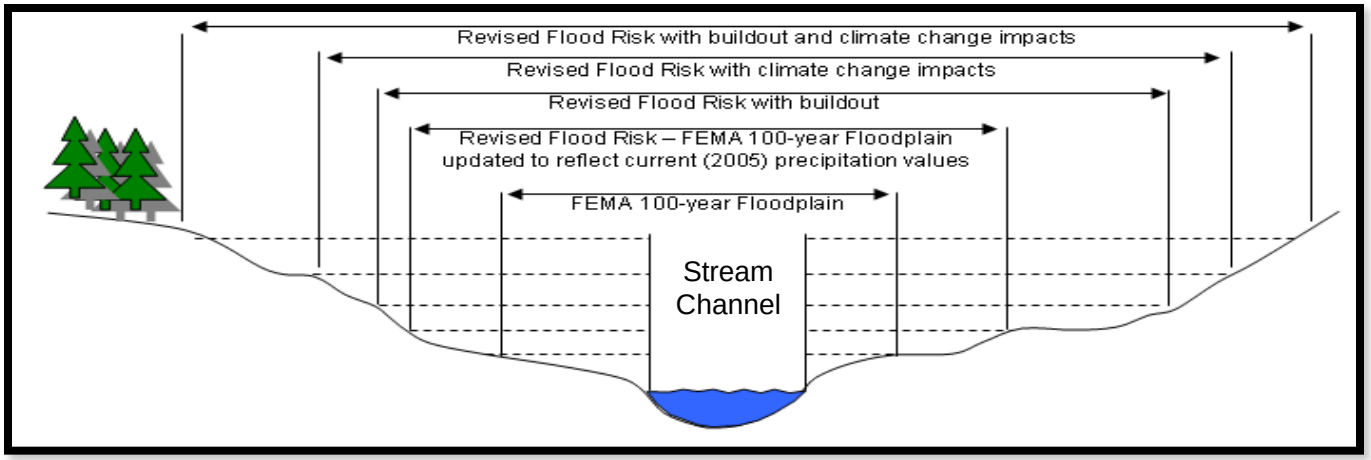
300% increase in developed areas in 45 years



Climate and Land Use Impacts on the 100-Yr Floodplain

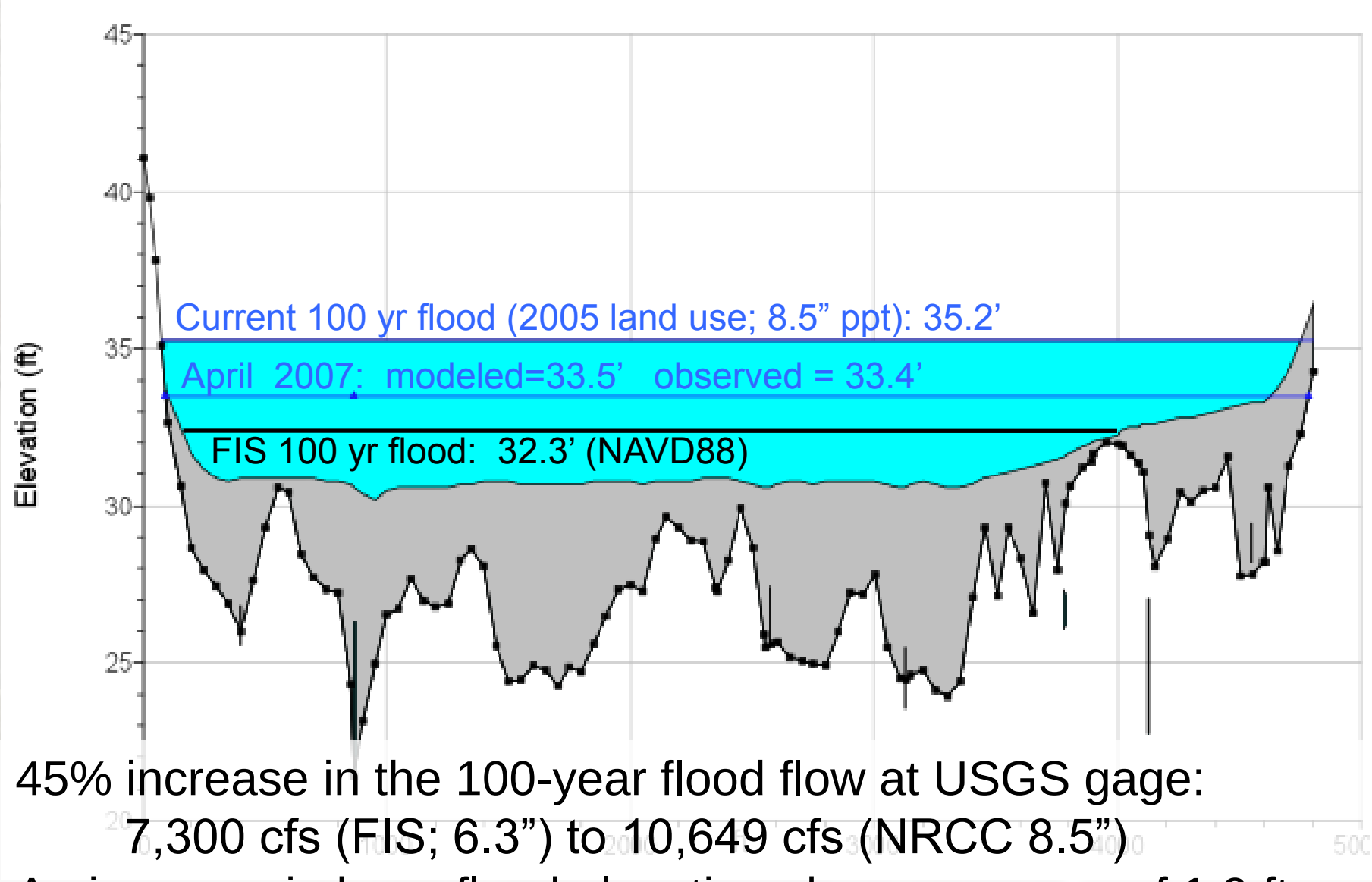
Land Use Conditions	Max 24-hr Precipitation (in)			
	FIRM	Current Climate	2050	2100
FIRM	6.3			
2005		8.5		
Conventional Build-out			8.5	11.4*
Build-out with LID			8.5	11.4*

