Greening Your Community

Cost-effective LID solutions

conserve restore protect save money

Worcester, MA
September 30, 2015

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NEIWPCC
New England Interstate Water Pollution Control Commission

This project was funded by an agreement (CE96184201) awarded by the Environmental Protection Agency to the New England Interstate Water Pollution Control Commission on behalf of the Narragansett Bay Estuary Program.

NARRAGANSETT BAY ESTUARY PROGRAM

Mass Audubon
Protecting the Nature of Massachusetts

CMRPC
Central Massachusetts Regional Planning Commission

Horsley Witten

The Blackstone River Coalition

SHAPING the Future of YOUR COMMUNITY

Overview

- CMRPC: Welcome & Technical Assistance
- Mass Audubon's Shaping: Introduction of problem and solutions
- Blackstone River Coalition: Water quality monitoring
- Horsley Witten: Case study review
- Wrap up & questions

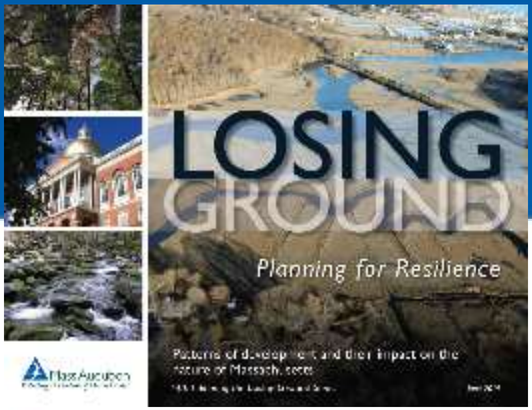
What is Low Impact Development?

“ LID is an approach to land development (or re-development) that **works with nature to manage stormwater** as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that **treat stormwater as a resource** rather than a waste product. ”

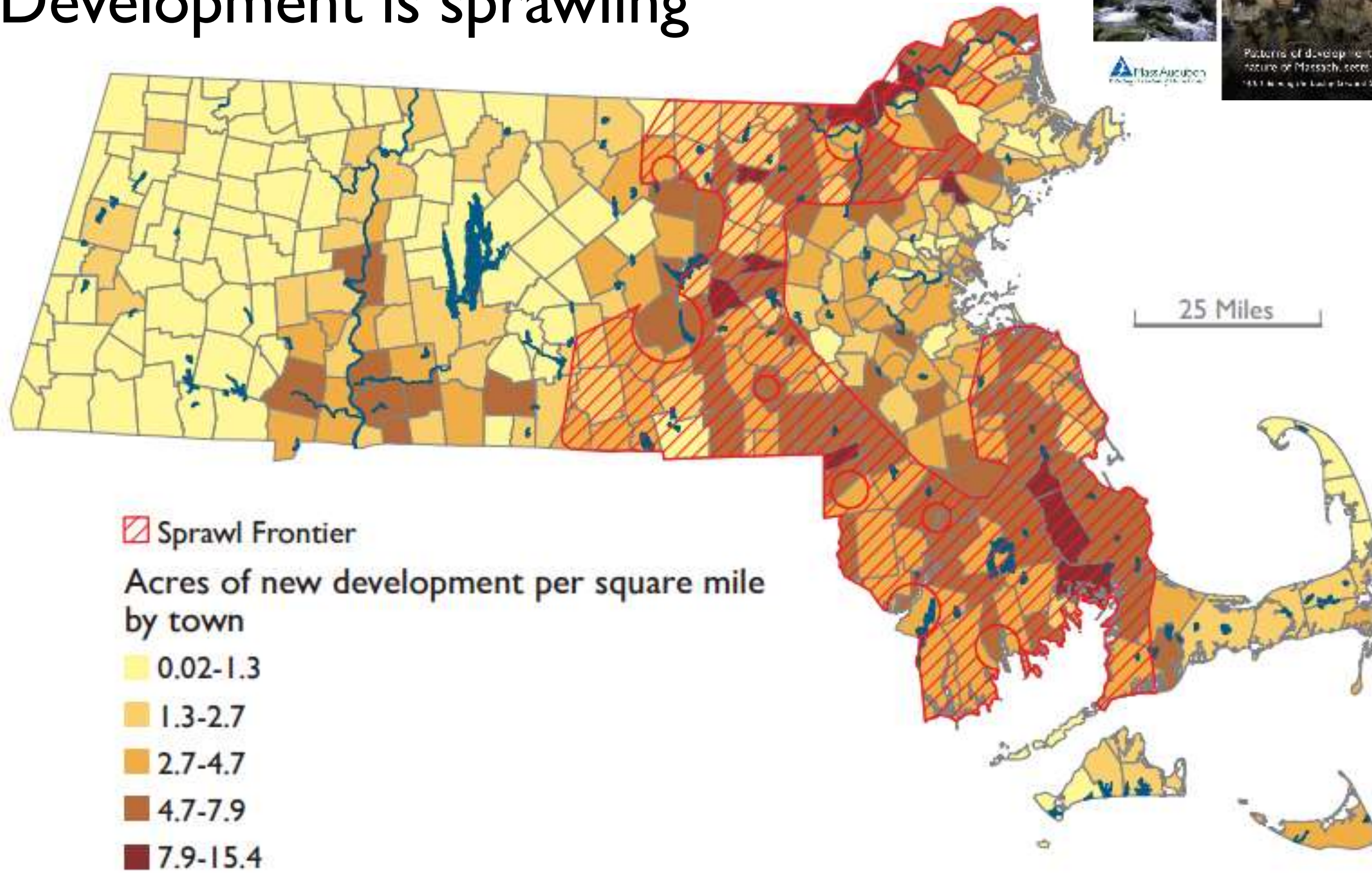
- EPA

Source Whole Buildings Design Guide

What's the Problem?

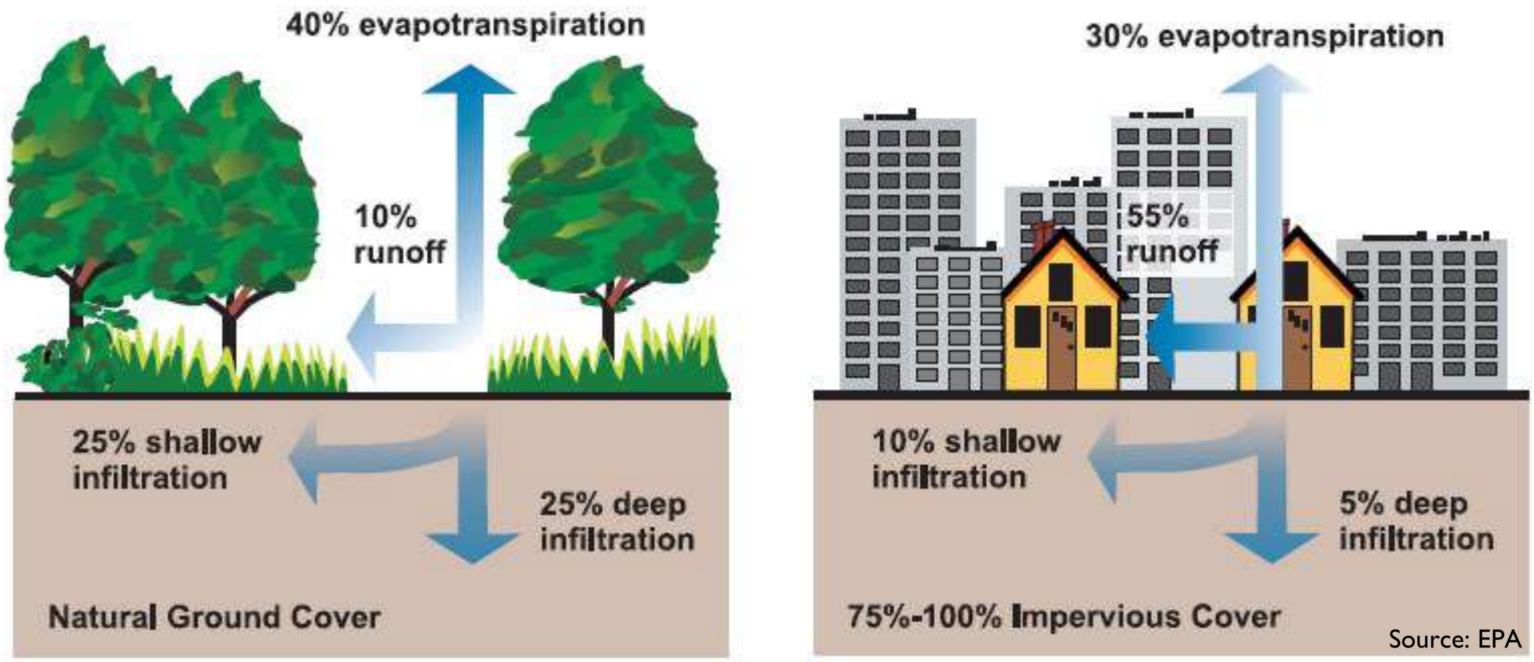


Development is sprawling



What's The Problem?

