LECTURE 7
SUSTAINABLE DEVELOPMENT

Youngstown State University

CEEN 4812: Construction Management
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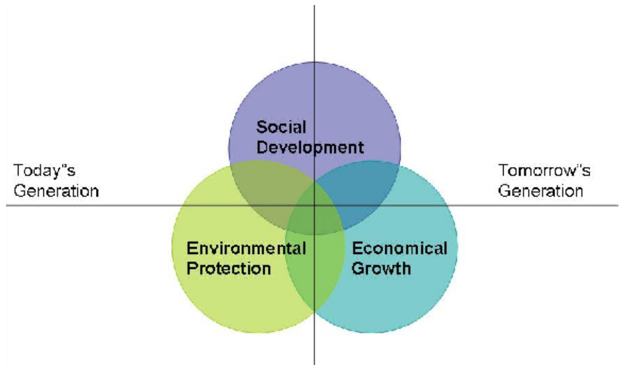
OUTLINE

- Definition
- Green wave
- Low Impact Development (LID)
- Best Management Practices (BMP)
- Storm water management using green design
  - Rain gardens
  - Green roofs
- Examples

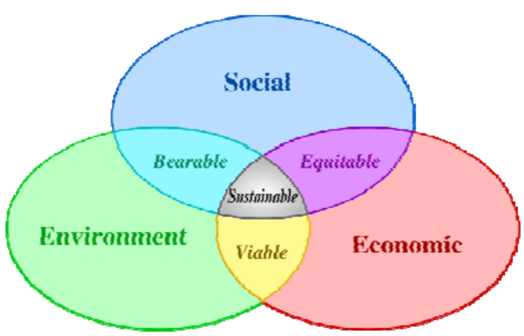
SUSTAINABLE DEVELOPMENT

- Sustainable development is a pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but in the indefinite future.



SUSTAINABLE DEVELOPMENT

- Sustainable development does not focus solely on environmental issues. Interdependent and mutually reinforcing pillars of sustainable development are:
  - Economic development
  - Social development, and
  - Environmental protection.



RIDING THE GREEN WAVE

- Green lexicon
  - Sustainable Growth
  - Sustainable Planning
  - Sustainable Design
  - Low Impact Development (LID)
  - Green Wave
  - Green Design
  - Green Development
  - Green Infrastructure

TOP ISSUES

- Energy Usage
- Land Use
- Transportation Network
- Alternative Modes of Travel
- Construction Materials
- Utility Infrastructure
- Storm Water Management (focus of this lecture)
- Resource Conservation
- Economy

SUSTAINABLE CRITERIA FOR BUILDINGS

(SAHELEY, ET. AL., CAN. J. CIV. ENG, 2005)

Table 1. Sustainability criteria and subcriteria for different infrastructure systems.

Overall criteria	Generic subcriteria	System-specific indicators: Buildings
Environmental	Resource use	Construction materials usage Energy usage Land use
	Residuals	Construction waste GHG emissions (GHG = Greenhouse gas)
Economic	Expenditures and revenues	Capital and operation and maintenance costs Affordability of housing
	Investment in innovation, research and development	Expenditures in research and development, technology change Reserve funds
Engineering	Performance (function)	Structural integrity Building envelope performance Heat and moisture flows
Social	Accessibility	Supply of housing
	Health and safety Acceptability	Indoor air quality Public participation

SUSTAINABLE CRITERIA INDICATORS FOR WATER SYSTEMS

(SAHELEY, ET. AL., CAN. J. CIV. ENG, 2005)

(A) Environmental criteria

Indicator	Selected generic subcriteria: Resource use
Electricity use	Minimize use of fossil resources
Chemical use	Minimize use of fossil energy and nonrenewable resources
Water use	Appropriate level to minimize freshwater resource depletion
Discharges of BOD, N, and P to water	
Sludge disposal to landfill	Minimize use of fossil energy
Energy recovery from biogas	Minimize use of fossil energy
Recycling of nutrients to agricultural land	Minimize use of fossil energy

SUSTAINABLE STORMWATER DRAINAGE

- Stormwater drainage is not new !
- Great Mosque, Tunisia (1023 AD)
- The courtyard was once tiled with terracotta tile, but today is paved with marble.
- The catch basins designed to filter and drain stormwater.
- The wells have curbs made from the base of ancient columns.
- The water is used for ablution.