*Represents maximum value from downscaling output from four GCMs (CCSM, GFDL, HADCM3, PCM) for a high emissions scenario (A1Fi)



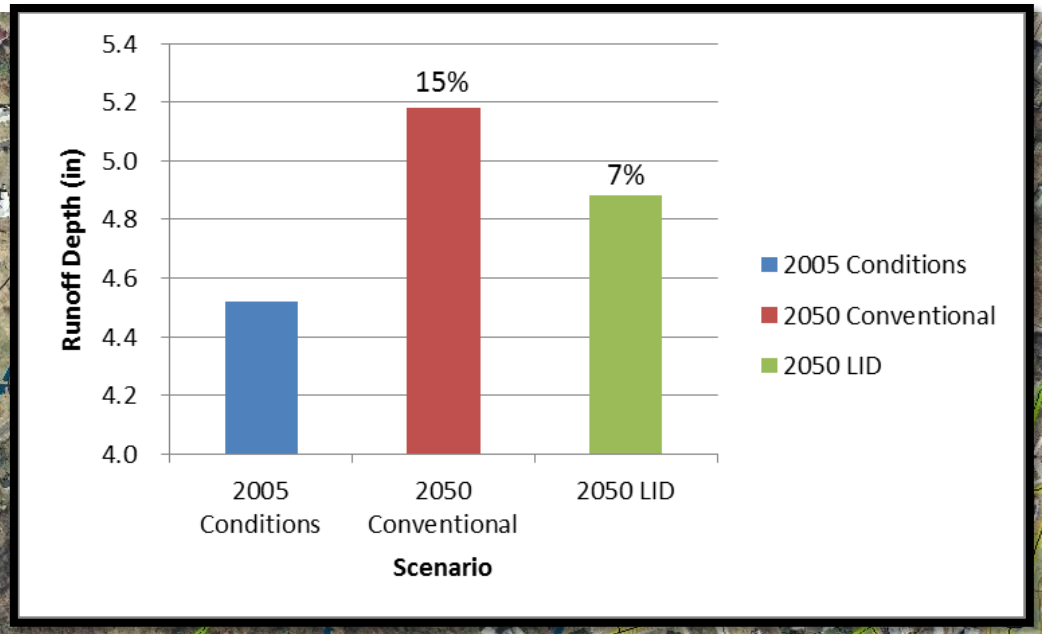
University of New Hampshire · Carbon Solutions New England (CarbonSolutionsNE.org) · SC · Antioch University New England · Great Bay National Estuarine Research Reserve · NOAA

Hydraulics Model – Calibration & Results – RT108



- 45% increase in the 100-year flood flow at USGS gage: 7,300 cfs (FIS; 6.3") to 10,649 cfs (NRCC 8.5")
- An increase in base flood elevations by an average of 1.9 ft along the 36 mile study reach (FIS compared to 2005)