Everywhere we develop, we reduce our resilience



Source: EPA

We Need to Change Course

Traditional development

Impervious surfaces

Stormwater runoff

Water quality impairment

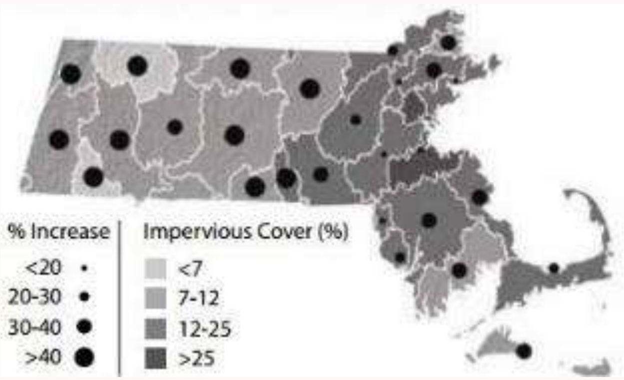
Infrastructure impacts

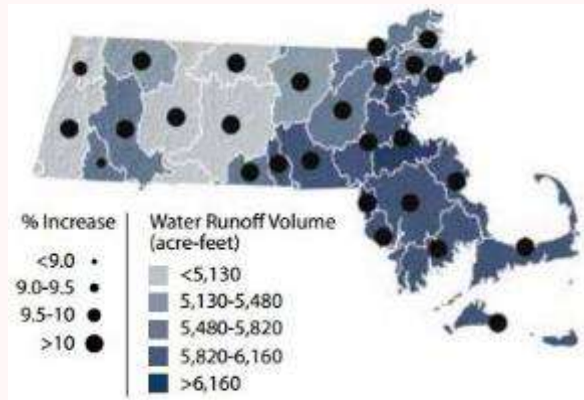
Financial and regulatory burden

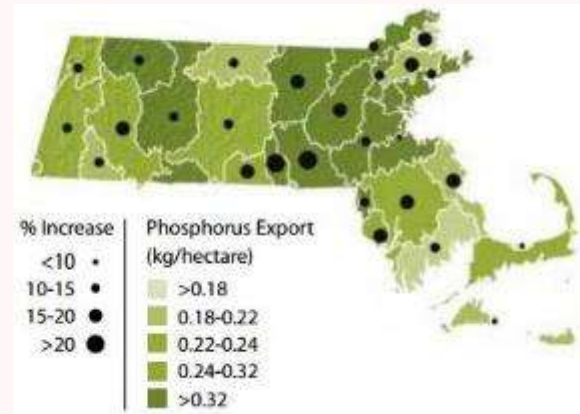
The Value of Green: Impervious, Runoff, Nutrients

Source: Harvard Forest *Changes to the Land* 2014

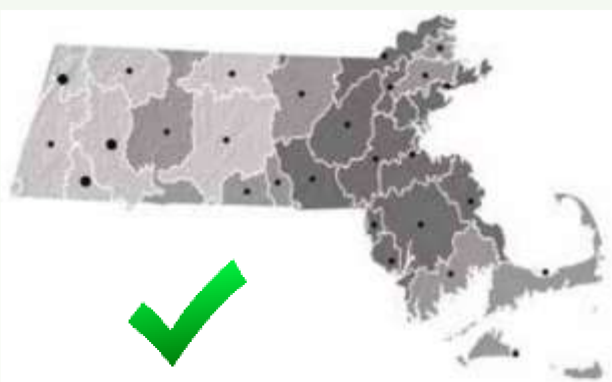
If we continue to follow opportunistic growth, in 2060:

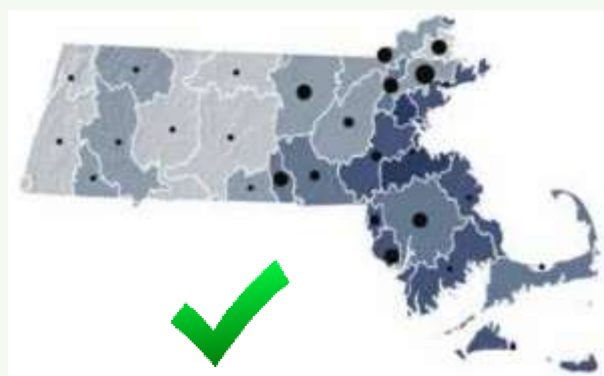


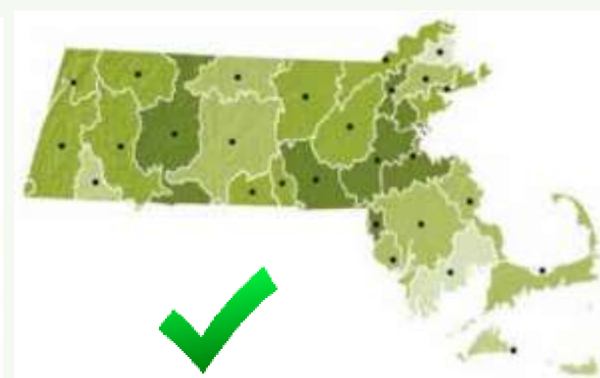




If we value forests as infrastructure, in 2060:







The Value of Green: Reducing Runoff

Source: Harvard Forest *Changes to the Land* 2014

By 2060	Number of MA watersheds experiencing >10% increase in runoff
Opportunistic Growth	25
Forests as Infrastructure	1

"Forests as Infrastructure" allows for nearly the **same amount of development** as what we're experiencing now, but 2/3 of it is **clustered** development.

A Different Direction: Greening Your Community

Sustainable development

Increased infiltration

Reduced runoff & more groundwater

Improved water quality

Intact infrastructure

Regulations met

Money saved

Start Here.

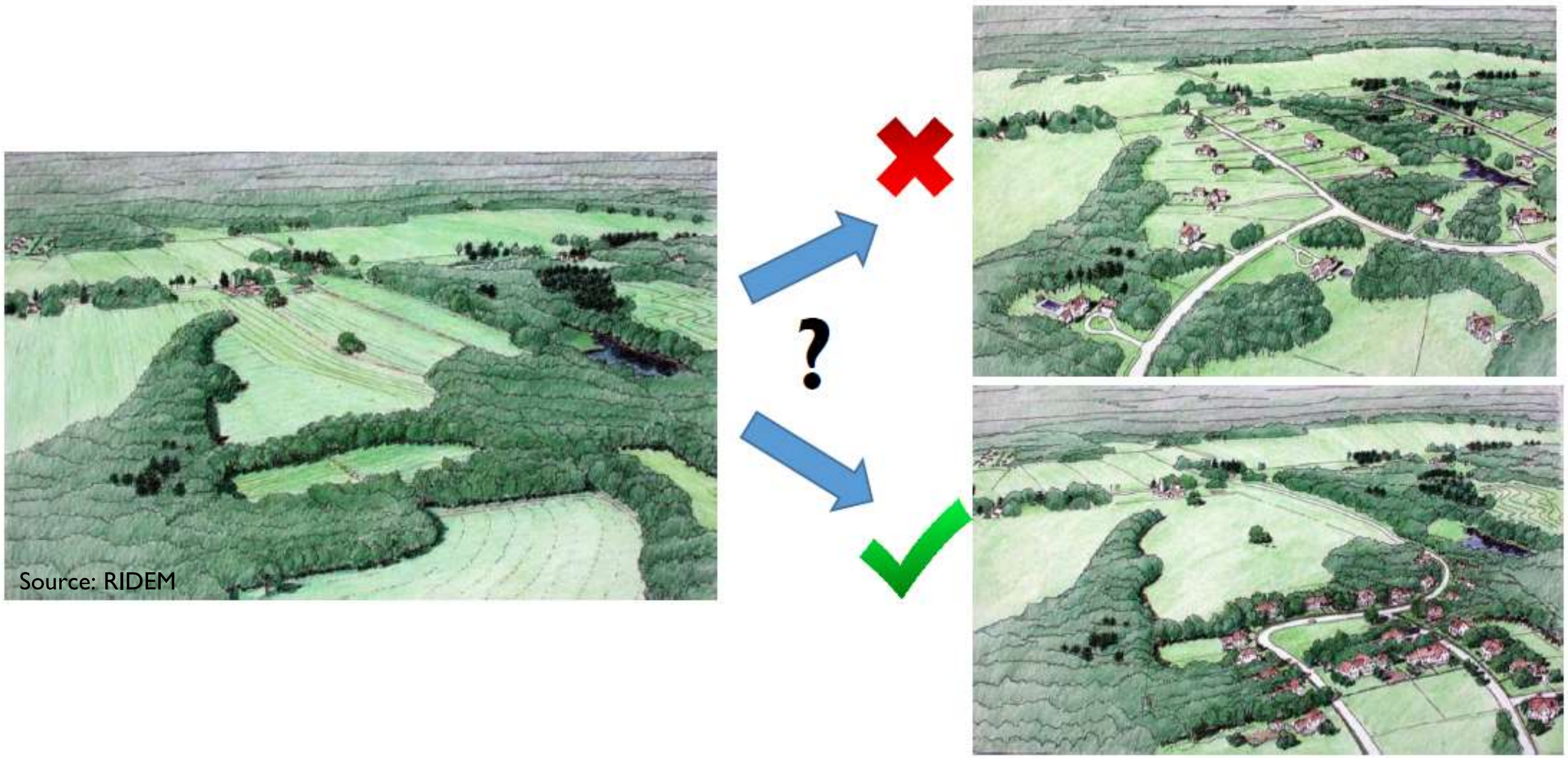
Conserve the natural green infrastructure already providing free ecosystem services
Incorporate LID and green infrastructure design into development
Restore the resiliency of urban landscapes through LID in redevelopment