TODAY'S CONVENTIONAL STORMWATER DRAINAGE

- Is this sustainable development?
- Why not?

Figure 3.4 Glasgow Flooding 2002 Showing the Exceedance of Sewerage Capacity (courtesy Scottish Water)

Figure 3.5 Glasgow Flooding 2002 Showing Accumulation of Floodwater in Low Lying Area (courtesy Scottish Water)

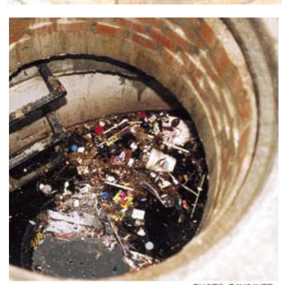
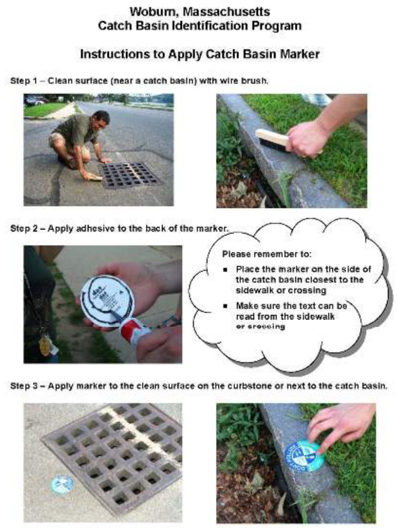


PHOTO: BAYSAVER

PUBLIC EDUCATION / PARTICIPATION

- Important but not enough to solve the entire problem.
- Need structural (construction) measures



Woburn, Massachusetts
Catch Basin Identification Program

Instructions to Apply Catch Basin Marker

Step 1 – Clean surface (near a catch basin) with wire brush.

Step 2 – Apply adhesive to the back of the marker.

Please remember to:

- Place the marker on the side of the catch basin closest to the sidewalk or crossing
- Make sure the text can be read from the sidewalk or crossing

Step 3 – Apply marker to the clean surface on the curbstone or next to the catch basin.

IS THIS GREEN?

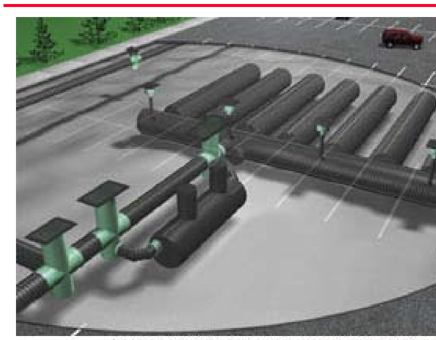


ILLUSTRATION: ADVANCED DRAINAGE SYSTEMS

PHOTO: ADVANCED DRAINAGE SYSTEMS

UNDERGROUND STORMWATER STORAGE IN LIEU OF A SURFACE POND

CLEANING

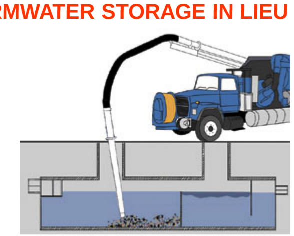


ILLUSTRATION: ADVANCED DRAINAGE SYSTEMS

UGLY VS. PRETTY

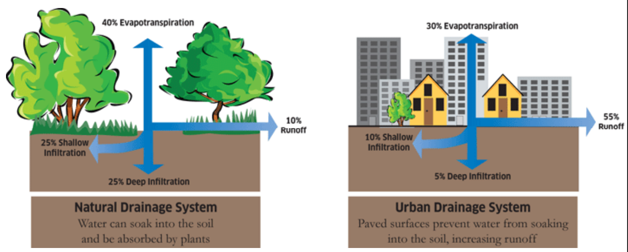
UGLY VS. PRETTY

STORMWATER RUNOFF DIRECTION (OLD SCHOOL)

