ENVIRONMENTAL ADVISORY BOARD

The Environmental Advisory Board of the City of Raleigh held a meeting on Thursday, May 11, 2017 at 4:30 p.m. in Room 303, Raleigh Municipal Building, 222 West Hargett Street, Avery C. Upchurch Government Complex, Raleigh, North Carolina, with the following present:

BOARD MEMBERS	**STAFF**
Anya Gordon, Chair	Megan Anderson, Sustainability Office
Rob Gelblum, Vice Chair	Cindy Holmes, Sustainability Office
Laurel Passera	Kevin Boyer, Stormwater
Brian Starkey	Grace Levin, AmeriCorps Vista
Beverley Clark	Lory Willard, Stormwater

ABSENT
Dave Toms
Larry Larson
Aranzazu Lascurain
Justin Senkbeil

I. Call to Order
Ms. Anya Gordon called the meeting to order at 4:30 pm.

II. Approval of Meeting Minutes
The minutes from the April meeting were approved as amended.

III. Public Comment
There were no public comments received.

IV. Presentation

V. Staff Reports

a. GI/LID update- Stormwater
Kevin Boyer, with the Stormwater Division of the Engineering Services Department provided an overview of the Green Infrastructure / Low Impact Development (GI/LID) project. The project originally was a joint project between the Environmental Advisory Board and the Stormwater Management Advisory Commission (SMAC). A copy of the presentation and the handout is attached to the minutes**.**

b. Overview of AmeriCorps Vista Project & GHG
Grace Levin, an AmeriCorps Vista in the Office of Sustainability provided an overview of her Vista project and how that relates to the Greenhouse Gas

Emissions Inventory that was completed earlier this year. A copy of the presentation is attached to the minutes.

c. iDEA Raleigh Update

Megan Anderson provided an update on the iDEA and shared that the voting was open for the different projects.

d. FY18 Work Plan

The board members had a discussion on submitting ideas for the FY18 workplan.

e. **Award Program revisions and Urban Agriculture**

The board discussed revisiting the categories and names for next year. Urban Ag day is set for October 21, 2017 at the Historic Mordecai Gardens Visitor Center.

VI. Other Business/Announcements - None

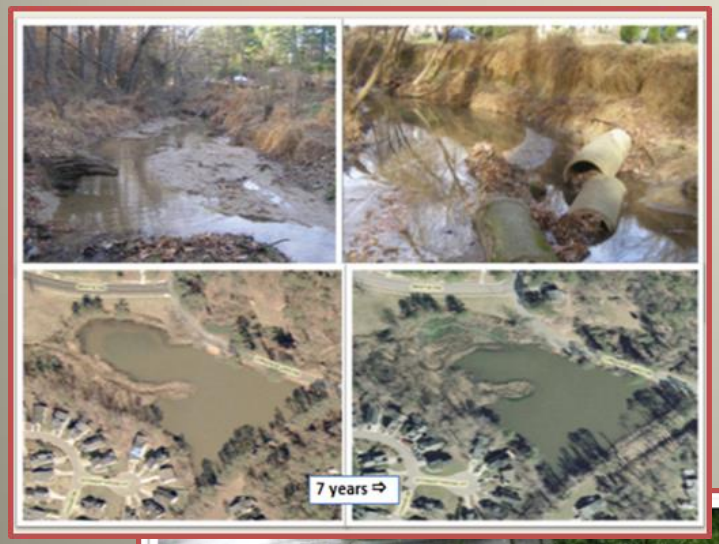
With no further business the meeting was adjourned at 6:30 pm.

Update on Advancing GI/LID in Raleigh

Kevin Boyer, Stormwater Management Division

Environmental Advisory Board

May 11, 2017



Stormwater GI/LID in Raleigh

- Stormwater + its management
- Some history
- Our GI/LID process
- Possibilities for the future
- GI/LID on the ground

Stormwater management in Raleigh…

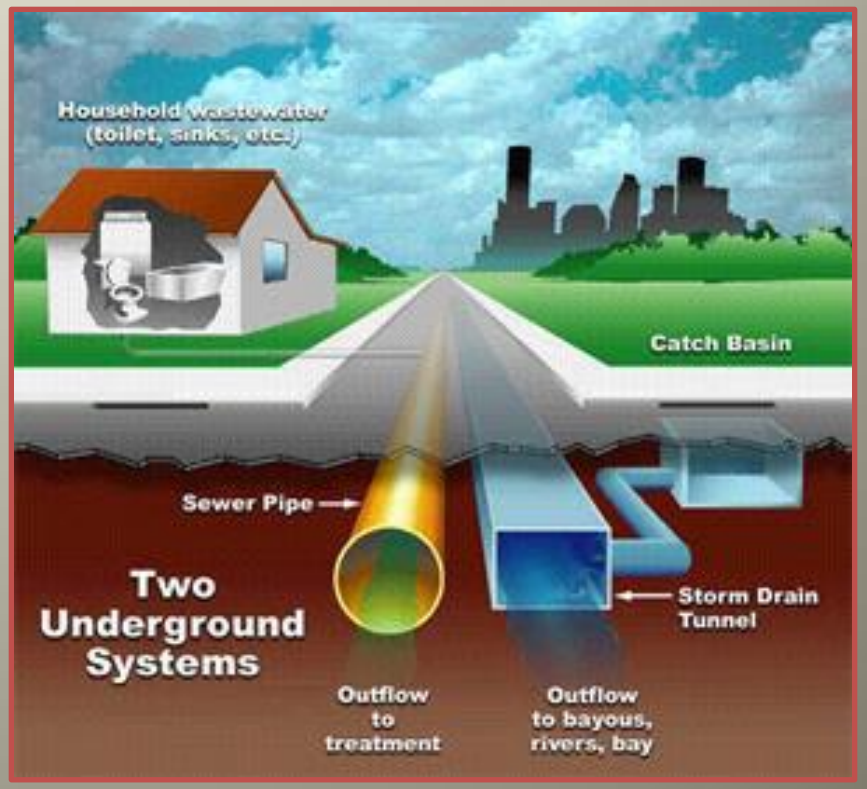
- Drainage of streets and roads
  (*public safety, emergency access*)
- Reducing destructive flooding
  (*public safety, property damage*)
- Protecting and restoring streams and lakes
  (*human health, stream health, recreation, aesthetics, downstream drinking water*)
- Complying with laws and regulations
  (*Clean Water Act, Neuse rules, others*)

Stormwater is…

- Rainwater that runs off
  (*sheds; runoff*)
- Flows to gutters, pipes, ditches, streams
  (*the stormwater conveyance system*)

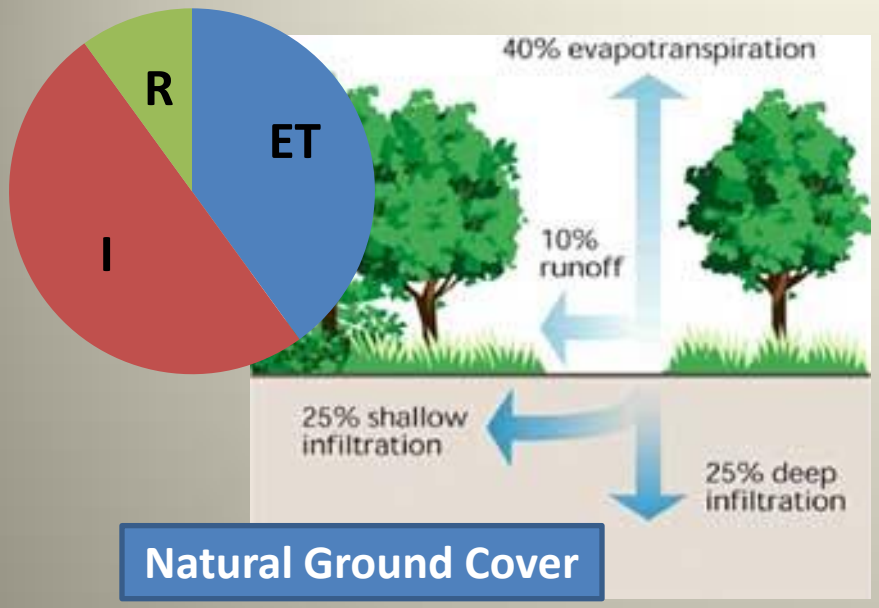
Stormwater is <u>not</u>…

- Rainwater with ‘fates’ other than runoff
- Dry-weather stream flows
- Tap water (*potable*)
- Sewage (*wastewater*)



Those "other" rainfall fates…

http://www.raingardennetwork.com/urban.htm



R = runoff

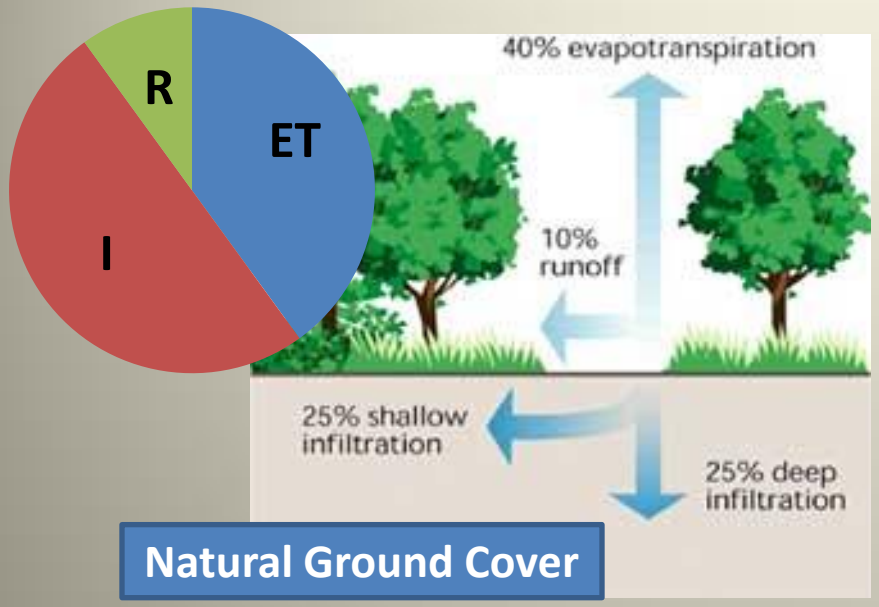
I = infiltration

ET = evapotranspiration

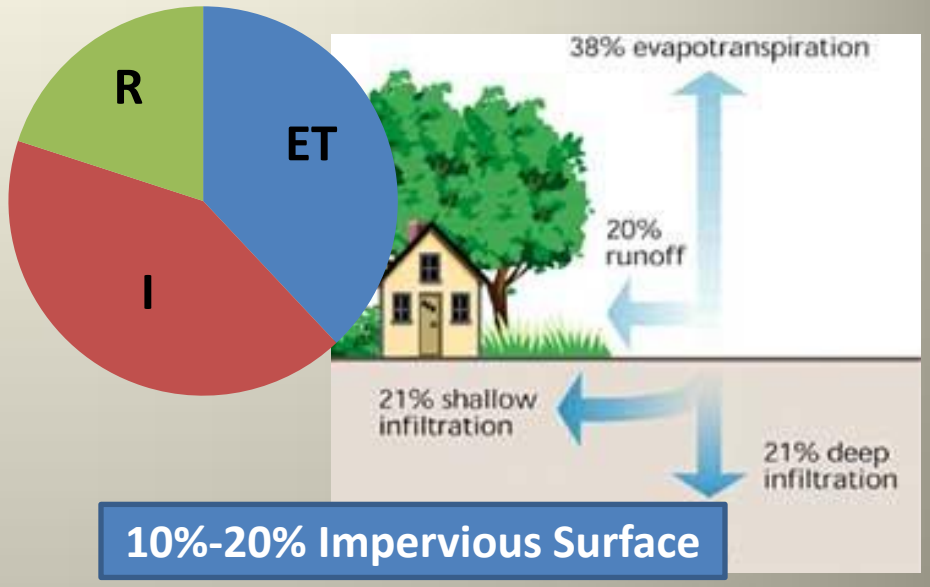
http://www.fs.fed.us/psw/programs/uesd/uep/products/11/800TreeCityUSABulletin_55.pdf