Conserve

Conserve the natural green infrastructure already providing free ecosystem services

Integrate LID and green infrastructure designs into current development projects

Restore the resiliency of urban landscapes through LID in redevelopment



Integrate

Conserve the natural green infrastructure already providing free ecosystem services

Integrate LID and green infrastructure designs into current development projects

Restore the resiliency of urban landscapes through LID in redevelopment

Source: Center for Neighborhood Technology

Restore

Conserve the natural green infrastructure already providing free ecosystem services
Integrate LID and green infrastructure designs into current development projects
Restore the resiliency of urban landscapes through LID in redevelopment

Benefits of LID Practices

Benefit	Reduces Stormwater Runoff											Improves Community Livability						
	Reduces Water Treatment Needs	Improves Water Quality	Reduces Grey Infrastructure Needs	Reduces Flooding	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 Aesthetics	Increases Recreational Opportunity	Reduces Noise Pollution	Improves Community Cohesion	Urban Agriculture	Improves Habitat	Cultivates Public Education Opportunities
Practice										CO_2								
Green Roofs	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Maybe	Yes	Maybe	Maybe	Yes	Yes
Tree Planting	Yes	Yes	Yes	Yes	No	Maybe	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Maybe	Yes	Yes
Bioretention & Infiltration	Yes	Yes	Yes	Yes	Maybe	Maybe	No	No	Yes	Yes	Yes	Yes	Yes	Maybe	Maybe	No	Yes	Yes
Permeable Pavement	Yes	Yes	Yes	Yes	No	Maybe	Yes	Maybe	Yes	Yes	Yes	No	No	Yes	No	No	No	Yes
Water Harvesting	Yes	Yes	Yes	Yes	Yes	Maybe	No	Maybe	Maybe	Maybe	No	No	No	No	No	No	No	Yes

Yes Maybe No

Source: Center for Neighborhood Technology's The Value of Green Infrastructure

Free Ecosystem Services:

Free services provided by the natural landscape

For every $1 invested in land conservation, there is a $4 *Return on Investment* in terms of these ecosystem service values

- **Flooding**: Floodplains provide flood protection and reduce infrastructure damage
- **Public Health**: Managing stormwater and reducing retention ponds reduces creation of mosquito habitat
- **Air Quality & Public Health**: Trees reduce the urban heat island effect, reducing smog creation and resulting asthma occurrences as well as reducing nitrogen dioxide and particulate matter
- **Water Quality**: Streamside vegetation filters pollutants and reduces erosion
- **Water Quantity**: Forests and wetlands store water, improve water quality, and recharge groundwater
- **Recreation**: Clean, flowing waters support recreation, including boating, fishing, and swimming while open space provides areas for hiking and biking
- **Quality of Life**: Open space and street trees create a more enjoyable walking environment, benefiting community connection, health, and economic benefit in downtowns and commercial areas
- **Property Value**: Healthy, mature trees add an average of 10-30% to a property's value

Addressing Regulations

Possible Action	Addresses Stormwater (MS4)	Addresses Water Management Act Mitigation	Helps with Climate Resilience
Revise bylaws to allow for Low Impact Development	★	★	★
Require porous pavement in certain situations, and allow for curb cuts to improve drainage to swales	★	★	★
Culvert replacements meeting stream crossing standards		★	★
Acquire/preserve property for resource protection	★	★	★

Source: Resilient Taunton Watershed Network

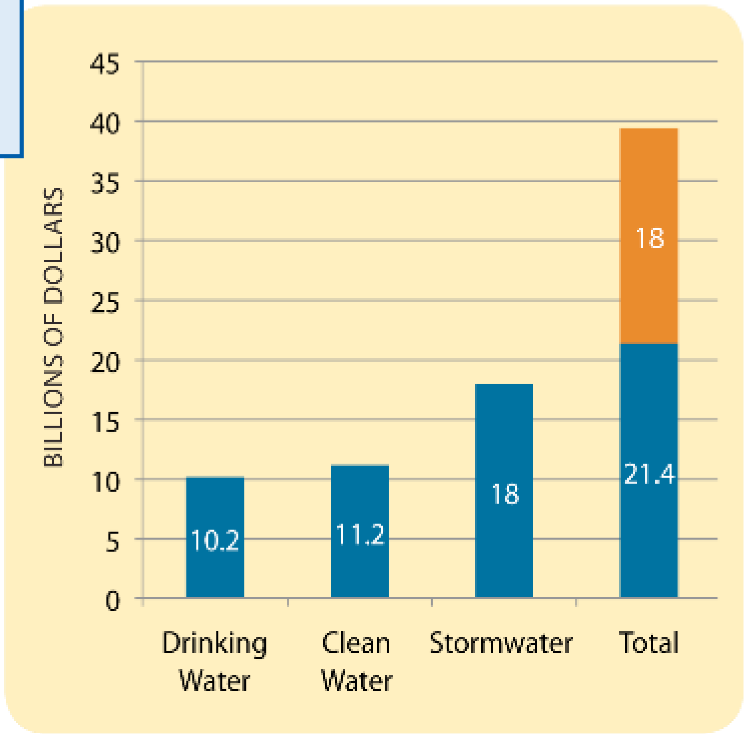
The Value of Green: Stormwater Infrastructure

Already facing a projected $18 billion in stormwater upgrades over the next 20 years

Climate change → increased wet weather → increased flooding

" As Massachusetts faces water management challenges related to aging civil waterworks and more intense storms, forest protection and land use offer a low-cost option for minimizing stormwater challenges and maintaining water quality. "