STORMWATER RUNOFF DIRECTION (GREEN DESIGN)

RAIN GARDENS

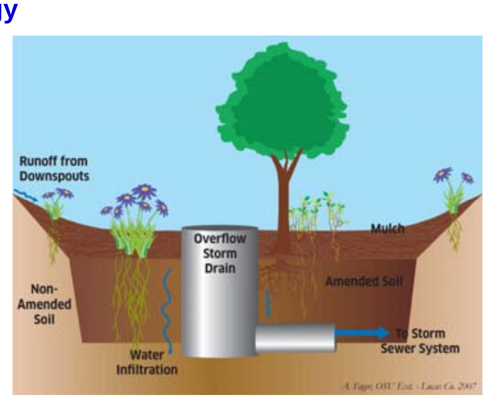
- A rain garden is a garden in a low spot that catches and slows storm water from downspouts, driveways, parking lots, and roads and allows it <u>to infiltrate into the soil</u> with the help of deep-rooted plants that like water.
- Also called Bioretention Systems



COMPONENT	OLD SCHOOL	GREEN DESIGN
EVAPORATION	30%	40%
RUNOFF	55%	10%
SHALLOW INFILTRATION	***10%***	***25%***
DEEP INFILTRATION	***5%***	***25%***

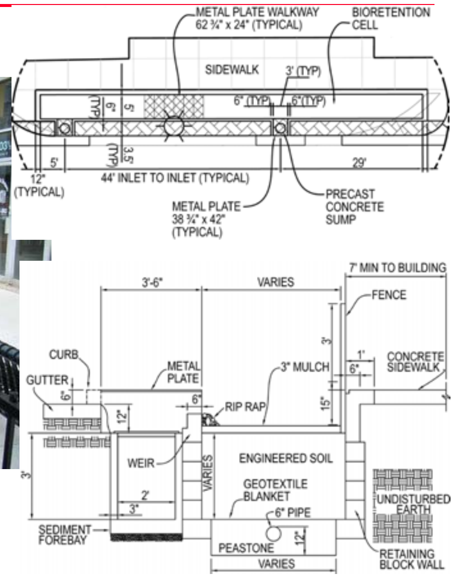
RAIN GARDENS

- Part of an area's landscaping plan
- Filter pollutants from the runoff that it captures and absorbs.
- Rain gardens mimic natural conditions by:
  - Slowing runoff near sources
  - Maintaining natural hydrology
  - Absorbing rainfall
  - Filtering pollutants
  - Providing habitat



www.raingardeninitiative.org/raingardens.html

RAIN GARDENS, LANSING, MICHIGAN



WE&T, July 2008

RAIN GARDENS, LANSING, MICHIGAN
ANNUAL MAINTENANCE COST

Rain Garden Maintenance Tasks

Task	Description	Frequency (once established)	Annual labor and material cost[1]	Volunteer assistance
Weeding	Weeding to control unwanted vegetation, no herbicides	Spring, midsummer, late summer	Labor, $2000 Material, $100	Yes
Litter removal	Litter removal for aesthetics and function	Every 2 weeks (May – October)	Labor, $4000 Material, $200	Yes
Plant thinning	Maintain original balance and proportion of species	Spring and fall	Labor, $1500 Material, $100	Yes
Plant replacement	Replace dead or diseased plants, as noted in fall	Spring	Labor, $1000 Material, $500	Yes
Mulching	Placement of 50 mm (2 in.) of untreated mulch	Every 2 years and as needed	Labor, $700 Material, $1000	Yes
Pruning	Prune trees and shrubs to maintain aesthetics	Spring and fall or as needed	Labor, $700 Material, $100	No
Drought weather watering	Water plants during times of severe drought	As needed	Labor, $250 per drought Material, $100	No
Sump cleaning	Inspect and remove litter and sediment from sump	Semiannually or as needed	Labor, $2500	No
Underdrain maintenance	Inspect and clean underdrain to avoid basement flooding	1 block each year	Labor, $650	No

[1]Labor cost assumes only city crews are used without assistance from volunteers.