Other rainfall fates…

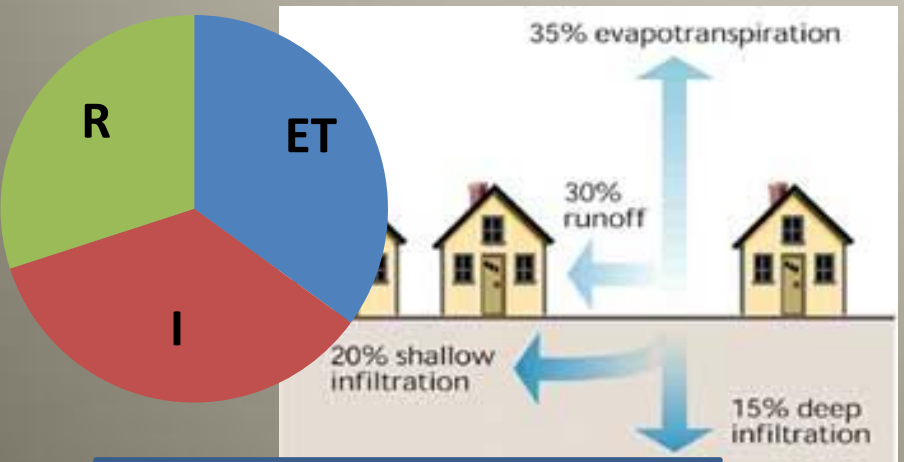
http://www.raingardennetwork.com/urban.htm



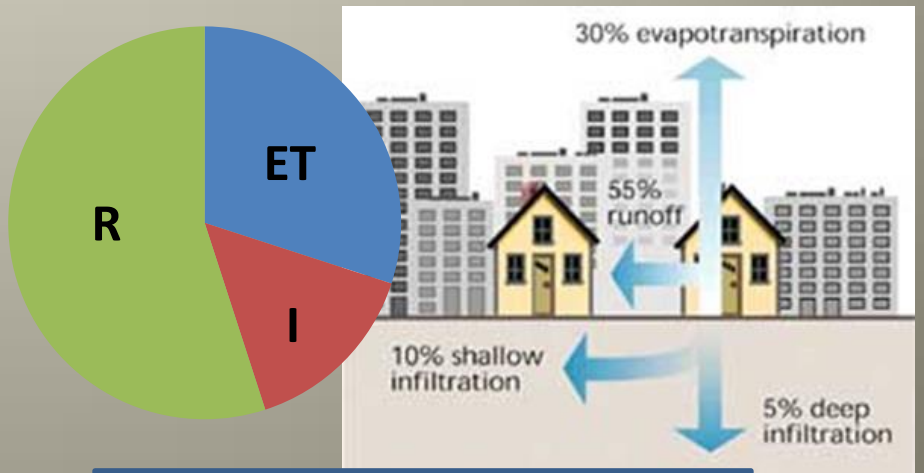
Natural Ground Cover



10%-20% Impervious Surface



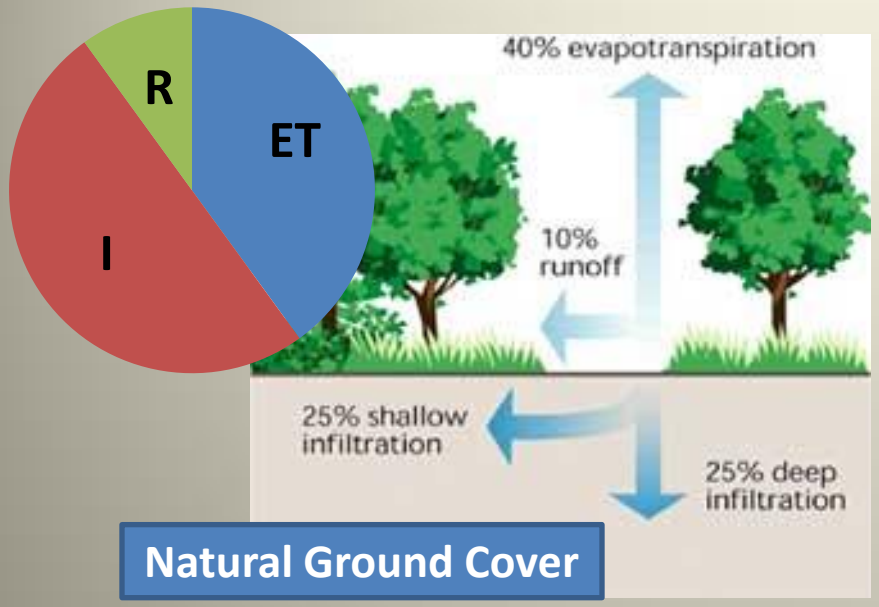
35%-50% Impervious Surface



75%-100% Impervious Surface

Timeline: Raleigh pre-1800…

http://www.raingardennetwork.com/urban.htm

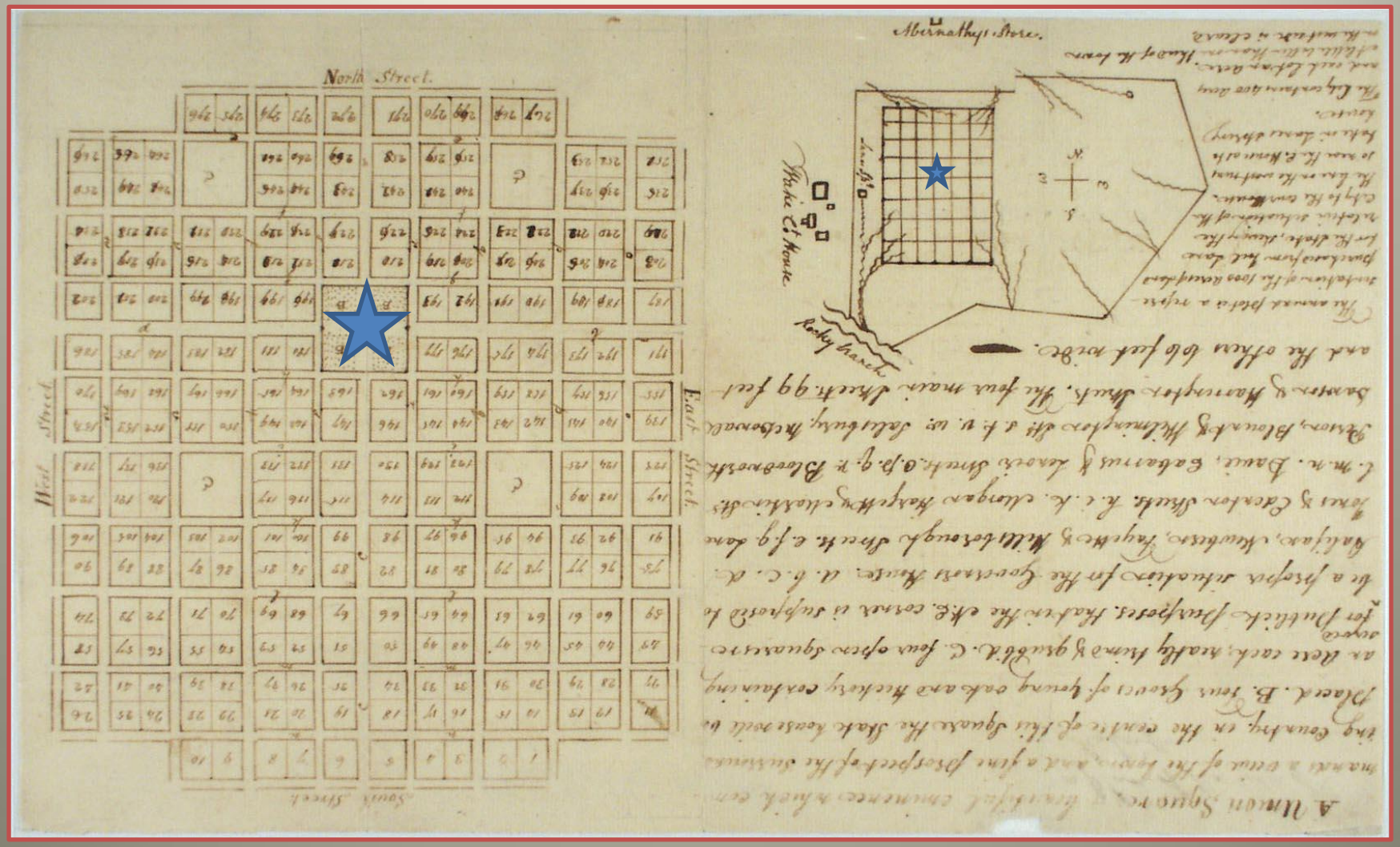


- Pre-settlement Raleigh – largely wooded
- Very little stormwater runoff,
  lots of infiltration

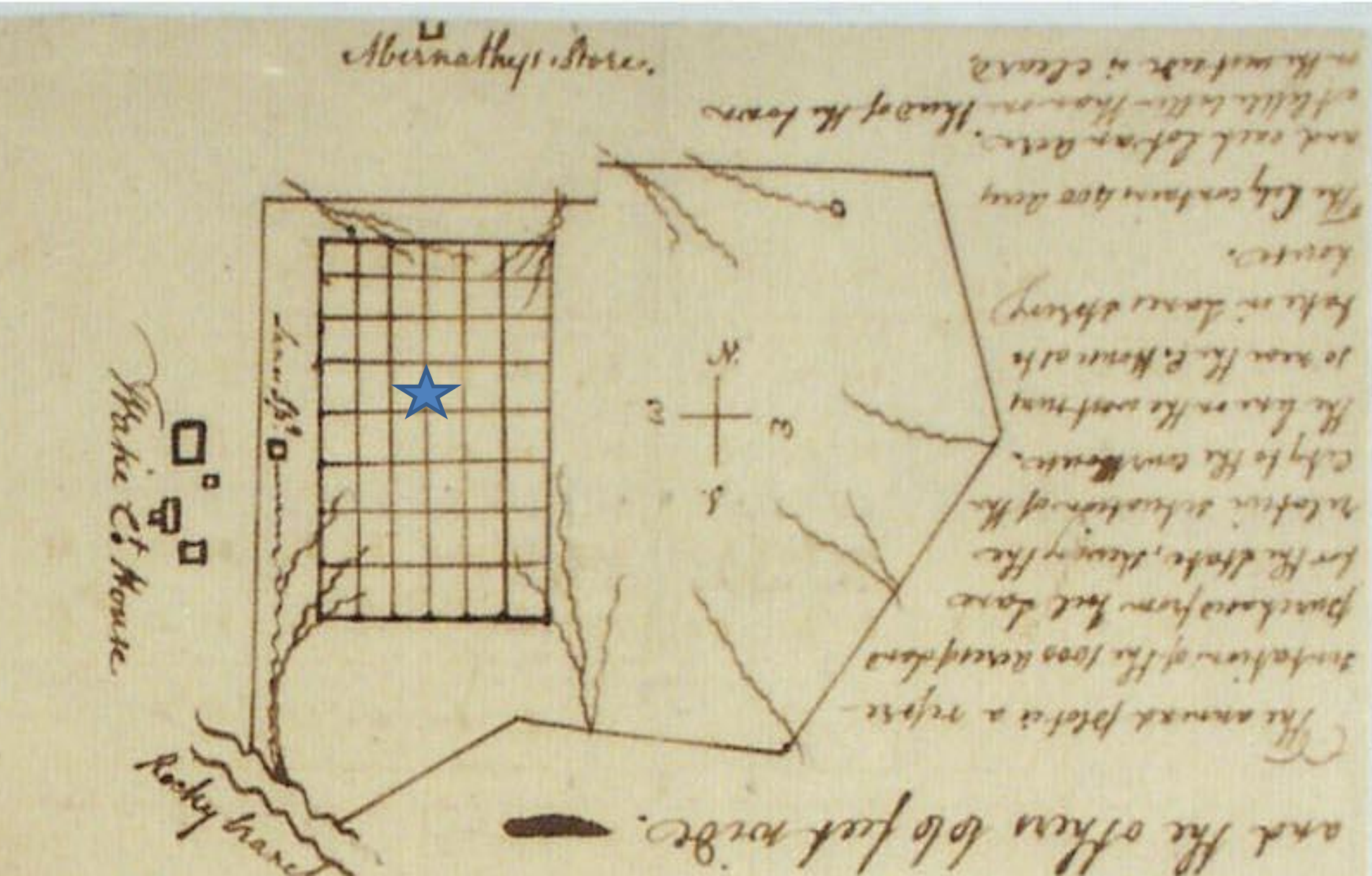
Timeline: 1800s…

- Buildings sited on high/dry ground (*Statehouse on the highest*)
- Avoided building on low land and wet areas (*gardens, pastures*)
- Bridges and culverts were few (railroads, streets)
- 1792 Christmas Plan; 1872 Bird's Eye View