- Harvard Forest: Changes to the Land

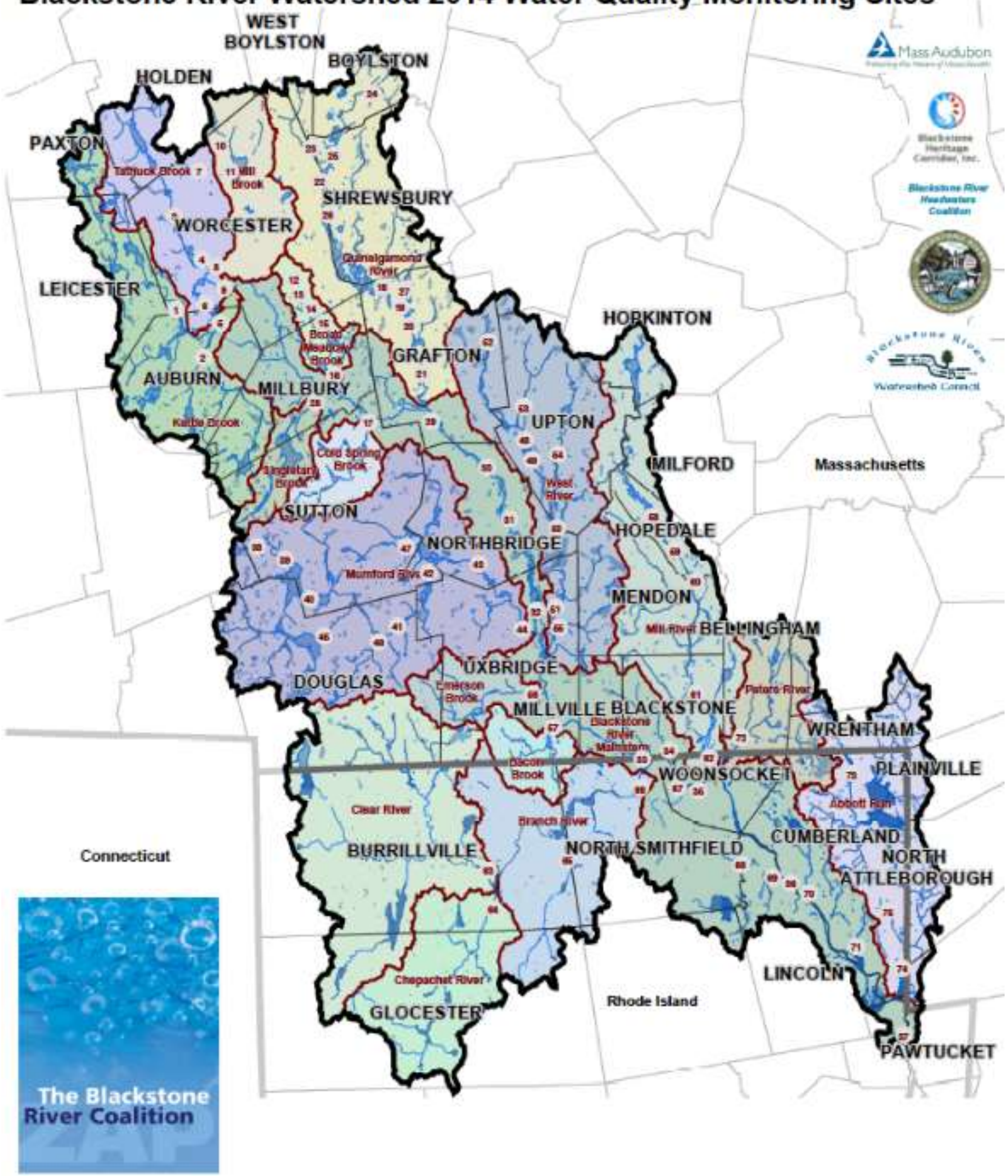


Gap in water infrastructure funding over next 20 years, Water Infrastructure Finance Commission, 2012

Blackstone River Coalition Water Quality Monitoring

- Conducted on monthly basis since 2004.
- Volunteers trained to monitor 75 sites from Worcester to Pawtucket.
- Data collected on site conditions including temperature, erosion, and water appearance.
- Tests run for turbidity, nutrients, dissolved oxygen, and conductivity.
- QAPP approved by EPA, MA DEP & RIDEM.

Blackstone River Watershed 2014 Water Quality Monitoring Sites



Worcester Area Sites

- Tatnuck Brook
- Kettle Brook
- Beaver Brook
- Broad Meadow Brook
- Ford Brook
- Delaney Brook
- Coal Mine Brook
- Poor Farm Brook
- Sewell Brook
- Middle River
- Leesville Pond

Indicators of Water Quality

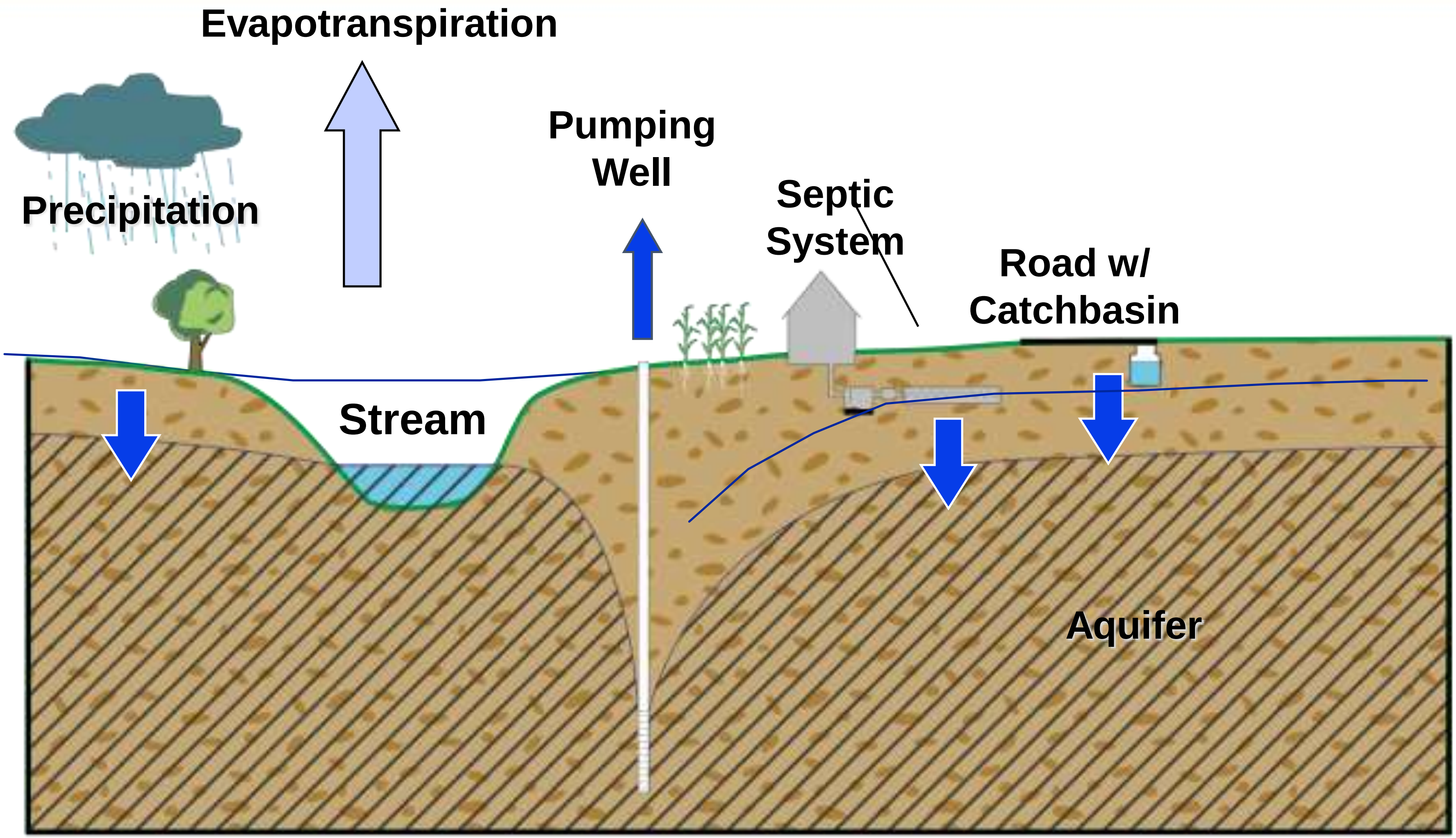
- **Dissolved Oxygen:** sufficient levels required for aquatic organisms to survive; higher standards set for cold water fisheries like trout.
- **Turbidity:** from local erosion and off-site runoff; can increase temperature and decrease oxygen, impair plant growth, and harm or kill aquatic organisms.
- **Phosphate & Nitrate:** Excess levels from storm runoff and point sources can cause algal blooms that reduce dissolved oxygen, leading to fish kills.
- **Conductivity**: Sudden shifts from baseline levels can indicate presence of petroleum or animal waste.

- **Bacteria:** presence indicates input of animal or human waste; elevated levels are harmful to aquatic life, and impairs drinking water for humans.