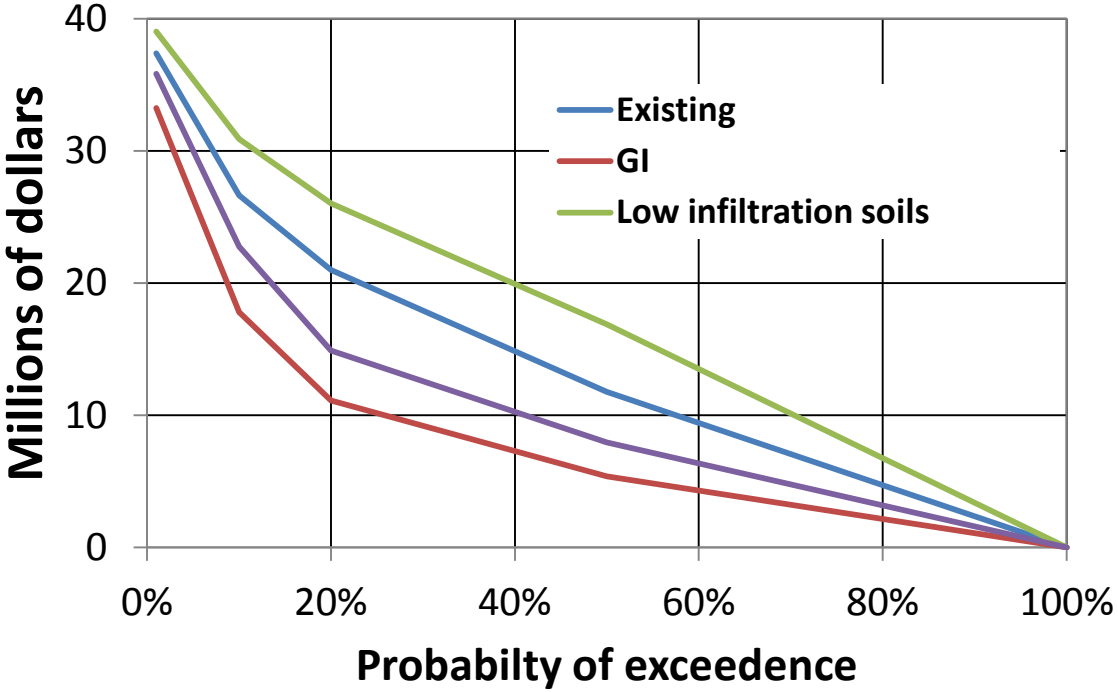
Newmarket, NH Moonlight Brook

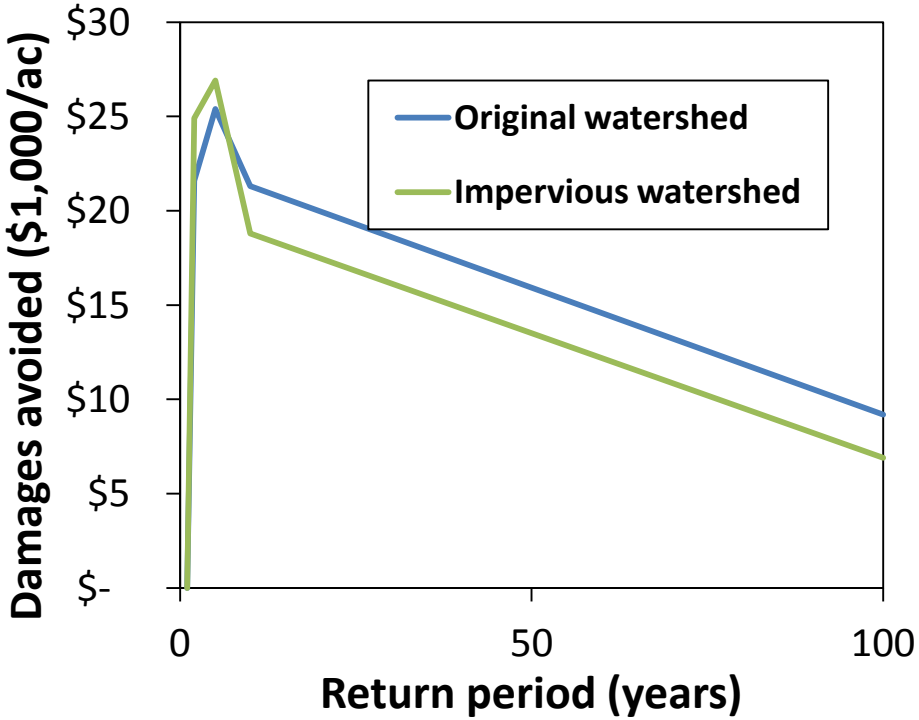


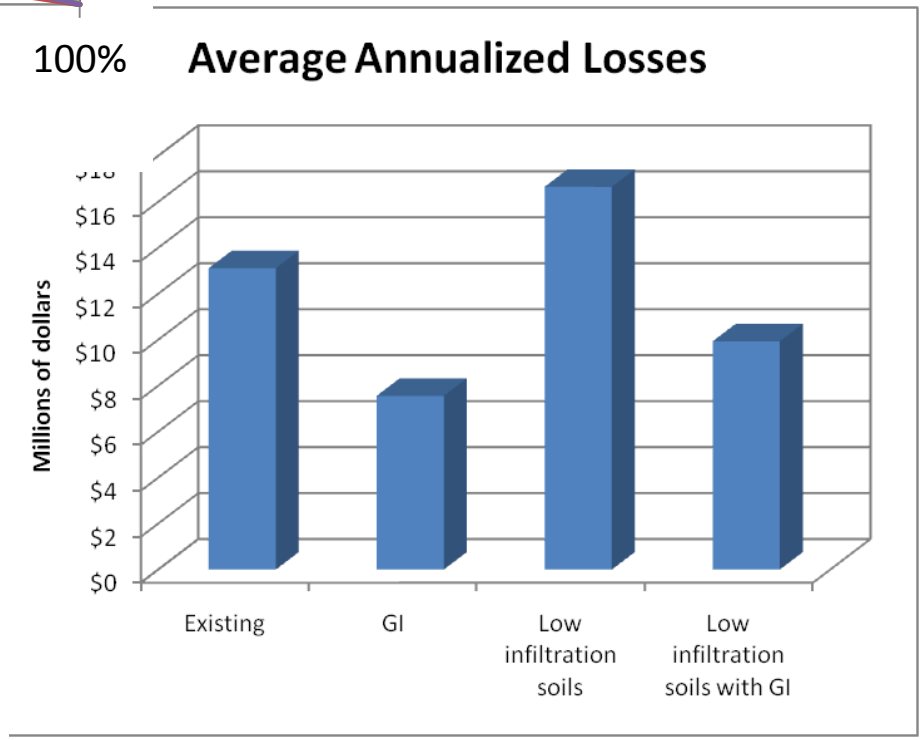
Flood Damage Analysis for GI

ATKINS

Source: Dan Medina, Jacquelyn Monfils, Zachary Baccala







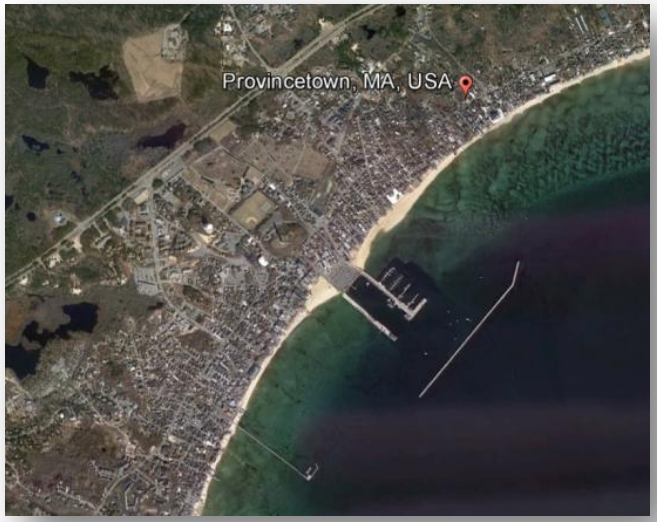
average annualized losses (AAL)= the summation of damages for each individual event multiplied by the probability of occurrence

Resiliency Conclusions

- LID is effective at reducing
  - Peak flows for large, infrequent events
  - Flood elevations
  - Greatest benefit is high impervious cover
- Relative reduction effects are more noticeable for more frequent storms – in some parts of the country
- A good measure of LID benefits for floodplain management is the avoided average annual losses due to flood damage

2012 Provincetown, MA Commercial Street Reconstruction

- 3000 feet of porous roadway
- Widespread infiltration will help address flooding, stormwater and beach impairments which occur from the discharge of untreated runoff from many outfalls.
- Manage runoff from Commercial Street, and rooftop runoff
- Evaluated the structural load capacity, suitability of the native soils, hydraulic loading upon the groundwater table