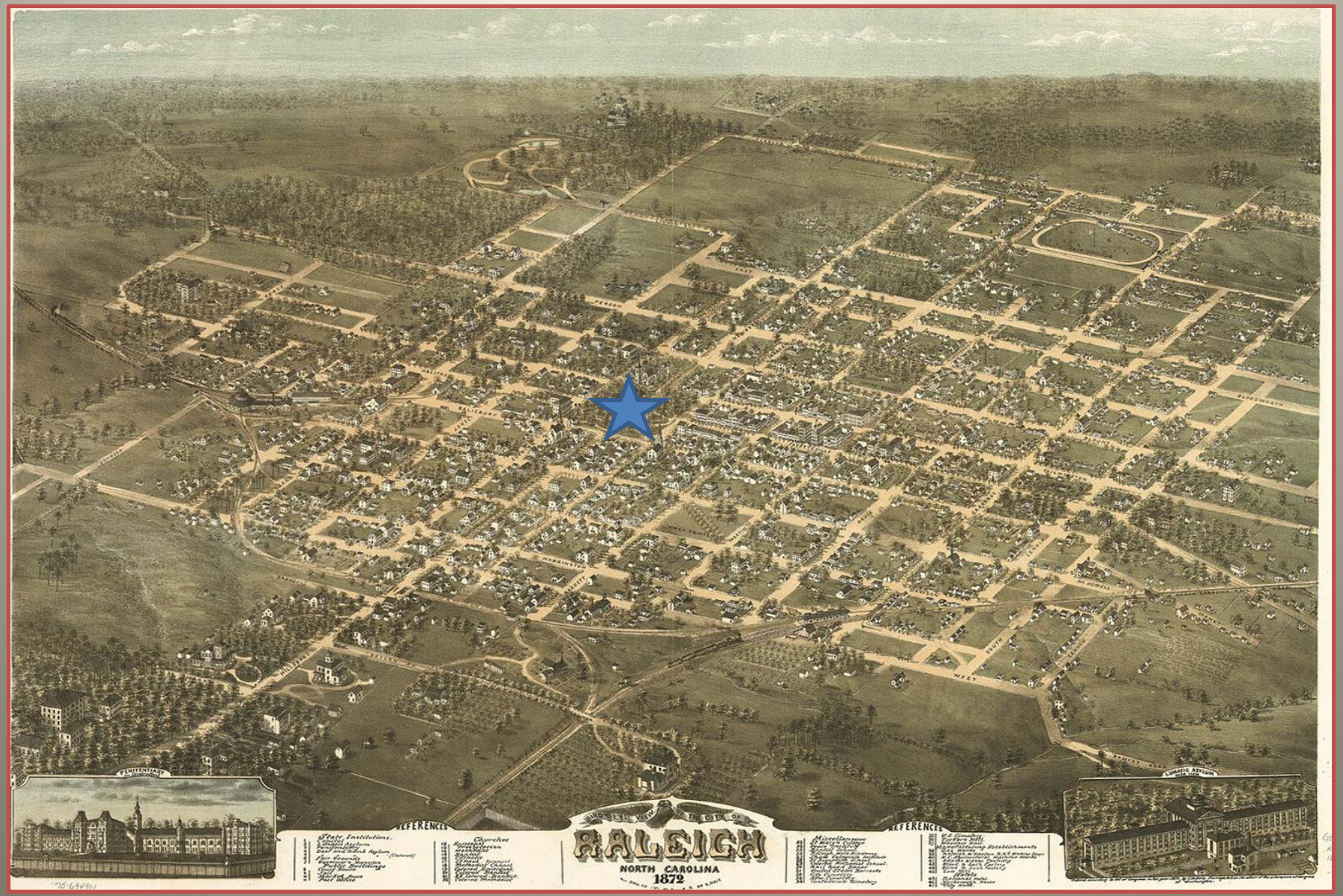
In 1792…


A Mean Square
North Street
South Street
West Street
East Street
Rocky Branch
Abernathy's Store

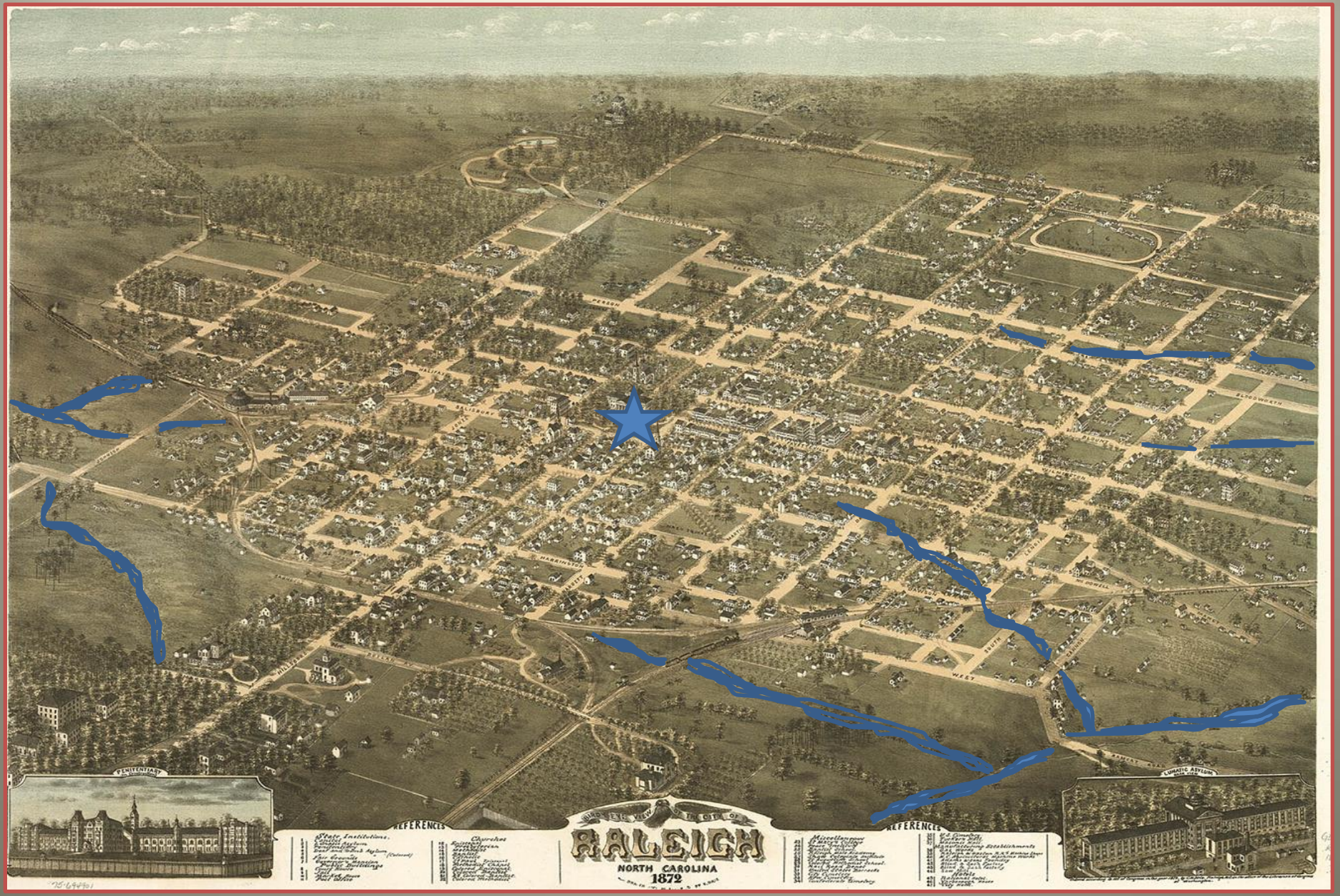
In 1792…



In 1872…


PENITENTIARY
REFERENCES
RALEIGH
NORTH CAROLINA
1872
REFERENCES
LUNATIC ASYLUM

In 1872…


BIRD'S EYE VIEW OF THE CITY OF
RALEIGH
NORTH CAROLINA
1872
REFERENCES
REFERENCES
PENITENTIARY
LUNATIC ASYLUM

Early 20th century…

- Straightened, moved creeks out of the way
- Piped inconvenient creeks, build on top them
- Growth, expansion, automobiles, land pricier
- Add C&G to elevate sidewalks, drain streets, remove runoff to pipes quickly
- Drainage piping system called ‘storm sewers’
- 1920 map: ~1 mile of storm sewers

In 1920…

MAP
SHOWING THE
DRAINAGE
SYSTEM
RALEIGH N C
GLENWOOD
JOHNSON
TUCKER
NORTH
LANE
JONES
EDENTON
HILLSBORO
MORGAN
HARGETT
MARTIN
DAVIE
PEACE
PAGE
N. BOUNDRY
POLK
OAKWOOD CEMETERY
OAKWOOD
NEWBERN
AVE
HALIFAX
FAYETTEVILLE
WILMINGTON
BLOUNT
BLOODWORTH
EAST
WEST
HARRINGTON
DAWSON
McDOWELL
ASHBURY
BOYLAN
ST. MARYS
GLENWOOD
ELM
LINDEN
HECK
N.C. STATE
PENITENTARY
BOYLAN HEIGHTS
BARRUS
LENOIR
SOUTH
STATE HOSPITAL
SMITHFIELD
SOUTH PARK
WATSON PARK
CITY
LIMITS