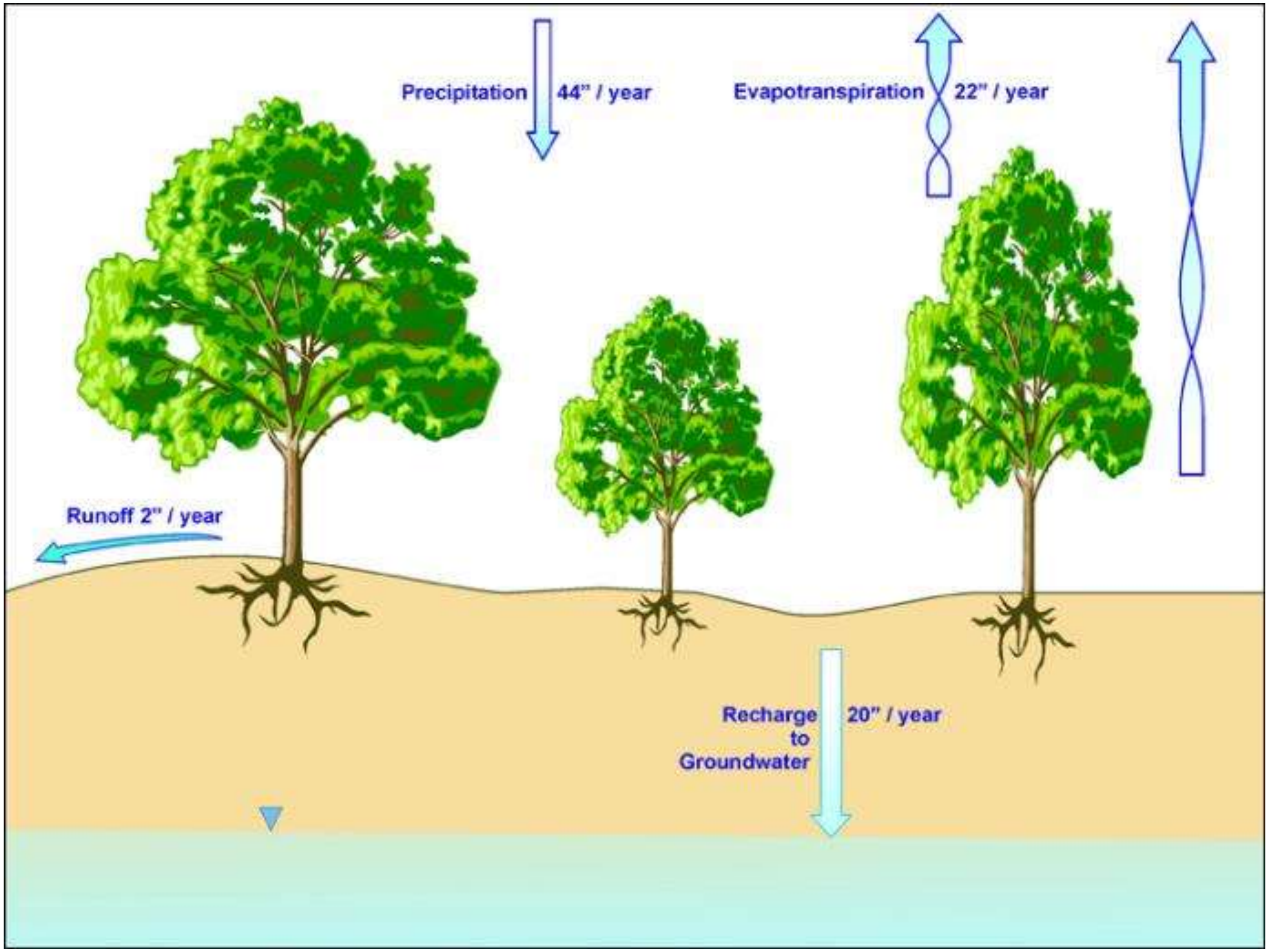
Examples of Impaired Water Quality: 2014 Field Season

- Coal Mine Brook - Plantation Street, Worcester Nutrient level graded “poor”.
- Poor Farm Brook - N.E. Cutoff, Worcester, Nutrient level graded “poor”.
- Sewall Brook on Holden Street, Shrewsbury Dissolved Oxygen graded “poor”.

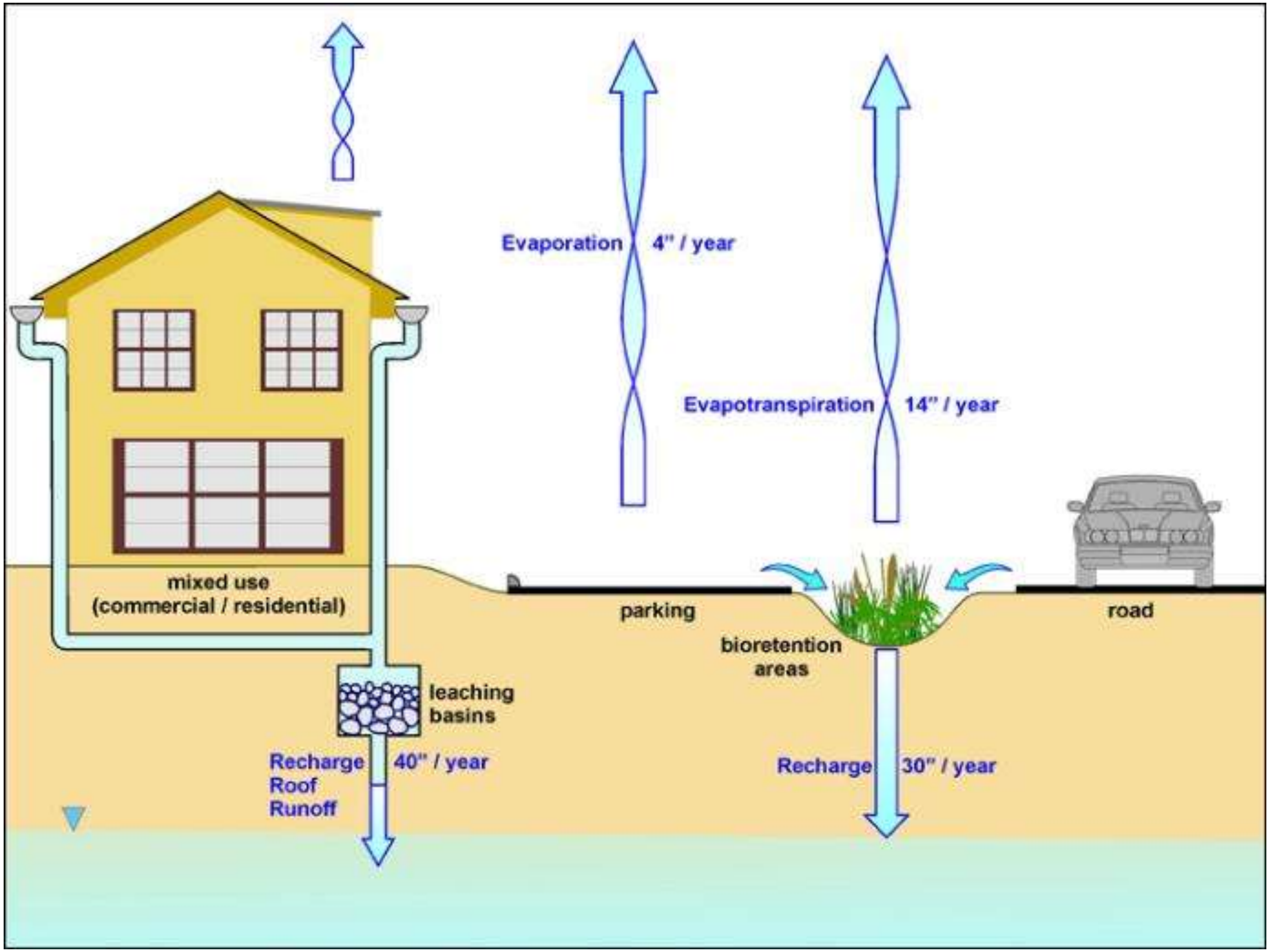
Hydrologic Budget



Pre-Development



Positive Impact Development

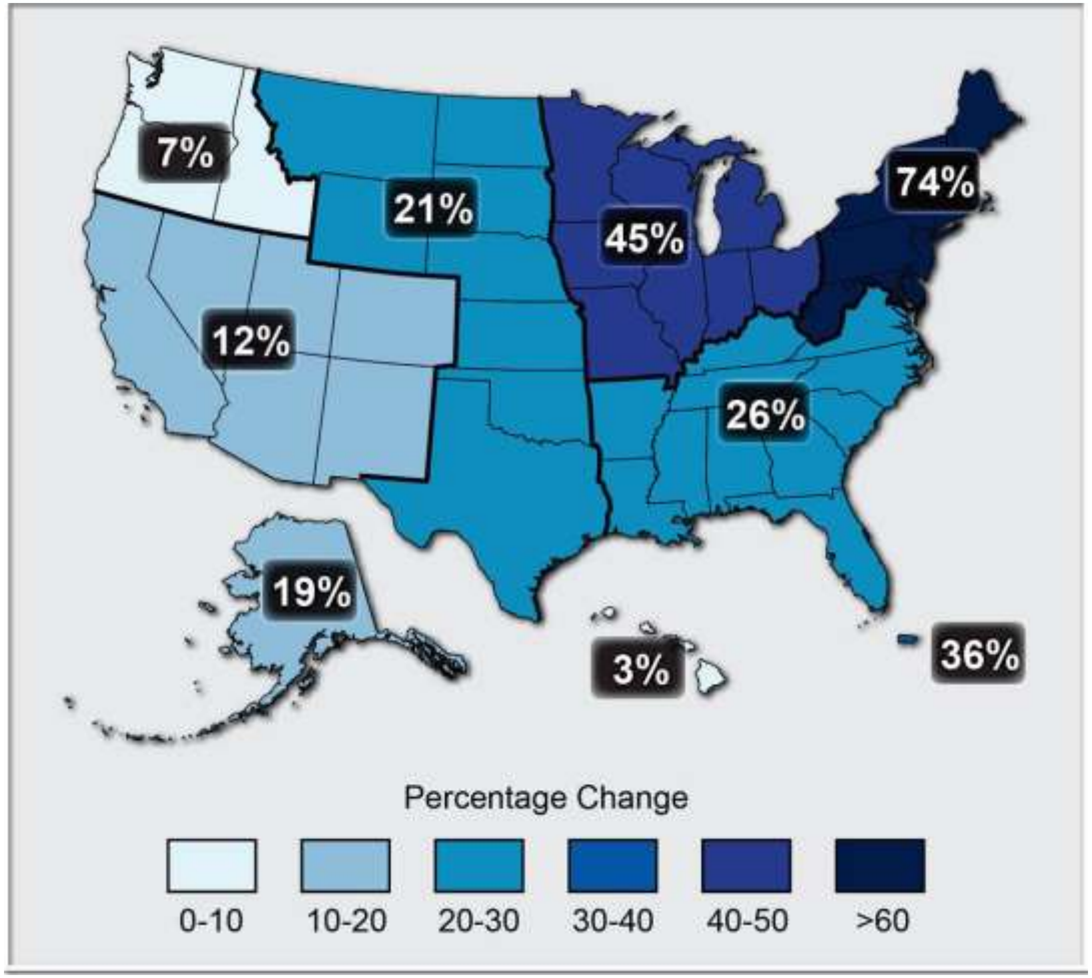


100-Year Design Storms (inches)