WE&T, July 2008

BAKER EXAMPLE: RAIN GARDEN IN CHARLESTON, WV


Charleston Daily Mail - Life - Groups ready to unveil city's first rain garden

Save up to 75% on Last-Minute Cruises
Best Price Guarantee

Charleston Daily Mail
Wednesday July 9, 2008
DAILYMAIL.COM

News | Sports | WVU Sports | Marshall Sports | Opinion | Obituaries

Life

Monday June 9, 2008

Groups ready to unveil city's first rain garden

by Charlotte Ferrell Smith
Daily Mail staff

Charleston's first rain garden is now complete.

Perhaps an explanation is in order. A rain garden is one that is designed to capture run-off water from a paved area. Instead of going into the city's storm sewer system, the water goes to the garden.

Fittingly enough the Charleston rain garden has been installed at a place that recycles items for the home - the Habitat for Humanity ReStore. It will officially be dedicated at 10 a.m. Wednesday.

STORMWATER BEST MANAGEMENT PRACTICES (BMPs)

- The problem: Stormwater management systems in many cities are inadequate and based on old paradigms which increase flooding problems and cause sewer overflows.
- Stormwater impacts: Sewer overflows, street flooding, basement flooding, poor water quality in receiving waters
- **BMP Definition: Any activity, facility, measure, or procedure used to protect, maintain, reclaim or restore the quantity and quality of waters and the existing and designated uses of waters**
- BMP Objective: reduce runoff, improve water quality and encourage infiltration
- BMP examples:
  - Structural BMPs
    - Rain Gardens (Bioretention Systems)
    - Rain Barrels
    - Infiltration Trenches / On-lot Seepage
    - Green roofs
    - Porous pavement
  - Non-Structural BMPs
    - Riparian Buffers
    - Plant trees
    - Street cleaning
- PADEP BMP Manual: www.depweb.state.pa.us/watershedmgmt/cwp/view.asp?a=1437&q=529063&watershedmgmtNav=|

BMP WATER QUALITY BENEFITS

Best Management Practice (BMP)	Adopted TSS Removal Rate (%)
Bioretention System	90
Constructed Stormwater Wetland	90
Dry Well	Volume Reduction Only[1]
Extended Detention Basin	40 to 60[2]
Infiltration Structure	80
Manufactured Treatment Device	See N.J.A.C. 7:8-5.7(d)[3]
Pervious Paving System	Volume Reduction Or 80[4]
Sand Filter	80
Vegetative Filter	60-80
Wet Pond	50-90[5]

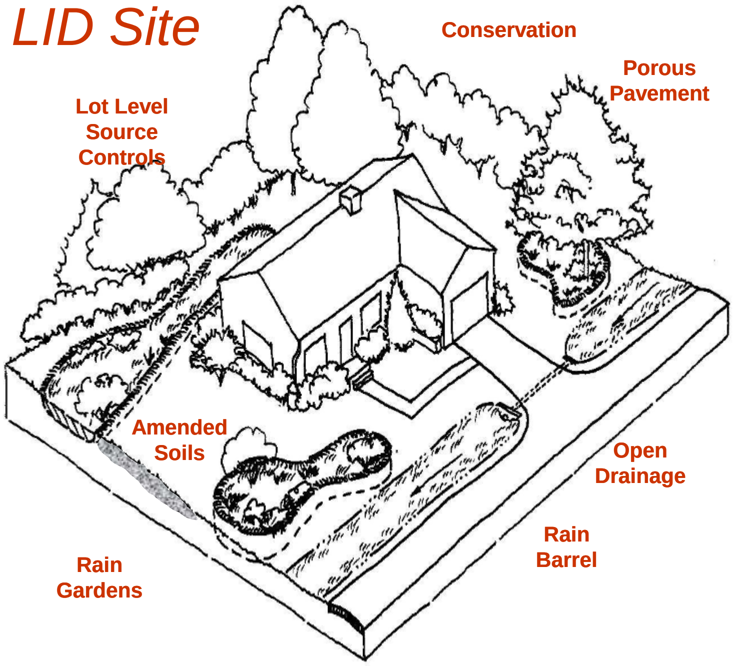
Best Management Practice (BMP)	Total Phosphorous Removal Rate (%)	Total Nitrogen Removal Rate (%)
Bioretention Basin	60	30
Constructed Stormwater Wetland	50	30
Extended Detention Basin	20	20
Infiltration Basin	60	50
Manufactured Treatment Devices	See N.J.A.C. 7:8-5.7(d)	See N.J.A.C. 7:8-5.7(d)
Pervious Paving[2]	60	50
Sand Filter	50	35
Vegetative Filter	30	30
Wet Pond	50	30