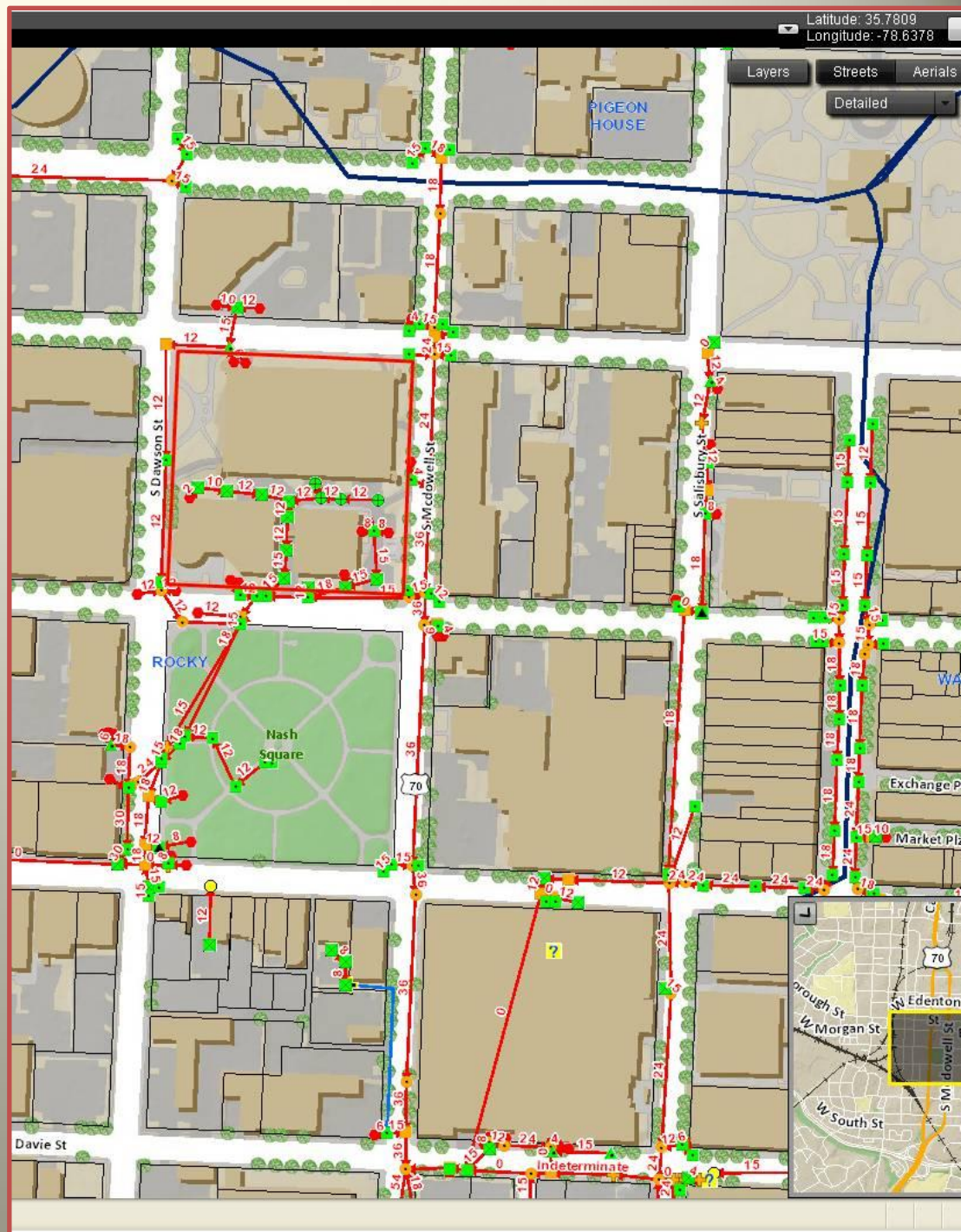
In 1920…

Within the City limits (4 square miles):
~ 1 mile of storm drain pipe
< 100 inlets

Fast forward to today…

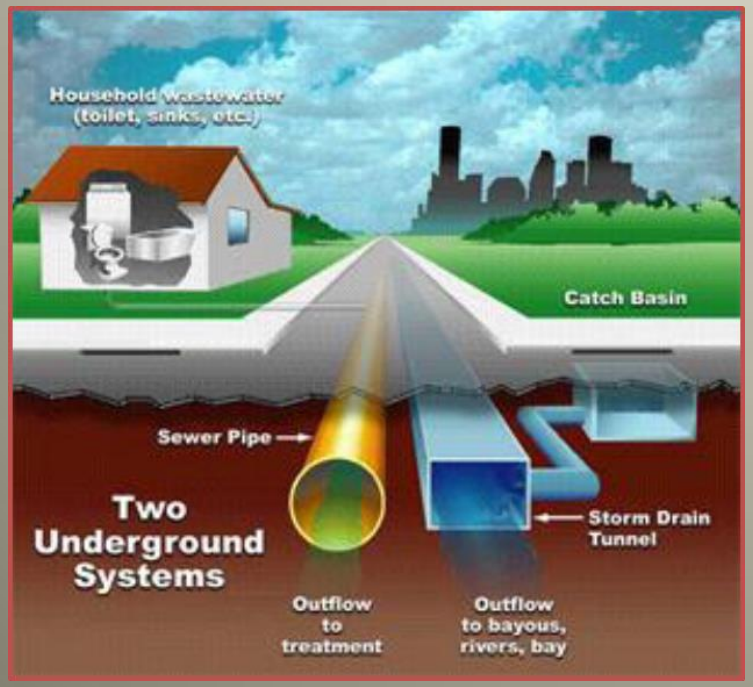
Within the City limits (~150 square miles):

- **1,200 miles of storm drain pipe**
- **54,000 inlets (e.g., catch basins)**
- **7,900 junctions (e.g., manholes)**

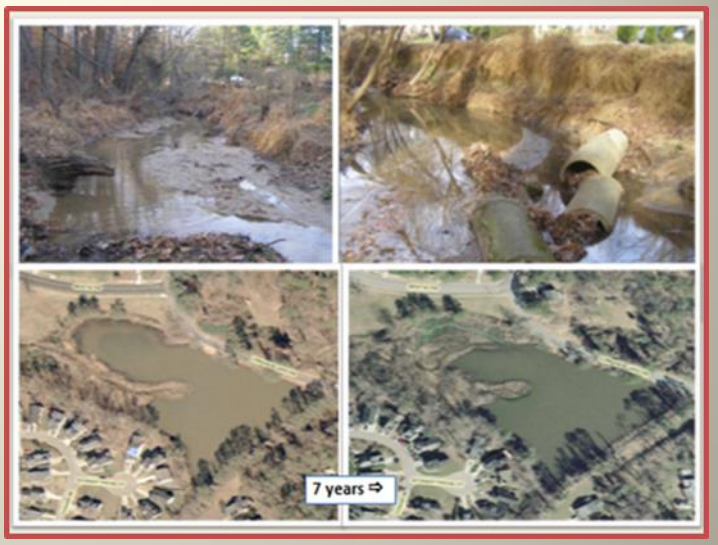


Sewers: storm, sanitary, combined

- By 1900, society saw CSOs' health problems
- Raleigh wisely built <u>separate</u> sanitary sewers
- Many other cities now have huge CSO liabilities



Mid-20th century…



- Post-WWII expansion
- How protective? (*storm frequency; 10-year storm*)
- Size pipes and channels: pass the 'peak runoff rate' (*volume/time*)
- Send it downstream – now it's their problem

1970s into early 2000s…

- Rapid growth, system expansion, larger CIPs
- Old infrastructure failing; wear & tear on streams
- Improving maintenance and level of service
- Pollutants control added to regulations
- Raleigh's early interest in LID concepts

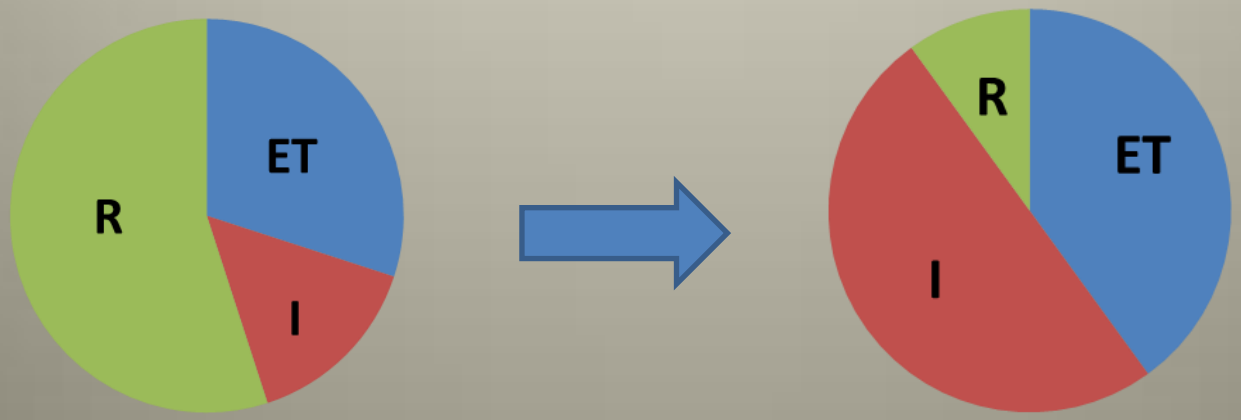
Green infrastructure, 2 meanings…

- Natural, undisturbed environment
  (forests, trees, streams, lakes, wetlands)

- Constructed infrastructure that reduces stormwater's impacts on streams & lakes
  (approach and devices similar to LID)

Low impact development…

An approach that ***reduces stormwater runoff volume*** *by promoting infiltration and evapotranspiration, taking advantage of existing natural features, and installing new features that mimic nature.*



Drivers for stormwater GI in Raleigh

NPDES Phase I stormwater permit? ☑ (1994)

Nutrient-sensitive waters rules? ☑ (1998/2003)

Stormwater utility and fee? ☑ (2003)

Water supply watershed protection? ☑

Rapid growth and urbanization? ☑

Want clean water/healthy streams? ☑

Shellfish waters? ☒

Swimming beaches? ☒

Combined sewer overflows? ☒

Consent decree or court order? ☒

Getting started, first time…

2007: City Council endorsed encouraging LID

Moving Raleigh Toward Low Impact Development (LID)

An Introduction to

LID Principles

October 30, 2007

City of Raleigh Stormwater Management

Encouraging policy…

2009: Raleigh's 2030 Comprehensive Plan and LID

Element C – Environmental Protection
<u>Element C narrative excerpts</u> · **Definition of LID** (from the glossary): A comprehensive land planning and engineering design approach with a goal of maintaining and enhancing the pre-development water characteristics and drainage of urban and developing watersheds. · The core **goals…keeping rainfall on-site as much as possible, mimicking the flow of water in a natural setting and reducing non-point source pollution from stormwater run-off…** · The City has a responsibility to **improve the health of local rivers, creeks…** · The **City's green infrastructure** cannot continue to be compromised, as it represents a direct lifeline to the vitality of the City. · Raleigh is uniquely **positioned to champion** the recovery of the Neuse River, a degraded resource.

Encouraging policy…

2009: Raleigh's 2030 Comprehensive Plan and LID

Element C – Environmental Protection
Policy EP 2.1: Green Infrastructure **Ensure protection of Raleigh's unique and significant green infrastructure – its natural resources, landscapes, and ecological systems – through best practices management stewardship and land use regulations.** **Policy EP 3.4: Low Impact Systems for Parking** **Well maintained pervious pavement or other low impact systems for parking areas should be encouraged throughout the City, especially in environmentally sensitive areas and floodplains, as appropriate.** **Policy EP 3.8: Low Impact Development** **Promote the use of LID techniques to mitigate the impact of stormwater runoff. This includes the use of green roofs, rain gardens, cisterns, rain barrels, and on-site wastewater reuse systems in urban and suburban landscapes.**

Getting restarted…

2011-2013: Citizen commissions jump-started LID

Environmental Advisory Board | Stormwater Management Advisory Commission
Sustainable Stormwater Report, August 7, 2012

The Charge from City Council

…the Environmental Advisory Board on August 4, 2011 provided City Council a report suggesting **consideration of alternatives to the current standard requiring traditional curb and gutter** (Streets, Sidewalks, and Driveways Access Handbook) and storm drains on roadways.

Observations and Recommendations

EAB's and SMAC's overarching recommendation is that the **City's strategies for managing stormwater on street and roadway-improvement emphasize** not only drainage, but also **treating stormwater by slowing, filtering, retaining, and absorbing runoff.** This emphasis should begin with the earliest planning and continue through implementation. Planners and designers should be allowed to incorporate proven alternative stormwater management practices as standard practices along with traditional curb and gutter, transitioning from mainly piped systems to systems with natural elements and that recognize stormwater is an important resource, not just a potential hazard.

Further, once these practices are made available, the City should take every opportunity to apply them on its street projects. **Recognizing that changes to established institutional practices come slowly and with difficulty, leadership from City administration will be needed to raise expectations** that staff and contracted designers will consider alternative stormwater techniques on par with traditional techniques.