	Springfield	Worcester	Boston
TP40 Design Storm (1930 – 1960)	6.5	6.5	6.6
Cornell Design Storm (1936 - 2008)	8.8	8.8	8.8

Hydrology Handbook for Conservation Commissions: Appendix F. Rainfall Data for Massachusetts from Rainfall Frequency Atlas of the United States (TP-40). Users of this Handbook should note that current MA DEP written guidance (see DEP Waterlines newsletter -- Fall 2000) requires the use of TP-40 Rainfall Data for calculations under the Wetlands Protection Regulations and the Stormwater Management Policy. More stringent design storms may be used under a local bylaw or ordinance.

Observed Changes in Storm Intensities



National Climate Assessment 2014

Stormwater Design for Climate Change

TABLE 5-2 Rainfall Design Depths from Climate Change for Oyster River Infrastructure Vulnerability Assessment

25-YEAR, 24-HOUR PRECIPITATION (IN.)				
	TP-40	1971-2000 (Baseline)	2046-2075 (A1b)	2046-2075 (A1fi)
+95% c.i.	5.1	7.46	9.53	12.22
"most likely"		5.37	6.86	8.35
-95% c.i.		3.85	4.92	5.66

Source: University of New Hampshire

Key Stormwater Regulations

Federal Clean Water Act, National Pollutant Discharge Elimination System (NPDES):

- EPA 2003 MS4 Permits
- EPA General Stormwater Permit (MA) *(expected 2016??)*

Massachusetts Initiatives:

- MA Stormwater Standards (jurisdiction under Wetlands Protection Regulations)
- MA Water Management Act (Sustainable Water Management Initiative, SWMI)
- MA Climate Change Adaptation Report/Regulatory Changes

Local Ordinance/Bylaw/Regulations (required MS4)

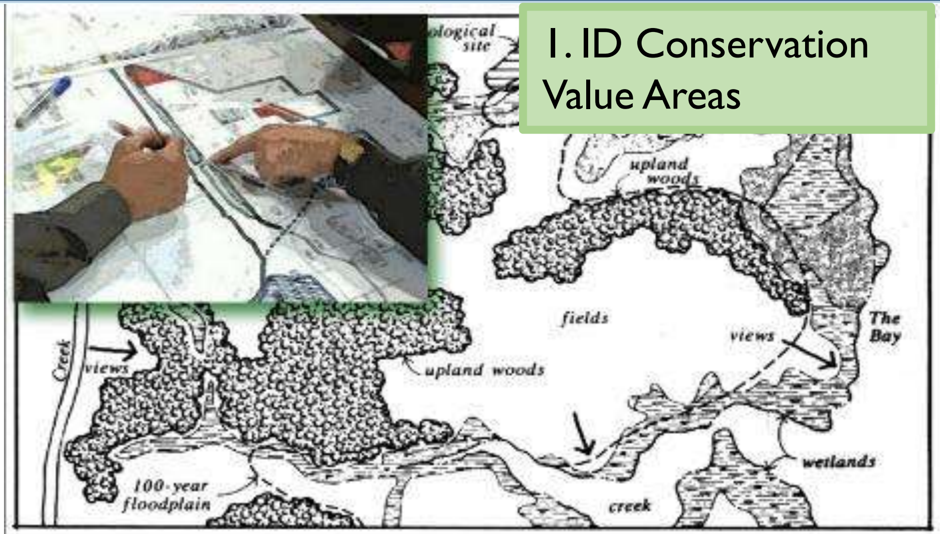
Water Quality Degradation: Eutrophication

Sources of Phosphorus in Stormwater

Upper Charles River Watershed

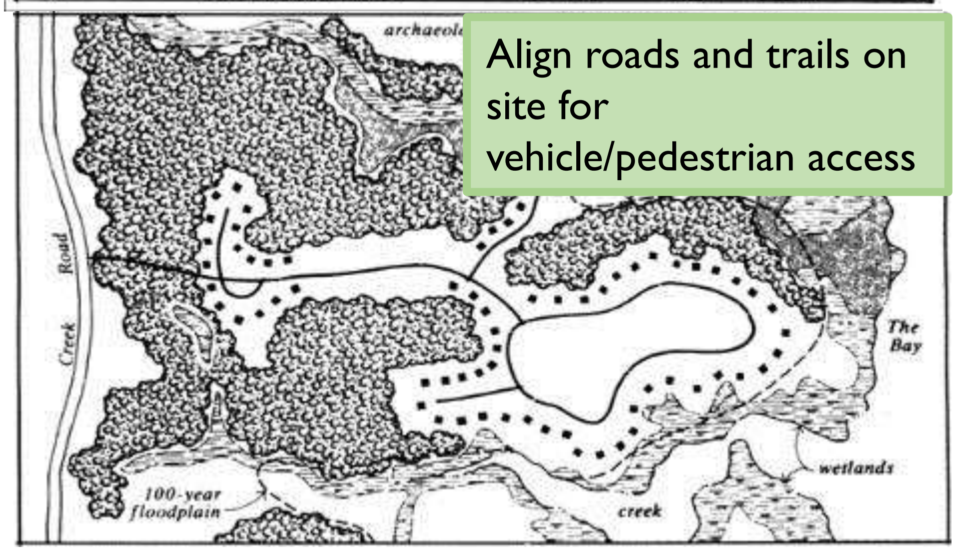
Source	Annual Phosphorus Input (kg yr^{-1})	Annual Phosphorus Loading (kg yr^{-1})	Percent of Total Load
Turf and Fertilizer Runoff	*174.13*	*24.33*	*18%*
Dog Waste	*232.22*	*23.22*	*18%*
Leaf Litter (Street Trees) Trees)	*27.92*	*20.94*	*16%*
Atmospheric Deposition Deposition	*126.19*	*19.00*	*14%*
Other	*unknown*	*13.08*	*10%*
Forest Runoff	*unknown*	*12.41*	*9%*
Winter Road Treatments Treatments	*6.64*	*6.64*	*5%*
Car Washing	*8.03*	*6.43*	*5%*
Motor Vehicle Traffic	*4.01*	*4.01*	*3%*
Grass Clippings	*569.06*	*1.48*	*1%*
Total	*1,148.20*	*131.54*	*100%*

Conservation Subdivisions

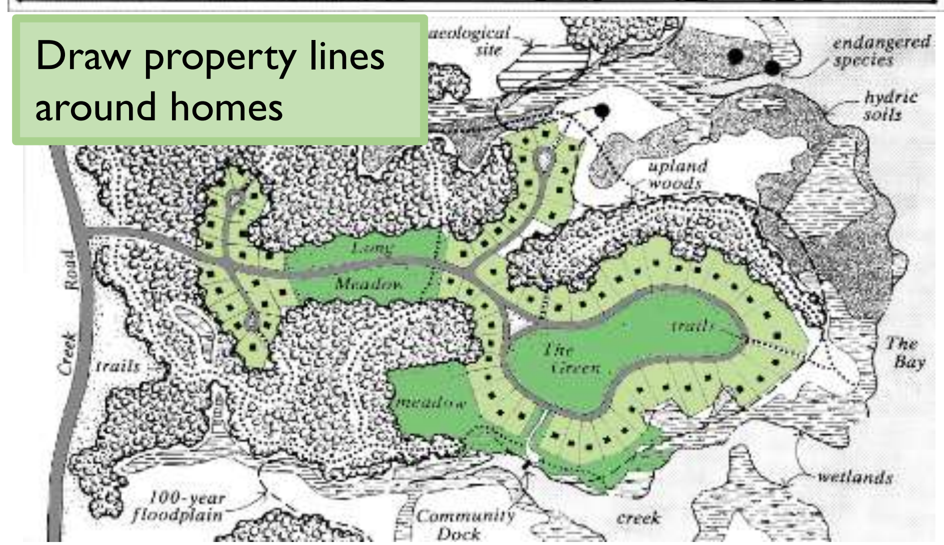


1. ID Conservation Value Areas

2. Place houses in remaining area to maximize access and views of open space



Align roads and trails on site for vehicle/pedestrian access



Draw property lines around homes

LID Stormwater Management Techniques

- Rain Barrels and Cisterns / Water Re-use
- Stormwater Planters, Tree Planting
- Permeable Paving
- Open Channels
- Bioretention
- Stormwater Wetlands
- Green Rooftop Systems
- Vegetative Buffers
- Infiltration