Ref.: NJDEP BMP Manual

LOW IMPACT DEVELOPMENT

- **Low impact development, also known as LID, is an innovative stormwater management approach modeled after nature.**
- **A new technique for stormwater management.**
- **Aims to maintain a site's predevelopment hydrologic cycle through distributed decentralized practices.**
- **Also includes measures to conserve the natural and physical resources at a site.**
- **LID = Structural BMP**

LID Site



LID EXAMPLE: RAIN GARDEN

Hill East Waterfront Redevelopment, Michael Baker, Jr. Inc.

Southern Interim Parking Lot

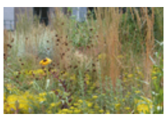
Bioretention Cell in Greenspace

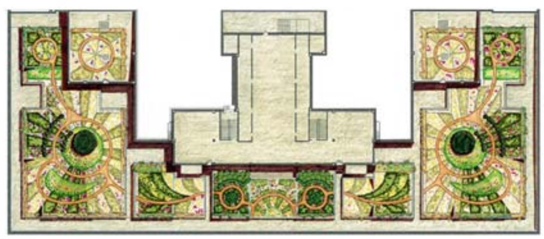
District locator

Southern Interim Parking Lot Section

LID EXAMPLE: GREEN ROOF, CHICAGO

- **Chicago city hall rooftop garden**
- **Drastically reduced rooftop temperature and is saving $3600/year in energy cost (WE&T, WEF, Aug. 2008)**

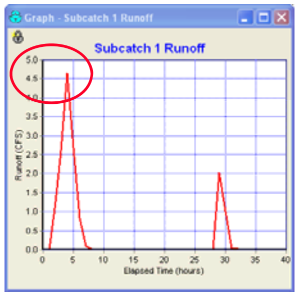


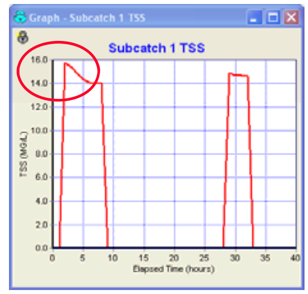


SUSTAINABLE DEVELOPMENT EXAMPLE

- Brownfield (abandoned industrial sites) redevelopment
- Summerset at Frick Park (Nine Mile Run), Pittsburgh, PA
  - Old steel mill slag dump site
  - Single family residential housing
  - 238 acres, approx. 700 homes
  - Phase 1 (221 homes) completed in 2007
  - Lottery for 270 Phase II homes

LID DESIGN EXAMPLE
PRE-LID RUNOFF AND TOTAL SUSPENDED SOLIDS (TSS)





Statistics - Subcatch 1 Runoff

Summary | Events | Histogram | Frequency Plot

Rank	Start Date	Event Duration (hours)	Event Total (ft3)
1	01/01/1998	10.0	43687.492
2	01/02/1998	7.0	11219.920

Statistics - Subcatch 1 TSS

Summary | Events | Histogram | Frequency Plot

Rank	Start Date	Event Duration (hours)	Event Total Load (kg)
1	01/01/1998	7.0	18.371
2	01/02/1998	4.0	4.700