Getting on track…

- 2013: New LID recommendations from Commission; Council again endorsed; City retained Tetra Tech
- 2014: Staff, consultant, stakeholders collaborated and planned GI/LID implementation:
  - Staff GI/LID Task Force:
  - Stakeholder review and input:
  - Final GI/LID Work Plan – 7 Work Items
- 2015/2016: Convened 2 collaboration work groups:
  - Code Review – ordinances, street templates, incentives
  - Implementation – cost-effectiveness, fact sheets, maintenance

GI/LID Work Plan items

Work Plan Item	Key Aspects
1. Review Ordinances and Policies as They Pertain to Using GI/LID	·***Activity***: Identify and evaluate barriers to using GI/LID; describe potential code revisions ·***Goals***: Fewer barriers, clear expectations for developers and designers; cross-department input and buy in

GI/LID code revisions

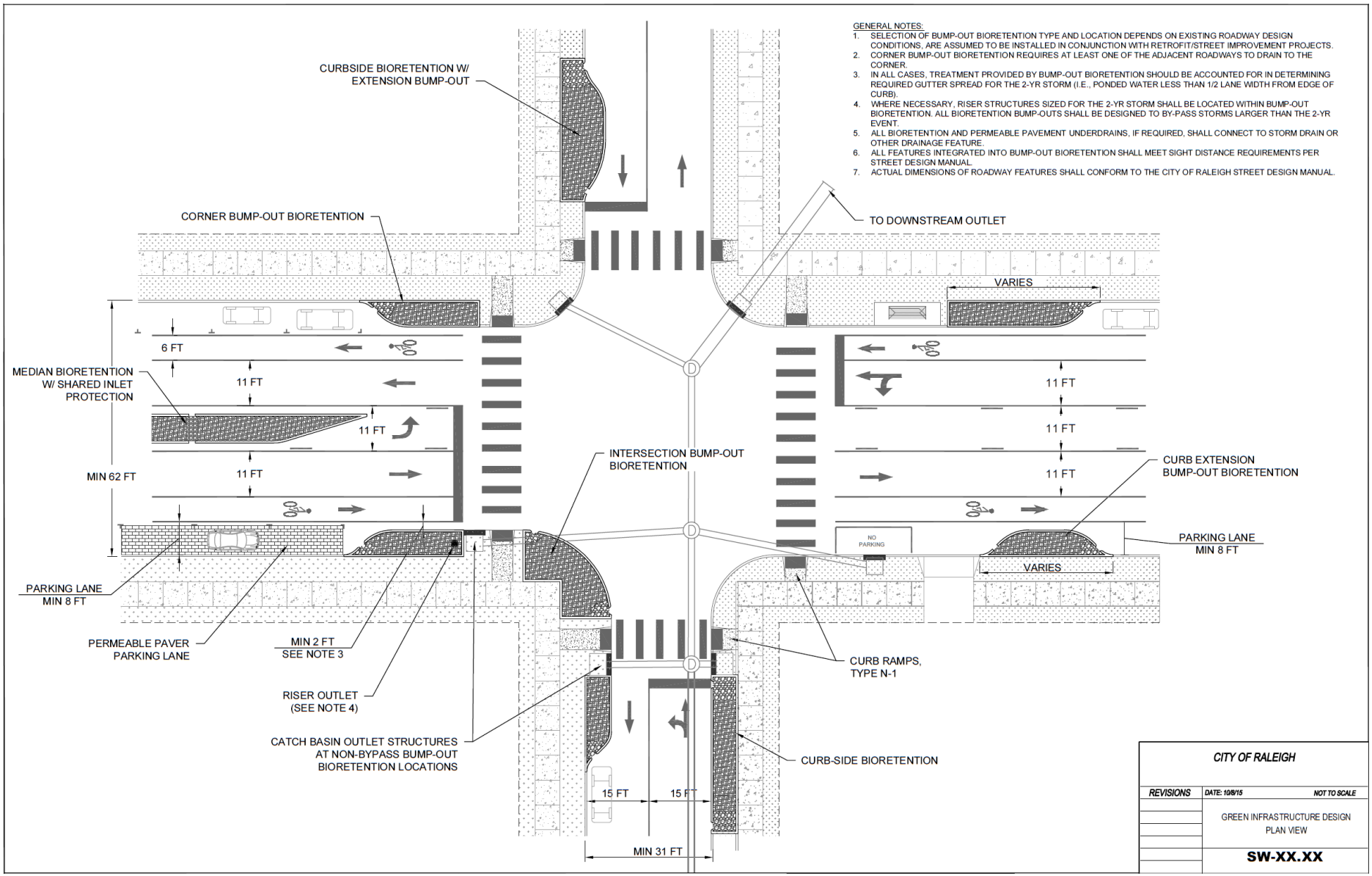
RECOMMENDED UDO TEXT CHANGES FOR ADVANCING GREEN INFRASTRUCTURE AND LOW IMPACT DEVELOPMENT IN RALEIGH
PREPARED FOR THE TEXT CHANGE COMMITTEE OF THE CITY OF RALEIGH PLANNING COMMISSION
COMMITTEE MEETING ON 5/16/2017

Current UDO Text	UDO Text Change	*Explanation*
UDO Chapter 1 – Introductory Provisions		
UDO Section 1.5.3.C. Measurement, Exceptions & General Rules of Applicability; Coverage General Requirements 7. Above-ground stormwater detention facilities shall not be considered an outdoor amenity area.	7. ~~Above-ground stormwater detention facilities~~ Stormwater detention wet ponds and dry ponds shall not be considered an outdoor amenity area. GSI practices may be used to meet up to 10% of the requirement for the amenity area.	*Text changes to Sections 1.5.3.C. and 1.5.3.D. would explicitly allow GSI practices in required designated landscape areas/amenity areas or for GSI practices to count toward required landscaping/amenities. These changes also would name specific types of stormwater devices that explicitly are not allowed as or within amenity areas.* *These changes are intended to encourage use of GSI practices by enabling them to be co-located with or within required amenity areas, potentially reducing site development costs for landscaping and stormwater management.*
UDO Section 1.5.3.D. Measurement, Exceptions & General Rules of Applicability; Additional Requirements for Urban Plazas 2. Amenity areas may contain any one of the following: benches, seats, tables, eating areas, plazas, courtyards, fountains, active recreation areas, or public art.	2. Amenity areas ~~may~~shall contain ~~any~~ one of the following: benches, seats, tables, eating areas, plazas, courtyards, fountains, active recreation areas, or public art. In addition, vegetated GSI practices may be located within the amenity area and may be used to meet up to 10% of the requirement for the amenity area. Stormwater detention wet ponds and dry ponds shall not be considered an outdoor amenity area.	
UDO Chapter 2 – Residential Districts		
UDO Section 2.5.2.A. Open Space Allocation 2. Natural resource buffers required along primary and secondary watercourses.	2. Natural resource buffers required along primary and secondary watercourses (see open space bonus allowance in Sec. 9.2.3 A.1.d).	*This text change would provide cross reference to the open space bonus being added as a text change to Sec. 9.2.3.A.1.d.*
UDO Chapter 7 – General Development Standards		
UDO Section 7.1.4. Parking, Vehicle Parking Reductions Not addressed in the current UDO.	E. Minimum required parking may be reduced by one parking space for each tree 12 inches in diameter or larger that is preserved within the parking lot or elsewhere on the development site within 50 feet of the parking area (reduction not to exceed 2 parking spaces or 10% of the total required parking spaces, whichever is greater). The preserved trees shall be specified on the recorded plat.	*This text change would allow preservation of mature trees within and/or near required parking areas by allowing reduction of the number of required parking spaces.* *This change is intended to preserve natural green infrastructure and aesthetics and decrease urban heating.*
UDO Section 7.1.7.A. Parking, Vehicle Parking Lot Landscaping, Intent 1. The intent of the vehicle parking lot landscaping requirements is to minimize the visual impacts of large areas of vehicular parking as viewed by the public right-of-way and dissipate the effects of the urban heat island.	1. The intent of the vehicle parking lot landscaping requirements is to minimize the visual impacts of large areas of vehicular parking as viewed by the public right-of-way, minimize the impacts of stormwater runoff, and dissipate the effects of the urban heat island.	*Text changes to Sections Section 7.1.4.A., 7.1.7.A., 7.1.7.C., 7.1.7.D., and 7.1.7.E. would explicitly allow GSI practices as part of or within required landscaping of parking lot islands.* *These changes are intended to encourage use of GSI practices by enabling them to meet requirements for both stormwater management and landscaping, thereby decreasing costs of landscaping and stormwater management.*
UDO Section 7.1.7.C. Parking, Vehicle Parking Lot Landscaping, Perimeter Islands 2. A landscaped perimeter island must be a minimum of 5 feet wide, landscaped with shrubs installed at a rate of 30 shrubs per 100 linear feet that under typical conditions can be expected to reach a height and spread of 3 feet within three years of planting. All shrubs shall be a minimum of 18 inches tall when planted. In lieu of planting a hedge, a wall at least three feet in height may be installed.	2. A landscaped perimeter island must be a minimum of 5 feet wide, landscaped with shrubs installed at a rate of 30 shrubs per 100 linear feet that under typical conditions can be expected to reach a height and spread of 3 feet within three years of planting. All shrubs shall be a minimum of 18 inches tall when planted. In lieu of planting a hedge, a wall at least three feet in height may be installed. GSI practices may be located in perimeter islands if part of an approved stormwater management plan for the site. The shrub requirements may be met within GSI practices.	

GI/LID Work Plan items

Work Plan Item	Key Aspects
2. Develop GI/LID Templates for Streets	**·*Activity*: Develop street typology templates that include GI/LID practices** **·*Goals*: Fewer barriers; clear GI/LID options for streets for use by developers and designers**