Permeable Pavement

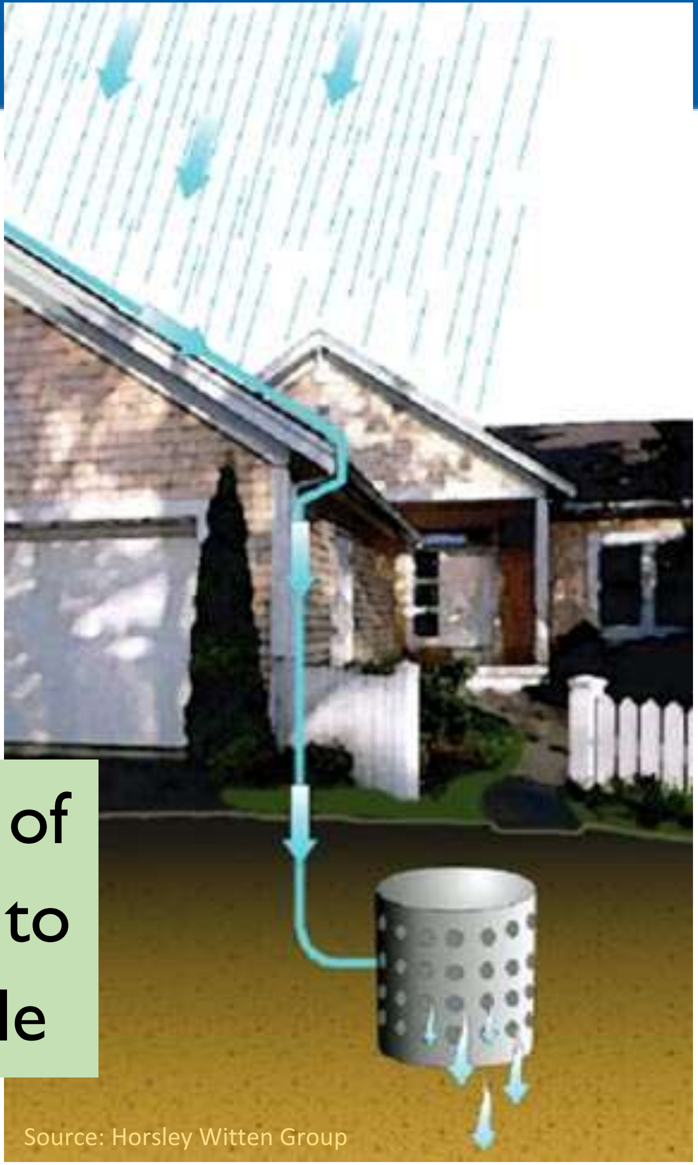

Circle #18 on Reader Service Card

Rain Barrels and Cisterns
Runoff Reduction & Water Conservation

- Downspouts directed to tanks or barrels
- 50 –10,000 gallons
- Excess diverted to drywell or rain garden
- Landscaping, car washing, other non-potable uses

Dry Well Infiltration of Roof Runoff

Disconnection of rooftop runoff to vegetated swale



Vegetated Swales
Conveyance, Treatment, Infiltration

- Roadside swales ("country drainage") for lower density and small-scale projects
- For small parking lots
- Mild side slopes and flat longitudinal slopes
- Provides area for snow storage & snowmelt treatment

Bioretention Applications

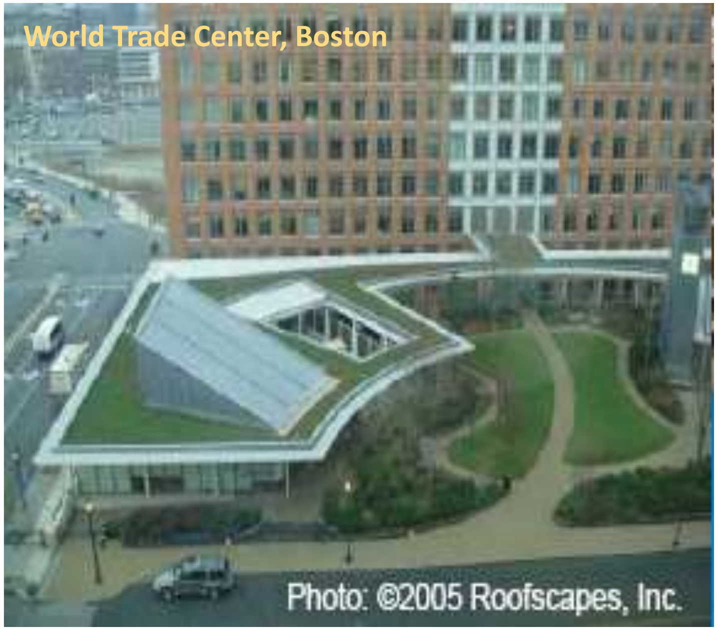
- Parking lot islands
- Median strips
- Residential lots
- Office parks

Reducing Impervious Surfaces

Rain Garden

Green Roofs

- Stormwater Runoff absorption/collection
- Reduced flooding of and damage to urban streets
- Interior heating and cooling benefits of 10 degrees or more
- Air purification
- Recreational amenity
- Improved aesthetics
- Extended roof life, estimated at 40 years



Green Roofs

Stormwater Planters

- Vegetative uptake of stormwater pollutants
- Pretreatment for suspended solids before they reach water-treatment facilities
- Aesthetically pleasing
- Reduction of peak discharge rate

Pet Waste Management

IMPLEMENTATION OF GREEN INFRASTRUCTURE

NYC Program Overview / Disston Park & American Legion Park

July 11, 2013

Eric Lienhard, PE
Dahlia Thompson, PE
Matthew Jones, PE, PhD
Richard Claytor, PE
Jennifer Reiners, PE

HAZEN AND SAWYER
Environmental Engineers & Scientists

Horsley Witten Group
Sustainable Environmental Solutions

NYC Green Infrastructure Plan

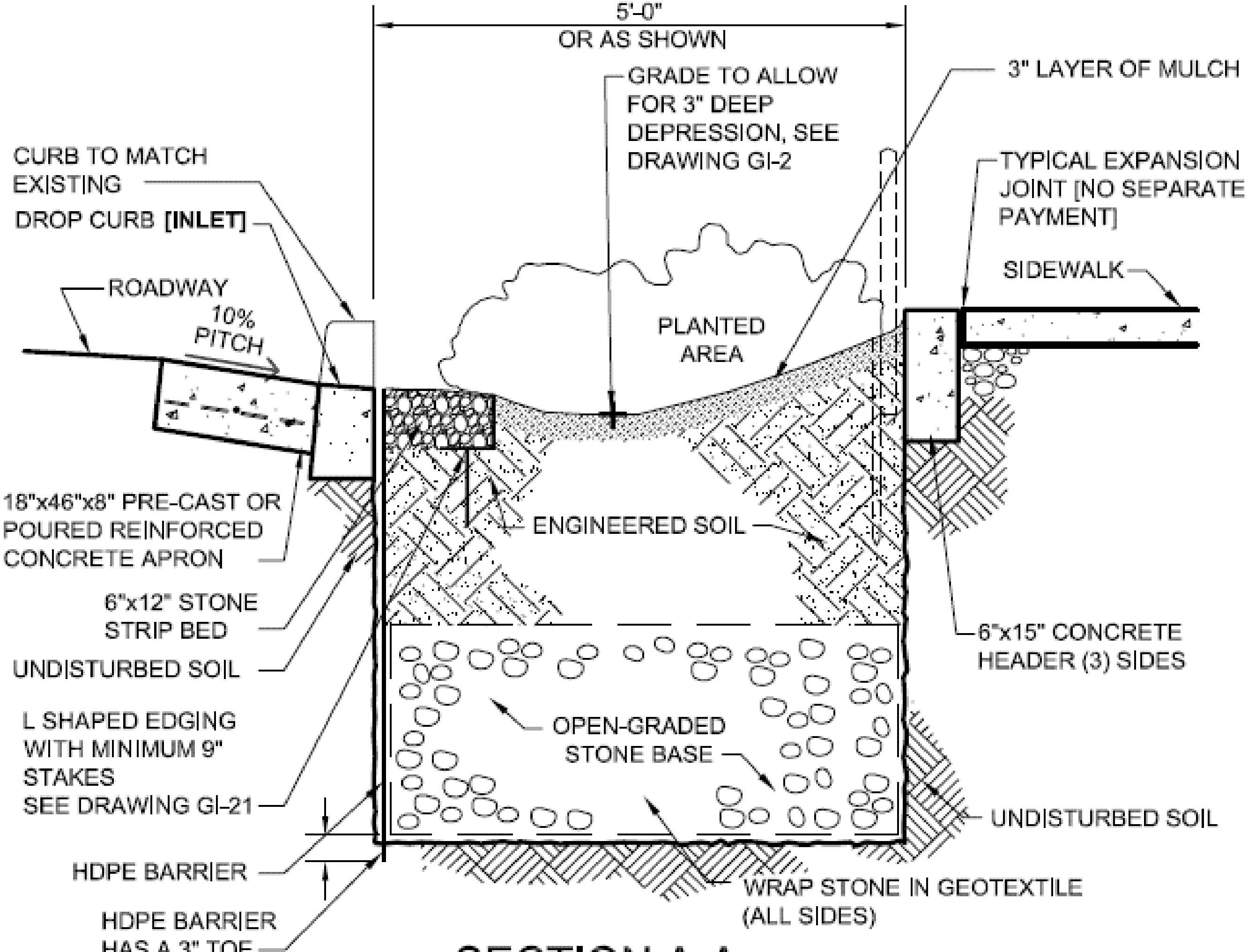
1. Build cost-effective grey infrastructure
2. Optimize the existing wastewater system
3. **Control runoff from 10% of impervious surfaces through green infrastructure and other source controls**
4. Institutionalize adaptive management, model impacts, measure CSOs, and monitor water quality
5. Sustain stakeholder engagement