GHD

SC UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER

Geosyntec consultants engineers | scientists | innovators

2012 Cottages at Capstone, Durham, NH

- 600+ Bed Student Housing complex
- Located in drinking water supply area
- Watershed impaired for Nitrogen
- Included gravel wetlands, porous pavements

Tighe&Bond

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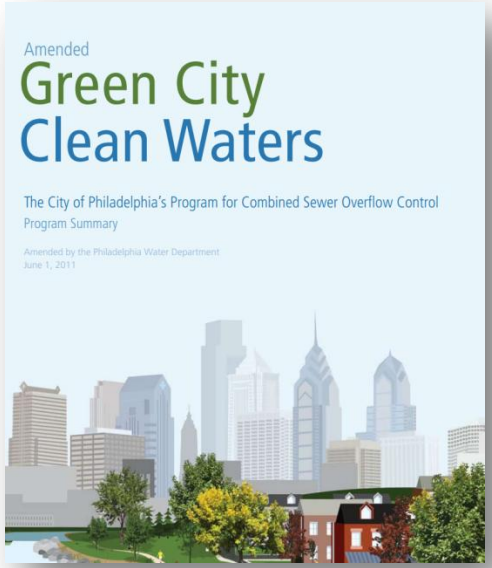
2011 Philadelphia
Green City, Clean Waters Program



LTCP--$2 billion over 25 years to become the greenest city in country---cleaner water for our citizens, cleaner air, a higher quality of life and meaningful jobs for future generations

Philly GI Programs

- Green Streets - public right-of-ways using tree trenches, planters, bump-outs, and pervious pavements.
- Green Schools --Schools are important neighborhood anchors and therefore offer excellent opportunities to educate the local community
- Green Public Facilities-- Allows public facilities to lead by example.
- Green Parking-- Retrofit and redesign of existing parking lots presents an opportunity to reduce stormwater runoff while also improving the visual appearance within communities.
- Green Parks- Enhances the visual appearance and the amenities at parks, in addition to managing stormwater runoff, and implement highly visible demonstration projects.
- Green Industry, Business, Commerce, and Institutions-- Regulations for development and redevelopment and the parcel-based billing for stormwater management services provide incentives for private entities to install green stormwater infrastructure.
- Green Alleys, Driveways, and Walkways– Infiltration retrofit of underutilized areas
- Green Homes--- Work with homeowners to help them undertake projects to mitigate the impact of roof runoff.

2011 Berry Brook Urban Watershed Renewal, Dover, NH

- Impervious Cover Reduction through the targeted implementation of Low Impact Development
- Stream and Wetland Restoration, and Base Flow Augmentation,
- Community Engagement and Public Participation.

2010 State Street Reconstruction Portsmouth, NH

- Award-winning CSO separation with GI in historic downtown
- Included tree filters, bioretention systems, and subsurface detention and filtration.

CMA ENGINEERS

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2009 Long Creek Watershed S. Portland, ME

- Surface Transportation ARRA Project
- First DOT PA road in the northeast-Sept 09
- 1500 feet of 6 Lane Highway Reconstruction
- 20,000 vehicles per day
- 2% cost differential in comparison with std build

MaineDOT

Acknowledgements

Friends and Colleagues at the UNHSC

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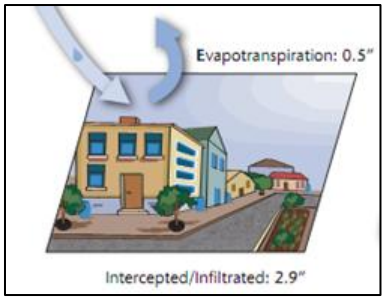
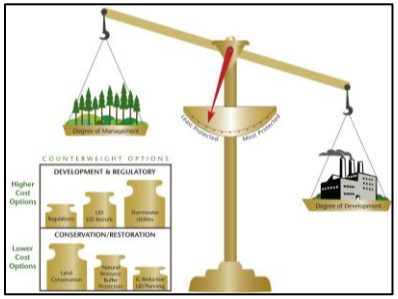
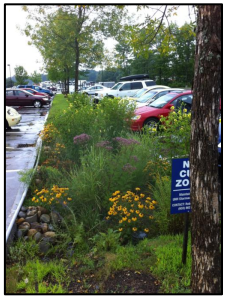
- Bill Owen, P.E., Engineering Services with the City of Portland Bureau of Environmental Services;
- Peter Mulvaney, Sustainable Infrastructure Administrator for the City of Chicago Department of Water Management.

Volunteer municipal decision makers that participated in the development of this project.

Questions?


Evapotranspiration: 0.5"
Intercepted/Infiltrated: 2.9"


COUNTERWEIGHT OPTIONS
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