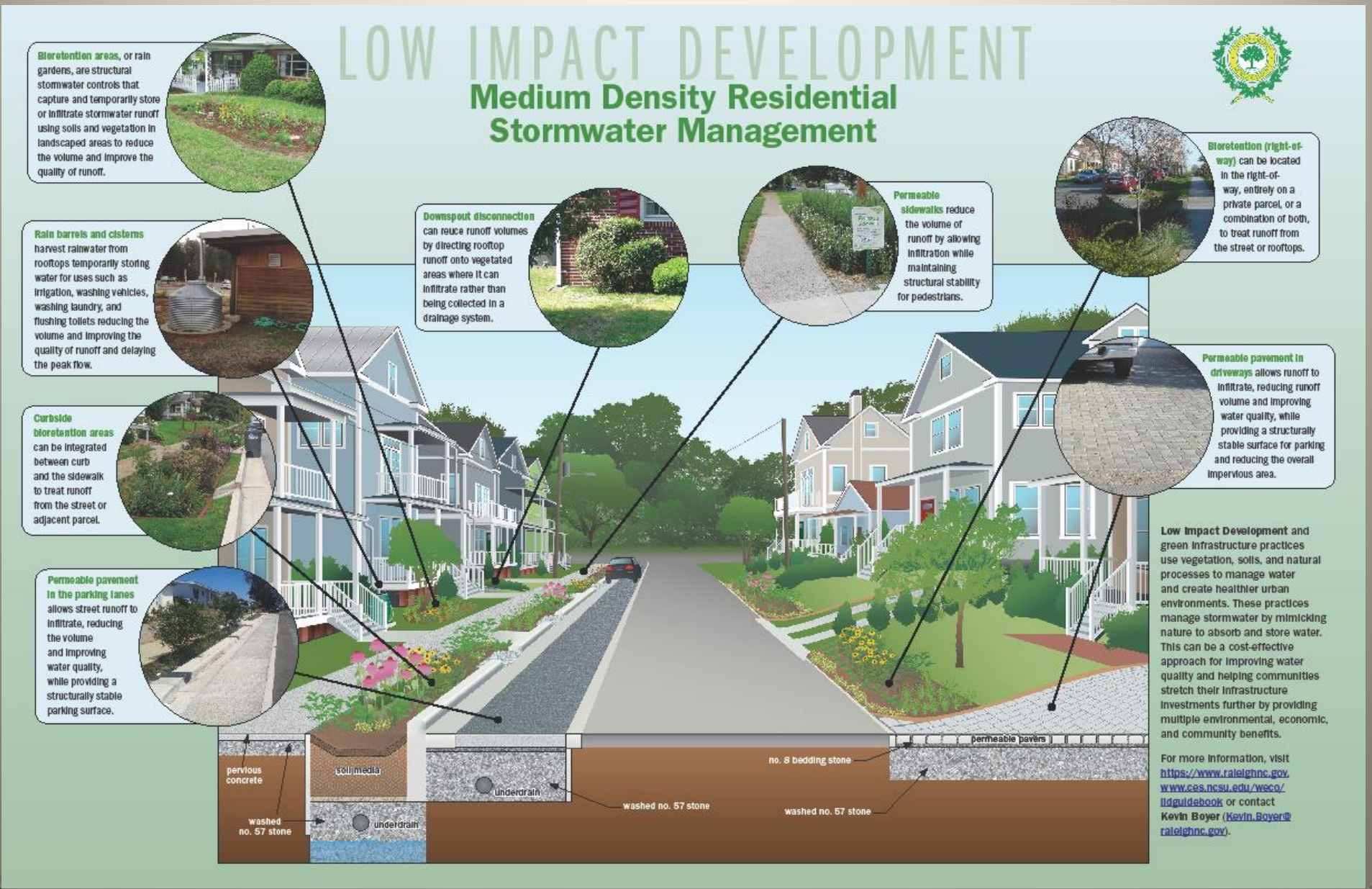
GI/LID street design templates



GI/LID Work Plan items

Work Plan Item	Key Aspects
3. Develop a Tool for Evaluating GI/LID's Cost-Effectiveness	·***Activity***: Evaluate cost-effectiveness tools and select; describe benefits of GI/LID in terms of triple bottom line ·***Goals***: Raise awareness among staff, developers, and designers about GI/LID's costs; build capacity for evaluating GI/LID for specific projects
4. Prepare Fact Sheets for GI/LID Practices	·***Activity***: Develop fact sheets and construction checklists for GI/LID practices ·***Goals***: Communicate "Raleigh welcomes GI/LID"; raise staff awareness; promote staff buy-in, coordination, and consistent policies and practices; promote early communication about GI/LID

GI/LID fact sheets



GI/LID Work Plan items

Work Plan Item	Key Aspects
5. Prepare a Guidance Framework for Maintaining GI/LID Practices	·***Activity***: Develop systems for tracking inspection and maintenance of GI/LID devices and producing management, compliance, and cost reports ·***Goals***: Get feedback about maintenance and costs for City use in rate setting and code evaluation and for developers'/designers' decision making
6. Identify Opportunities for GI/LID Retrofits on Developed Properties	·***Activity***: GI/LID practices in designs for new City facilities and modifications to existing; retrofit practices on existing facilities and in street ROWs ·***Goals***: Accelerate and improve the City stormwater retrofit program; get cross-department input and buy in

GI/LID Work Plan items

Work Plan Item	Key Aspects
7. Evaluate Using Incentives to Encourage GI/LID	·***Activity***: Evaluate various monetary and non-monetary incentives for private owners and developers to use GI/LID ·***Goals***: Establish GI/LID as "business as usual"; reduce developers' actual or perceived risk of using GI/LID; establish development and redevelopment as opportunities for using GI/LID; get development community input and buy in

Bioretention in curb extensions

Planted swales and bioswales

Planted roofs

Bioretention in medians

Missed opportunities

Fayetteville Street, Raleigh

Gresham, Oregon

Missed opportunities

Portland,
Oregon

Pending opportunities

Oxford Road, Raleigh

Coolamee Street, Raleigh

Opportunities

Glascock Street, Raleigh

Stormwater wisdom

"The health of our waters is the principal measure of how we live on the land."

- *Luna Leopold*

"A stream is the report card for its watershed."

- *Alan Levere*

"Do unto those downstream as you would have those upstream do unto you."

- *Wendell Berry*

"Why treat the runoff, when you can eliminate the runoff?"

- *Boyd DeVane*

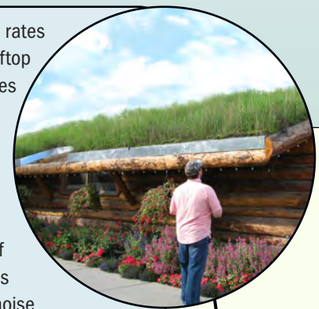
If we were to reinvent stormwater management today….

What would it look like?

OPTIONS FOR GREENING RALEIGH

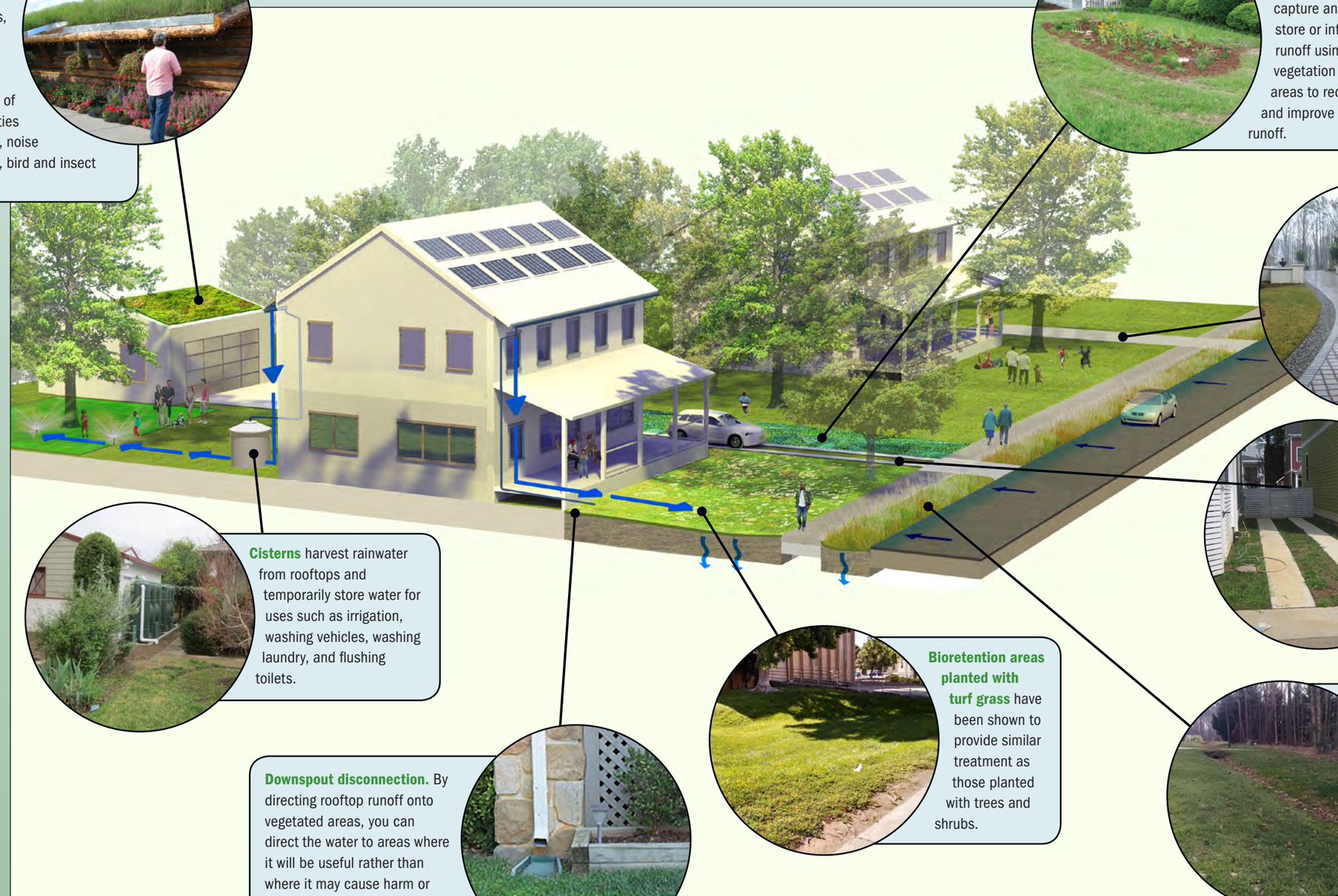
Low-Density Residential Development Stormwater Management

March 2016



Green roofs reduce runoff volume and rates by intercepting rainfall in a layer of rooftop growing media that is typically six inches (extensive) or deeper (intensive). Green roofs offer an array of benefits, including extended roof lifespan (due to additional sealing, liners, and insulation), improved building insulation and energy use, reduction of urban heat island effects, opportunities for recreation and rooftop gardening, noise attenuation, air quality improvement, bird and insect habitat, and improved aesthetics.

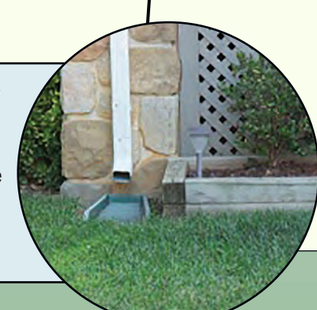
Bioretention areas, or rain gardens, are structural stormwater controls that capture and temporarily store or infiltrate stormwater runoff using soils and vegetation in landscaped areas to reduce the volume and improve the quality of runoff.



Permeable pavement in driveways allows runoff from the driveway, and potentially the rooftop, to infiltrate, reducing the volume and improving water quality, while providing a structurally stable parking surface.

Cisterns harvest rainwater from rooftops and temporarily store water for uses such as irrigation, washing vehicles, washing laundry, and flushing toilets.

Bioretention areas planted with turf grass have been shown to provide similar treatment as those planted with trees and shrubs.



Downspout disconnection. By directing rooftop runoff onto vegetated areas, you can direct the water to areas where it will be useful rather than where it may cause harm or overload pipe systems.

Vegetated swales are shallow, open grass channels that can be an alternative to traditional curbs and gutters. Vegetated swales are designed to convey runoff while providing limited pollutant removal by sedimentation and horizontal filtration through vegetation.

Green Infrastructure practices use vegetation, soils, and natural processes to manage stormwater runoff by mimicking nature to absorb and store water. Integrating these practices into a site can reduce the area required for conventional stormwater management by incorporating treatment within landscaping features and surfaces that would otherwise be impervious. This can be a cost-effective approach to treating stormwater by making more efficient use of a site with the potential for reduced construction costs, increased property values, and greater revenue generation from the additional space made available.