Total runoff volume: 54,907 CF
Peak runoff rate: 4.66 cfs

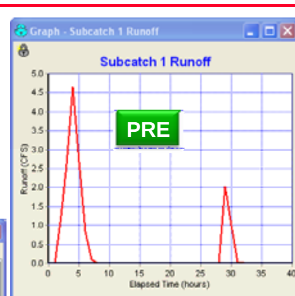
Total TSS Load: 23.1 Kg
Peak TSS concentration: 16 MG/L

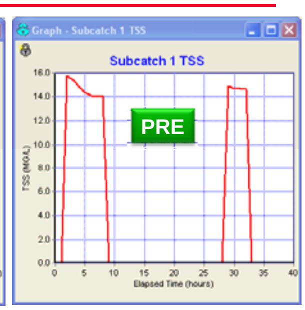
LID DESIGN EXAMPLE
NON-STRUCTURAL BMP (PLANT MORE TREES AND VEGETATION) ONLY

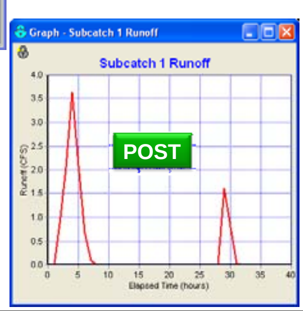
- Decrease % Imperviousness from 50% to 40%
- Peak runoff rate and volume reduced by 22%
- no WQ improvement

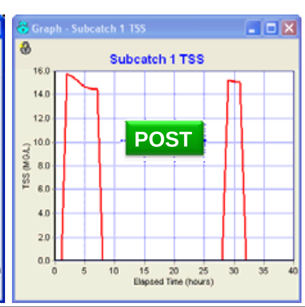
Statistics - Subcatch 1 Runoff — PRE

Rank	Start Date	Event Duration (hours)	Event Total (ft3)
1	01/01/1998	10.0	43687.492
2	01/02/1998	7.0	11219.920







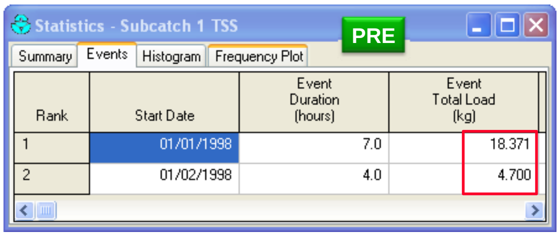


Statistics - Subcatch 1 Runoff — POST

Rank	Start Date	Event Duration (hours)	Event Total (ft3)
1	01/01/1998	9.0	34469.805
2	01/02/1998	6.0	8879.408

LID DESIGN EXAMPLE
BMP AND LID (RAIN GARDEN)

- **Huge WQ improvement:**
- **TSS peak load: reduced by 90%**
- **TSS total load: reduced by 92%**



Rank	Start Date	Event Duration (hours)	Event Total Load (kg)
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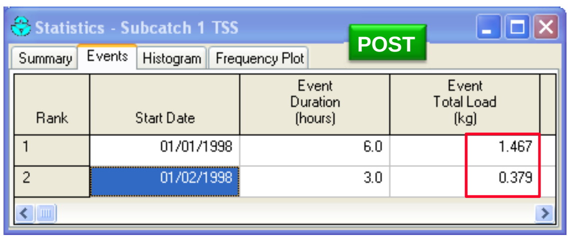
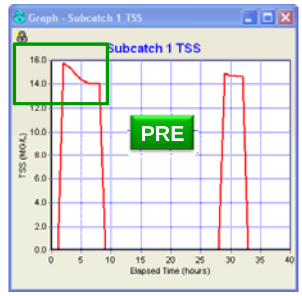
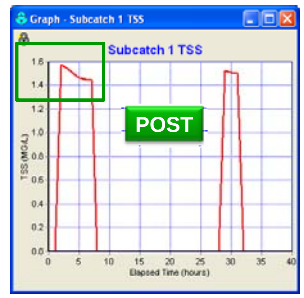
2	01/02/1998	4.0	4.700