NYC GI Design Criteria

HAZEN AND SAWYER
Environmental Engineers & Scientists

Horsley Witten Group
Sustainable Environmental Solutions

ROW Bioswale Standard Details



SECTION A-A
AT BIOSWALE INLET

Bioswales in Right of Way

The Value of Green: Redevelopment of Devens, MA

- Army base transformed into modern community
- Requires LID for all new and redevelopment projects, including retention of native vegetation
- Narrower roads and bioswales reduced impervious surfaces and increase infiltration
- Each home has a rain garden to manage its own stormwater runoff

27 Jackson Road

Total Traditional Project Cost:	**$1,004,000**
LID Reduced site paving	-$32,000
LID Reduced curbing	-$50,000
LID Reduced stormwater piping	-$14,000
LID Reduced stormwater structures	-$68,000
LID Increased landscaping	+$12,000
LID Increased site preparation	+$10,000
LID Increased soil mix	+$18,000
Total Estimated LID Savings:	**-$124,000 (12%)**

Apex bio-filtration landscape islands

Development Priorities

- New development avoids steep grades to minimize grading impacts
- Formal green at neighborhood core
- natural features
- Connections to trail network and existing pedestrian friendly streets encourage walking
- Connected back to existing neighborhoods – no “gated community”
- Existing trees maintained to highest degree possible
- Civic spaces that can be programmed by residents

The Value of Green: By The Numbers

Traditional paving costs \$5-7/ft^2. Reducing a just a short two-mile road from 28' to 20' equates to a savings of **\$422,400 - \$591,360**.

That's ***half a million dollars saved*** by reducing a short stretch of pavement by just four feet per lane!

When the entire road is shortened for a condensed subdivision instead of sprawling development, that savings grows to the ***millions***.

Reduced Clearing & Grading

- A 20-unit development with two-acre lots requires 40 acres to be cleared and graded.
- Conservation subdivisions that preserve 50% of land save $200,000-300,000, while maintaining the same amount of development.

The more **land** you save, the more **money** you save.

Benefits of Green Infrastructure & LID

Regulatory

- Assistance in meeting regulatory requirements

Public safety

- Reduced flooding
  - FEMA estimates that 25% of the $1 billion in annual damages from caused by flooding are linked to stormwater
- Improved water quality
- Increased climate change resiliency
- Reduced urban heat island effect

Quality of Life

- Protect and restore natural features for improved aesthetics

Value

- Increased property values 10-30%

Cost Savings

- Reduced development costs for infrastructure and maintenance
- Reduced energy costs for residents
  - One young, healthy tree near a home cools as much as 10 room-size AC units operating 20 hours/day

Leominster Urban Water Quality

- Monoosnoc Brook impacted by phosphorus and other urban runoff issues
- Multiple LID features installed:
  - Bioretention
  - Tree planters
  - Infiltration systems
  - Gravel wetlands

BMP Benefits

Comparison of Nitrogen (N), Phosphorus (P), and Total Suspended Solids (TSS) Reduction:

	Percent reduction:	0	10	20	30	40	50	60	70	80	90	100
Bioretention	N				30-50%							
	P				30-90%							
	TSS									90%		
Deep Sump Catch Basin	TSS			25%								
Gravel Wetlands	N								75%			
	P						58%					
Hydrodynamic Separator	TSS				35%							
Infiltration Trench	N					40-70%						
	P					40-70%						
	TSS									80%		

BMPs By The Numbers

Rain Garden

- $2-12/ft^2 installed
- $200/year in labor for maintenance
- Reduces runoff by 90%
- Reduces N, P, metals, and TSS by 65-90%

Tree Filter

- $20,000 - 25,000 installed
- $200/year in labor for maintenance
- Removes estimated 80% TSS

Source: EEA Project 10-13/319

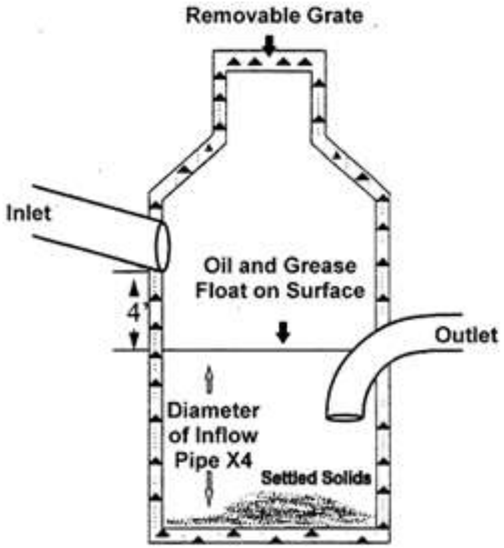
BMPs By The Numbers

Bioswale

- $300-500/year in labor for maintenance (varies by size of swale)
- 70% TSS removal credit with adequate pretreatment

Deep Sump Catch Basins

- $5,000 – 6,000 installed
- $200/year in labor for sediment removal & disposal
- 25%TSS removal credit when used for pretreatment



Deep Sump Catch Basin

BMPs By The Numbers

Gravel Wetland

- $25,000-30,000 per acre of impervious area treated
- $1,500-2,000/yr. in labor for maintenance and vegetation control
- 80% TSS removal credit with adequate pretreatment
- Varied % removal of nutrients, metals & pathogens

Hydrodynamic Separator

- Total P removal of 10-30%
- TSS removal 35%
- Fine particle removal down to 50 microns

Sediment Vault

- $15,000 – 20,000 installed per acre of impervious area treated
- $400-600 /year for sediment removal & disposal
- 80% TSS removal with adequate pretreatment
- Varied % removal of nutrients, metals and pathogens

LID BMPs at the Linwood Mill Apts.

670 Linwood Avenue
Northbridge, MA

Conservation Way, Westford

Site Section

RIVERWALK - CONCORD, MA

Funding Stormwater Management

There are costs to stormwater management even with LID. Options for funding include:

- Utilities: dedicated funding based on impervious surfaces, incentives to reduce effective imperviousness
  www.mapc.org/Stormwater_Financing
- Private commercial/industrial site maintenance and annual reporting requirements (Westboro)
- Regional Stormwater Collaboratives provide efficiencies and cost savings
  www.centralmastormwater.org

CMRSWC

Take Home Messages

- Green infrastructure provides numerous **free** or low cost **services** – through both natural and engineered plants and soils.
- We need to treat stormwater and precipitation as a **resource**, not a waste product.
- LID and GI provide several value-added **financial** and **quality of life benefits** for communities of all types – rural, suburban, urban.

Take Home Messages

We can't continue on our current, business as usual path.

- Conservation design, narrow streets, LID drainage need to be the **preferred**, easy-to-permit development/redevelopment option.
- Does **your** LID bylaw work well with your subdivision and other regulations?

For more information, please visit www.massaudubon.org/LIDcost

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