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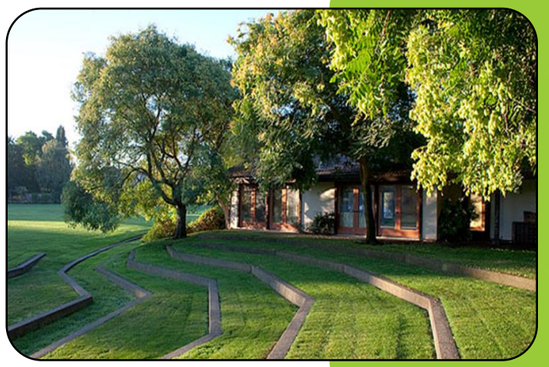
Cost Savings for Low-Density Residential Green Stormwater Management

Boulder Hills Development

- Pelham, NH
- Porous asphalt instead of conventional pavement
- Saved $50,000 (6%) by avoiding curbing, outlet control structures, large stormwater detention ponds



Village Homes Development

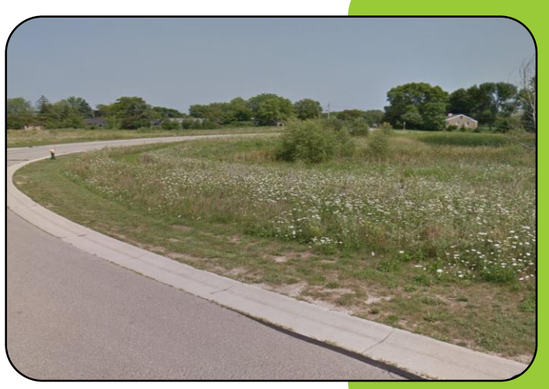
- Davis, CA
- Vegetated swales, rain gardens, open space, narrow streets, clustered lots
- Saved $800 per lot, $192,000 for entire neighborhood compared to conventional development

2nd Avenue Neighborhood

- Seattle, WA
- Bioswales, added vegetation, wetlands, reduced impervious area
- Saved $217,255 (25%) compared to conventional retrofits

Gap Creek Subdivision

- Sherwood, AR
- Preserved natural drainage areas, traffic-calming circles, reduced street width
- Saved $4,800 per lot, $678,500 (15%) total compared to conventional development



Auburn Hills Subdivision

- Racine, WI
- 40% of site preserved as open space with wetlands, green space, added open swales, bioretention
- Saved $761,396 compared to conventional development

Downspout Disconnection Program

- Portland, OR
- City offers financial incentives for disconnections ($13-$53 per downspout)
- Estimated reduction = 1 billion gallons of stormwater annually, $250 million reduction in construction for underground pipes citywide (based on 44,000 homeowners participating)

OPTIONS FOR GREENING RALEIGH

Medium-Density Residential Development Stormwater Management

March 2016

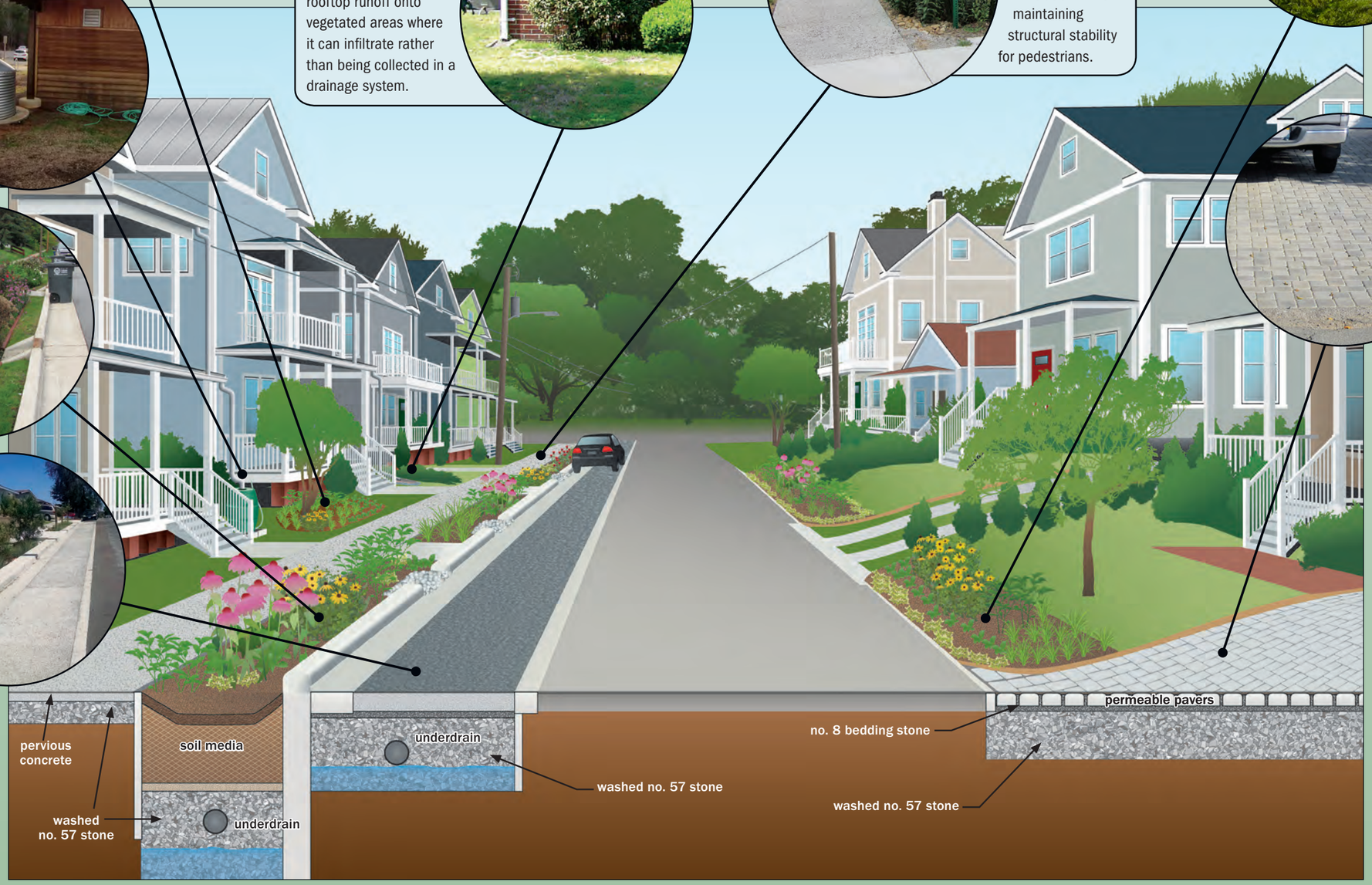
Bioretention areas, or rain gardens, are structural stormwater controls that capture and temporarily store or infiltrate stormwater runoff using soils and vegetation in landscaped areas to reduce the volume and improve the quality of runoff.

Rain barrels and cisterns harvest rainwater from rooftops temporarily storing water for uses such as irrigation, washing vehicles, washing laundry, and flushing toilets reducing the volume and improving the quality of runoff and delaying the peak flow.

Bioretention areas located between the curb and sidewalk can treat runoff from the street or adjacent parcel.

Permeable pavement in the parking lanes allows street runoff to infiltrate, reducing the volume and improving water quality, while providing a structurally stable parking surface.

Downspout disconnection can reduce runoff volumes by directing rooftop runoff onto vegetated areas where it can infiltrate rather than being collected in a drainage system.



Permeable sidewalks reduce the volume of runoff by allowing infiltration while maintaining structural stability for pedestrians.

Bioretention located in the right-of-way can treat runoff from the street or rooftops.

Permeable pavement in driveways allows runoff to infiltrate, reducing runoff volume and improving water quality, while providing a structurally stable surface for parking and reducing the overall impervious area.

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Cost Savings for Medium-Density Residential Green Stormwater Management

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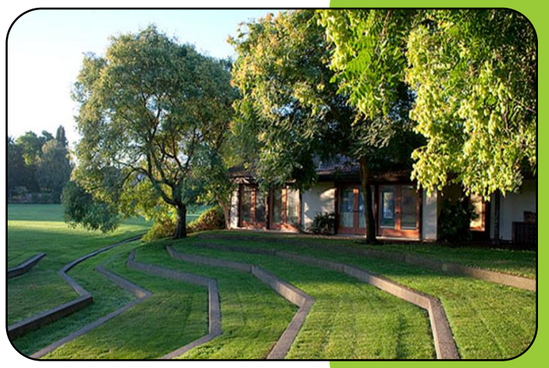

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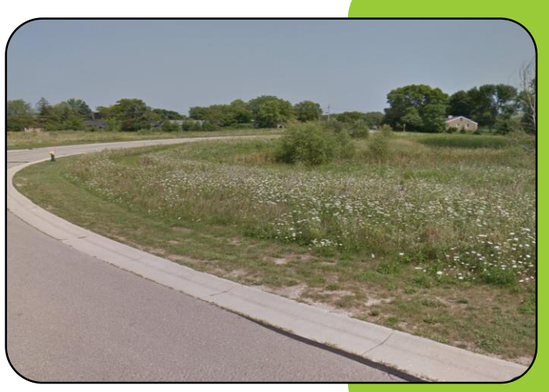

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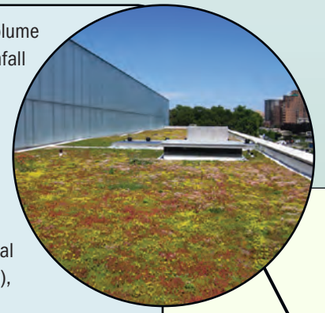
OPTIONS FOR GREENING RALEIGH

High-Density Residential Development Stormwater Management

March 2016



Green roofs reduce runoff volume and rates by intercepting rainfall in a layer of rooftop growing media that is typically six inches (extensive) or deeper (intensive). Green roofs offer an array of benefits, including extended roof lifespan (due to additional sealing, liners, and insulation), improved building insulation and energy use, reduction of urban heat island effects, opportunities for recreation and rooftop gardening, noise attenuation, air quality improvement, bird and insect habitat, and improved aesthetics.

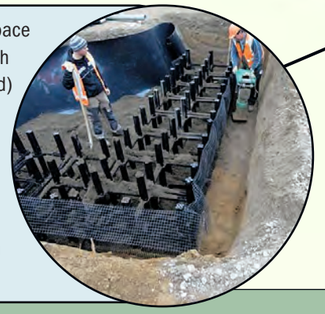
Urban agriculture is the cultivation, processing, marketing, and distribution of food in urbanized areas. Research regarding soil and water interactions with ecologically-based food production systems indicates that large-scale implementation of urban agriculture can help restore urban hydrology and water quality.

Cisterns harvest rainwater from rooftops and temporarily store water for uses such as irrigation, washing vehicles, washing laundry, and flushing toilets.

Permeable pavement in the parking lane allows rain that falls on the parking lane and the street to infiltrate, reducing the volume and improving water quality, while providing a structurally stable parking surface.

Permeable pavement sidewalks allow rain that falls on the sidewalk and, potentially, the rooftops to infiltrate, reducing the volume and improving water quality, while providing a structurally stable surface.

Pervious plazas. Incorporating permeable pavement in plazas, sidewalks, or open space area can reduce impervious area and provide additional opportunities for treatment and infiltrating stormwater runoff.



Suspended pavement maintains void space underneath paved areas that is filled with high-quality soil media (often engineered) and prevents compaction in heavily paved environments allowing for treatment below the surface to reduce the volume and improve the quality of runoff. Suspended pavements are ideal for urban areas and promote tree health by keeping soils loose.

Bioretention areas, or rain gardens, are structural stormwater controls that capture and temporarily store or infiltrate stormwater runoff using soils and vegetation in landscaped areas to reduce the volume and improve the quality of runoff. Street trees can be incorporated into bioretention areas to maximize stormwater treatment and meet landscaping requirements.

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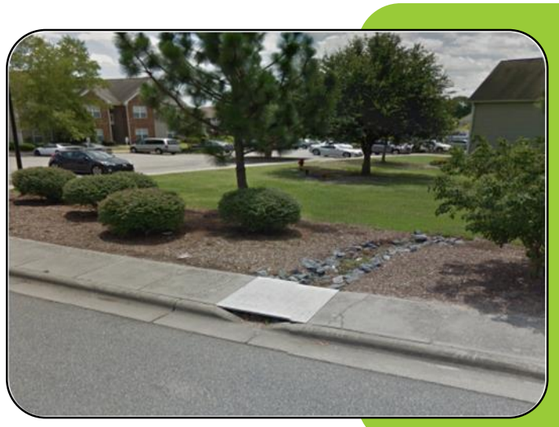
Cost Savings for High-Density Residential Green Stormwater Management

Bronx River Houses

- New York, NY
- Blue and green roofs, rain gardens, perforated pipes, subsurface stormwater chambers
- NYC Green Infrastructure Plan expected to save $2.4 billion in avoided conventional stormwater infrastructure construction

Panther Hollow (Study, not implemented)

- Pittsburgh, PA
- Analysis of green roof cost-saving potential for high-density residential: $260/year/roof saved in conventional stormwater drainage infrastructure



Poplar Street Apartments

- Aberdeen, NC
- 270-unit apartment complex
- Bioretention, channels, swales, stormwater basins
- Saved $175,000 (72%) compared to conventional development

The Natural Resources Defense Council (NRDC) estimates that, using green roofs, strategic tree planting, bioswales, and rain gardens can save $43,500/year for a single building (study assumes 34,000 square feet and 4 stories). This includes: energy cost reduction, tax credits, avoided conventional roof replacement, increased property values, increased rental income, and stormwater fee reduction.