Rank	Start Date	Event Duration (hours)	Event Total Load (kg)
1	01/01/1998	6.0	1.467
2	01/02/1998	3.0	0.379





BAKER SUSTAINABLE STORMWATER CASE STUDY
ANACOSTIA WATERFRONT, WASHINGTON, DC

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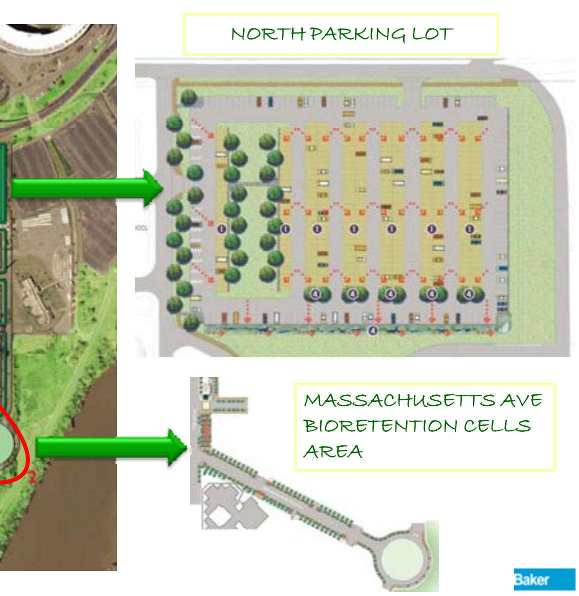
- **Create a livable urban waterfront**
- **Restore water quality**
- **Enhance natural beauty of the river**
- **Connect neighborhoods to each other**
- **Promote sustainable development**

Baker

TRANSFORMING THE SITE USING LIDs

Baker

GREEN INFRASTRUCTURE DESIGN



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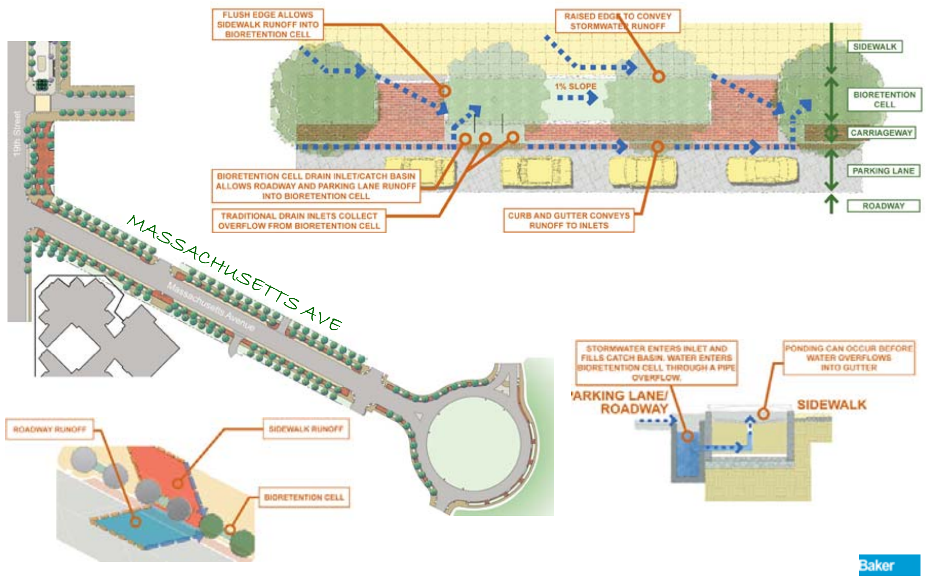
MASS. AVE. BIORETENTION CELL DESIGN



Baker

HOW MUCH WATER IS COLLECTED?

- The system collects the 1-in / 24 hour storm.
- Each bioretention cell collects sidewalk and roadway runoff and can retain 600 cubic feet of water.
- That's enough water to fill 60 regular bathtubs each time it rains more than one inch.
- There are 45 bioretention cells on Mass. Ave.
- That's a total of 27,000 cubic feet of water!!!!

Baker