Silver Creek Watershed Area

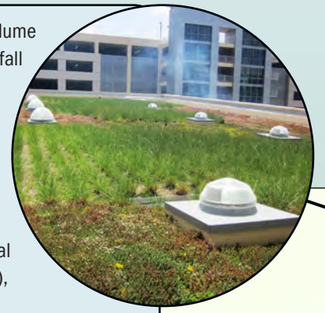
- Toledo, OH
- Highly developed downtown area, subject to flooding
- Blue roofs, bioswales, permeable pavement
- Estimated benefits, including reduced flooding, exceeding $39,500 annually

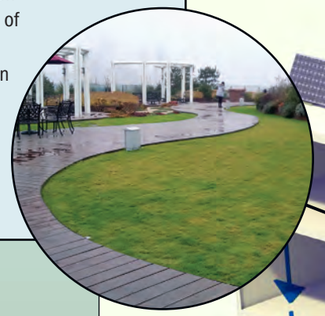
OPTIONS FOR GREENING RALEIGH

Mixed-Use Development Stormwater Management

March 2016

Green roofs reduce runoff volume and rates by intercepting rainfall in a layer of rooftop growing media that is typically six inches (extensive) or deeper (intensive). Green roofs offer an array of benefits, including extended roof lifespan (due to additional sealing, liners, and insulation), improved building insulation and energy use, reduction of urban heat island effects, opportunities for recreation and rooftop gardening, noise attenuation, air quality improvement, bird and insect habitat, and improved aesthetics.



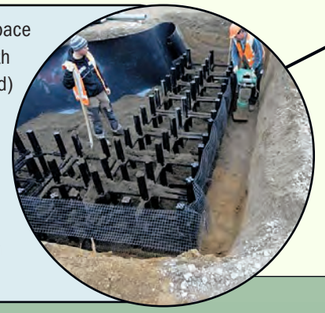


Urban agriculture is the cultivation, processing, marketing, and distribution of food in urbanized areas. Research regarding soil and water interactions with ecologically-based food production systems indicates that large-scale implementation of urban agriculture can help restore urban hydrology and water quality.

Permeable pavement in the parking lane allows rain that falls on the parking lane and the street to infiltrate, reducing the volume and improving water quality, while providing a structurally stable parking surface.

Cisterns harvest rainwater from rooftops and temporarily store water for uses such as irrigation, washing vehicles, washing laundry, and flushing toilets. Cisterns in highly impervious areas can be installed in parking garages or under buildings and can store a significant amount of water.

Suspended pavement maintains void space underneath paved areas that is filled with high-quality soil media (often engineered) and prevents compaction in heavily paved environments allowing for treatment below the surface to reduce the volume and improve the quality of runoff. Suspended pavements are ideal for urban areas and promote tree health by keeping soils loose.



Permeable pavement sidewalks allow rain that falls on the sidewalk and, potentially, the rooftops to infiltrate, reducing the volume and improving water quality, while providing a structurally stable surface.

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Green Infrastructure practices use vegetation, soils, and natural processes to manage stormwater runoff by mimicking nature to absorb and store water. Integrating these practices into a site can reduce the area required for conventional stormwater management by incorporating treatment within landscaping features and surfaces that would otherwise be impervious. This can be a cost-effective approach to treating stormwater by making more efficient use of a site with the potential for reduced construction costs, increased property values, and greater revenue generation from the additional space made available.

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Cost Savings for Mixed-Use Development Green Stormwater Management

Mill Creek

- Kane County, IL
- 1,500 acre mixed-use community with conservation design principles. 45% open space reduces stormwater costs and increases natural beauty.
- Saved $3,411 per lot (27%)

Green Downtown Area

- West Union, IA
- Implementing permeable pavers rather than traditional pavement results in long-term cost savings
- Estimated cumulative savings of a 57-year period of about $2.5 million compared to traditional pavement options with typical maintenance

Capitol Region Watershed District

- St. Paul, MN
- Rain gardens, stormwater planters, infiltration trenches, tree trenches
- Estimated $500,000 saved (20%) compared to conventional stormwater drainage infrastructure

Panther Hollow (Study, not implemented)

- Pittsburgh, PA
- Area is 9.6% commercial, 30% high density residential, 60.4% low density residential
- Estimated $295/year saved in stormwater drainage costs per green roof

City Sidewalks

- Olympia, WA
- City-wide sidewalk analysis determined traditional sidewalks costs $101 per square yard and pervious sidewalks cost $54 per square yard
- Considered construction and long term maintenance costs and the cost for conventional stormwater management required with traditional sidewalks.

OPTIONS FOR GREENING RALEIGH

Commercial Development Stormwater Management

March 2016

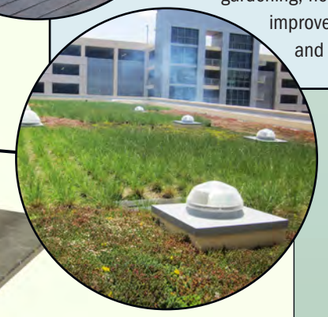
Permeable pavement in the parking stalls allows runoff from the parking lot to infiltrate, reducing the volume and improving water quality, while providing a structurally stable parking surface.

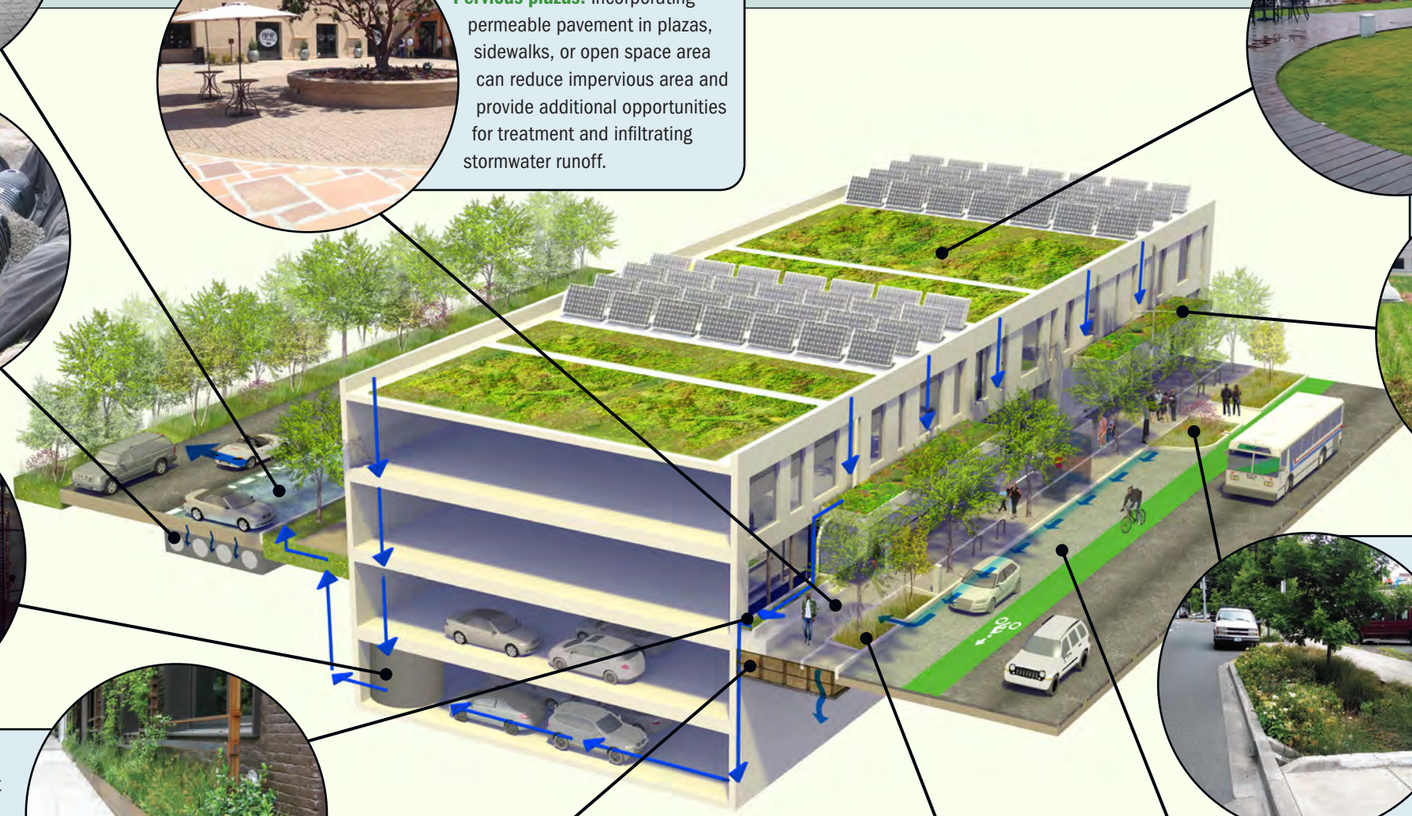
Subsurface storage can be an option on sites were space is a constraint. Below ground systems can be configured to store water for use on site or for treatment through infiltration.

Cisterns harvest rainwater from rooftops and temporarily store water for uses such as irrigation, washing vehicles, washing laundry, and flushing toilets.

Pervious plazas. Incorporating permeable pavement in plazas, sidewalks, or open space area can reduce impervious area and provide additional opportunities for treatment and infiltrating stormwater runoff.

Green roofs reduce runoff volume and rates by intercepting rainfall in a layer of rooftop growing media that is typically six inches (extensive) or deeper (intensive). Green roofs offer an array of benefits, including extended roof lifespan (due to additional sealing, liners, and insulation), improved building insulation and energy use, reduction of urban heat island effects, opportunities for recreation and rooftop gardening, noise attenuation, air quality improvement, bird and insect habitat, and improved aesthetics.





Curb bump out bioretention areas can be integrated into traffic calming measures to treat stormwater runoff from the street and meet landscaping requirements.

Planter boxes use bioretention functions, including filtration and plant uptake, to treat runoff directly adjacent to structures and foundations without impacting the structural stability of surrounding infrastructure.

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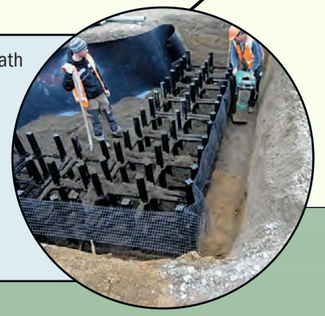

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Cost Savings for Commercial Development Green Stormwater Management

US EPA Building

- RTP, NC
- Grassy swales, water quality ponds, bioretention, preserved natural areas, 100-ft lake buffer established
- Saved $500,000 by avoiding curb and gutter and oil-grit separators

Greenland Meadows Retail

- Greenland, NH
- 4.5 acres of porous asphalt, catch basins, sand filter, sub-surface crushed stone reservoir
- Saved $930,000 compared to conventional stormwater management

Vancouver Island Tech Park

- Saanich, British Columbia
- Constructed wetlands, grassy swales and open channels, ponds, permeable pavement, native plants
- Saved $530,000 compared to conventional stormwater management

Tellabs Corporate Campus

- Naperville, IL
  - 330,000 sq ft office space
  - Preserved natural wetlands and drainage, bioswales
  - Saved $461,510 (14%) compared to conventional stormwater retrofits

Oregon Museum of Science and Industry

- Portland, OR
- 6-acre parking lot retrofit with vegetation and bioswales
- Saved $78,000 compared to conventional stormwater management

City Hall, Bloedel Donovan Park

- Bellingham, WA
- Parking lot rain garden retrofits. City Hall converted 5% of parking lot, and Park converted 550 square feet to rain gardens
- Saved $22,000 (80%) and $40,000 (76%) respectively